भारत सरकार
Government of India
जल शक्ति मंत्रालय,
Ministry of Jal Shakti,
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग,
Department of Water Resources,
River Development and
Ganga Rejuvenation

केंद्रीय भूमि जल बोर्ड
Central Ground Water Board

NAQUIM 2.0

जलभृत प्रबंधन योजना
Aquifer Management Plan

बागपत जिला, उत्तर प्रदेश
Baghpat District, Uttar Pradesh

Northern Region (NR)
Lucknow
2024

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Aquifer Management Plan

बागपत जिला, उत्तर प्रदेश

Baghpat District, Uttar Pradesh

प्राथमिकता प्रकार : जल संकटग्रस्त क्षेत्र

Priority Type: Water Stressed Area

Northern Region (NR)

Lucknow

2024

डॉ. सुनील कुमार अम्बष्ट
अध्यक्ष
Dr. Sunil Kumar Ambast
Chairman

भारत सरकार
जल शक्ति मंत्रालय
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Message

National Aquifer Mapping and Management Programme (NAQUIM) was initiated by Central Ground Water Board (CGWB) in 2012 with the goal of mapping and managing aquifers across India to promote sustainable groundwater use. So far the entire mappable area of 25 lakh km^2 has been covered under the NAQUIM programme. While these initial efforts have been highly impactful, they faced certain limitations especially in terms of spatial resolution.

Taking it forward, CGWB has now initiated **NAQUIM 2.0,** the next phase of aquifer mapping designed to provide a deeper, more detailed understanding of India's groundwater systems. During 2023-24, CGWB had completed NAQUIM 2.0 studies in 68 study areas. The study areas were selected in consultation with the State/UT government agencies.

I am confident that this report of NAQUIM 2.0 study will serve as a critical resource for government agencies, research institutions, NGOs, and the general public. By fostering a collaborative approach to groundwater management, this report will play a key role in safeguarding and sustaining India's precious ground water resources.

(Dr. Sunil Kumar Ambast)

Chairman, CGWB

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डॉ. ए. असोकन
सदस्य
Dr. A. Asokan
Member

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जल संसाधन, नदी विकास
और गंगा संरक्षण विभाग
केंद्रीय भूमि जल बोर्ड

Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development and Ganga Rejuvenation
Central Ground Water Board

MESSAGE

The continuous increase in population, industrialization, and growing water demands have placed significant stress on water resources. This has resulted in an increased demand for water while simultaneously reducing groundwater recharge.

The NAQUIM 2.0 study was undertaken in the **water-stressed areas of Baghpat District**, Uttar Pradesh, with the objective of understanding aquifer disposition, geometry, characteristics, potential, and yield sustainability. The study also focuses on monitoring aquifer-wise groundwater levels, delineating recharge areas, assessing aquifer-wise groundwater resources, and managing groundwater quality. Additionally, it involves identifying safer aquifers and strategies for ensuring the sustainability of drinking water sources.

I congratulate the Regional Director, NR, Lucknow, and the team of officers involved in this study for bringing out this report. The recommendations provided in the report can be effectively utilized by water supply agencies to ensure the provision of safe and sustainable drinking water and to address groundwater management issues prevalent in the area.

(Dr A Asokan)
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आज़ादी का अमृत महोत्सव

Foreword

Ground water plays a vital role in sustaining the livelihood of the populace residing in the present NAQUIM 2.0 area covering the whole district of Baghpat, Uttar Pradesh. The population of the district, being a part of National Capital Region, is increasing comparatively at a higher rate. As the whole district is covered by a very fertile soil, the agricultural activities are intensifying enormously through growing multiple crops throughout the year including the sugarcane which is the major cash crop presently being grown in more than 70% of the cultivated land of the district. Moreover, sugar mills, textile, paper pulp, dyeing and chemical industries have been established in Baghpat district since a long time ago, which are constantly increasing in numbers. Due to all these activities related to ever-increasing population, cultivation and industrialisation, the demand of water, more specifically ground water is rising immensely, as the surface water resource in the district is limited. So, during last few years the withdrawal of ground water has been escalated manyfold in order to cater to the demand of drinking & domestic sector, industrial sector and most importantly the agriculture sector. The volume of ground water extraction from the shallow unconfined aquifers is always exceeding the volume of natural and artificial recharge into those aquifers from the inadequate rainfall and this imbalancing phenomena has become perennial.

In NAQUIM 2.0 area the ground water level is constantly declining and the shallow unconfined aquifer is being dewatered, which is manifested by depleting of dynamic resource and coming of all the administrative blocks under OCS (over-exploited, critical and semi-critical) category in terms of ground water extraction. Thus, it has become essential to thoroughly decipher the geometry and hydrogeological charateristics of the aquifers and then to formulate a pragmatic and sustainable plan for judicious development and management of different aquifers and their ground water resources with the aim of alleviating the water stressed condition of Baghpat district.

Consistent with this objective, Central Ground Water Board, Norhern Region had taken up the National Aquifer Mapping and Management work (NAQUIM 2.0) under AAP 2023-24 in all six blocks of Baghpat district, belonging to the 'OCS' catergory, which covers an area of 1350 sq. km.

The efforts of S/Shri S. M. Hossain, Scientist-D, Rahul Kumar, AHG, Vidya Bhooshan, AHG, Karam Singh, Scientist-C (Chemist) and Aniruddh Singh, AGP in carrying out rigorous field work and bringing out this report are really appreciable. The report is compiled in a comprehensive manner incorporating a huge volume of technical data and an efficacious management plan involving the supply side and demand side interventions and thus expected to be of immense help for the administrators, planners, water resource managers, researchers, academicians and other ground water stake holders as a reference material for development and management of ground water.

संजय
(S. G. Bhartariya)
Regional Director

ACKNOWLEDGEMENT

First of all, we would like to express our sincere thanks and gratitude to Shri Sanjay Gopal Bhartariya, Regional Director, Central Ground water Board, Northern Region, Lucknow for giving us the opportumity to carry out this NAQUIM 2.0 work in the water stressed OCS blocks of Baghpat district, Uttar Pradesh under Annual Action Plan 2023-24. Continuous technical guidance and infrastructural support by the Regional Director helped us enormously in accomplishing this work and composing the NAQUIM 2.0 report in a befitting manner within the specified time frame.

We would also like to thank officers of Ground Water Department, Jal Nigam, Minor Irrigation, Agricultural Department and other State Govt. Agencies linked to Baghpat district for providing the technical data pertaining to their departments.

The authors are also thankful to Shri Jagdamba Prasad, Scientist-D, Shri P. K. Singh, Scientist-D, CGWB, NR, lucknow for their valuable suggestions and advices at various stages of field work as well as during the compilation of this report.

Special thanks are due to Shri Amitosh Chandra, Scientist-B (Geophysics) and Shri J. K. Tandon, Draftsman, CGWB, NR, Lucknow for preparation of some thematic maps, water level and water quality maps, 2D diagrams and 3D models of aquifers.

We also earnestly thank Dr. Fakhre Alam, Scientist-B, CGWB, NR, Lucknow for initial scrutinization of the draft report.

At last, profuse thanks are deserved by all officers and officials of CGWB, NR, Lucknow, who directly or indirectly contributed in compilation of this report.

Seikh Mahdood Hossain

Scientist–D (Team Lead, NAQUIM 2.0-Baghpat)

Central Ground Water Board

Northern Region, Lucknow

EXECUTIVE SUMMARY

The National Aquifer Mapping and Management 2.0 (NAQUIM 2.0) work has been carried out by CGWB, NR, Lucknow during the Annual Action Plan 2023-24 in an area of 1350 sq. km. covering the entire Baghpat district located in the National Capital Region (NCR) of Uttar Pradesh including all the 6 blocks of the district coming under OCS category.

Broad objectives were to decipher the geometry and disposition of aquifer systems in horizontal and vertical directions, characterize the individual aquifers and the bunch of similar aquifers for grouping, delineate the recharge and discharge areas, prepare the aquifer maps, 2D and 3D models of aquifers and finally to devise the aquifer management plans.

The NAQUIM 2.0 area falls in Survey of India Degree Sheets 53G and 53H and in toposheets 53 G/3, 53 G/7, 53 G/4, 53 G/8, 53 H/1 and 53 H/5, which is confined between latitudes 28.7833˚ and 29.2976˚ North and longitudes 77.1376˚ and 77.5055˚ East. As per 2011 census, total population is 13,03,048 with density 965 person/km^2. Average population growth from 2001 to 2011 is 11.94%.

Climate of NAQUIM 2.0 area is sub-humid to sub-tropical and characterised by dryness of air with an intensely hot summer and an extremely cold winter. In summer, the mean daily maximum and minimum temperature are recorded as 40°C and 24.80°C, whereas in winter those are recorded as 20.60°C and 7.90°C. The average annual rainfall for the period from 2013 to 2022 is 540.46 mm, whereas the normal annual rainfall is 674.76 mm. Mean monthly morning relative humidity is 67%.

Major part of the area is covered by minor loam, sandy loam and sandy soils, which are well draining and generally very fertile. During 2020-21, total cultivable area was 111573 Ha (82.66% of total NAQUIM area), whereas the net cultivated/shown area was 107553 Ha (96.40% of cultivable area). Only 1.84 % of NAQUIM 2.0 area was covered by cultivable waste land, 14.11 % area under non-agricultural use, 1.13% under current fallow and 1.20 % area was under forest land.

Geomorphologically, the area can be divided into 3 broad morpho-stratigraphic units - Older Alluvial Plain, Older Flood Plain of Yamuna and Hindon rivers and their Active Flood Plains. Older Alluvial Plain is the oldest geomorphic unit, covering 80% of NAQUIM 2.0 area with a number of ‘tals’, lakes. As a part of Yamuna-Hindon ‘doab’ area, it shows an even, homogeneous topography with elevation from 218 to 233 m amsl and an average gradient of 0.15 m/km with the central part exhibiting slightly higher elevation, which acts as water divide between Yamuna and Hindon.

Yamuna, Hindon and Krishni are the major drainages. The whole area is covered by thick alluvial formations composed of fluvial sediments deposited during Quaternary period locally as the flood plain deposits by Yamuna and Hindon rivers, the right bank tributaries of River Ganga, and regionally as the deposits of Central Ganga Alluvial Plains.

In the NAQUIM 2.0 area, more than 50% of population is directly engaged in cultivation and 70% of population is directly or indirectly dependent upon agriculture and allied activities for their livelihood. Principal crops are Sugarcane, Wheat, Paddy, Mustard, Potato, Vegetables etc. Agricultural land devoid of sugarcane cultivation is normally used for growing 3 crops in a year with the cropping pattern (Kharif Paddy/Pulses/Fodder Crops) – (Wheat/Mustard/Rabi Vegetables/ Potato/ Pulses) – (Pulses/Vegetables/Fodder crops). Average cropping intensity is 160.43%.

Ground water based irrigation is done mainly by Deep Tube Wells (DTW), Medium Depth Tube Wells (MDTW) and Shallow Tube Wells (STW) with an irrigated area of 105794 Ha (98.55% of net irrigated area). The surface water based irrigation is solely done by East Yamuna Canal with a network length of 486 km and coverage of 1556 Ha. The net area irrigated by ground water and surface water is 107350 Ha, which is 96.21% of total cultivable area and 99.81% of net sown area.

Geologically, the area is underlain by a huge thickness (up to the explored depth of 473 m) of unconsolidated sediments of Quaternary age deposited over the Precambrian basement (Quartzite of Delhi Supergroup) comprising silt, clay, sand of various grades (very fine to coarse), gravels and kankar in varying proportions, whose thickness generally increases from west to east (from Yamuna to Hindon) according to the basin configuration. Broadly, two distinct geological units are identified: (i) Older Alluvium or Varanasi Alluvium or Upland area and inter fluvial area between Yamuna and Hindon (ii) Younger Alluvium, occurring over a small area in Older Flood Plains along with narrow depositional terraces of rivers and in present-day Active Flood Plains along Yamuna and Hindon.

Ground water in the NAQUIM 2.0 area occurs under unconfined to semi-confined and confined conditions. The aquifers at the top sometimes overlain or dissected by silty or silty clay layers, which makes them semi-confined. Cumulative thickness of sand layers up to the 100 m depth increases towards northeast and southeast whereas thickness of clay beds towards northwest and southwest and thickness of individual aquifers increases towards river Hindon i.e. from west to east. In depth range 100-200 m, sand is less than 40% in western part and maximum (60%) in northeastern part, whereas in depth range of 300-400 m the collective granular zone has sand below 40%.

In NAQUIM 2.0 area, 4 groups of aquifers have been identified within the explored depth of 473 m, which are separated by three distinct clay horizons. Aquifer Group-I: from 0.0 to 59 m bgl (min.) and to 166 m bgl (max.); Aquifer Group–II: from 84 m bgl min.) to 301 m bgl (max.); Aquifer Group–III: from 215 m bgl (min.) to 404 m bgl (max.) and Aquifer Group–IV: from 316 m (min) to 473 m bgl. Granular zones in Aquifer Group–I are normally thick-bedded, regionally extensive and having comparatively coarser materials than deeper Aquifer Groups–II, III and IV, where the aquifers are relatively thin bedded sometimes lensoid in nature consisting of finer sediments dominated by silty and clayey materials. Aquifer Group-I is again divided into two parts- I(A) (from 0.00 to 80 m bgl max.) and I(B) (from 55 m bgl min. to 166 m max.). Clay beds separating Aquifer Groups-II, III and IV are relatively thicker than clay beds in between Aquifer Group-I(A), I(B) and II. Aquifer Group-I shows the highest resistivity from 35 to 40 ohm.m, whereas Aquifer Group-II shows resistivity from 15 to 25 ohm. and Aquifer Groups-III and IV have resistivity from 15 to 20 ohm.m. Resistivity of the aquifer groups generally decreases with depth, which indicates a general decrease in granularity with depth due to mixing of silts and clays. It is interpreted that the lateral resistivity/granularity variations of Aquifer Group-I are higher than that of deeper aquifer groups.

Average initial and final infiltration rate is 169.7 mm/hr and 13.3 mm/hr respectively, whereas average infiltration rate for all phases is estimated as 91.5 mm/hr. Higher infiltration rates are found at Asara, Kashampur Kheri, Makara, Osika and Pura sites indicating sandy nature of local soils.

Northern, north-western and western fringes of the NAQUIM 2.0 area may be considered as natural recharge areas especially along Yamuna River, where very thick and prolific Group–I(A) aquifers with coarser granular materials are existing. Yamuna river bordering NAQUIM 2.0 area is showing its influent nature for its major length and thus the area adjacent to its left bank is suitable for induced recharge of shallow ground water through tube wells. Rest of the area may be considered as ground water discharge area for shallow aquifers. Highly polluted Hindon river marking the eastern boundary generally shows an effluent nature. However, a large elongated ground water trough covering major parts of Pilana and Khekra and southern part of Binauli block has been created and consequently adjacent section of Hindon river course in the south has become influent. So, further construction of wells tapping shallow unconfined aquifers near the west bank of Hindon and induced recharge should be restricted as this may trigger the contamination of shallow aquifers. The recharge area for Aquifers-I(B), II, III & IV is situated far away, towards north and north-west and outside NAQUIM area. Whole area is suitable for artificial recharge into Group–I(A) aquifers.

Group-I aquifers are yielding from 1557 to 3458 lpm with drawdown from 4.53 to 7.15 m. Hydraulic Conductivity (K) of Aquifer-I(A) measured at a site is 49 m/day and that of Aquifer Group-I(B) at another site is 19.5 m/day. Transmissivity (T) of Aquifer Group-I(A) varies from 1712 to 2458 m^2/day and that of Group-I(B) ranges from 474 to 1500 m^2/day. Storativity (S) of Aquifer–I(B) ranges from $2.438x10^{-5}$ to $2.5x10^{-3}$, which indicates that these aquifers are fully confined in nature. Yield of Group-II aquifers is from 1987 to 2300 lpm with drawdown varying from 6.30 to 14.44 m and Transmissivity ranges from 270 to 837 m^2/day, hydraulic conductivity from 4.38 to 12.50 m/day and Storativity varies from $7.75x10^{-4}$ to$1.26x10^{-3}$. Limited data available for Aquifer Group-III show a yield ranging from 1360 to 2200 lpm with drawdown from 9.22 to 25.55 m, Transmissivity value varies from 345 to 2285 m^2/day, hydraulic conductivity from 3.5 to 23 m/day and Storativity spans from 7.70×10^{-4} to 5.63×10^{-3}. Further less data available for Aquifer Group-IV confirm that the yield varies from 2100 to 2200 lpm against drawdown ranging from 12.52 to 22.62 m with a lower Transmissivity value varying from 301 to 763 m^2/day, Hydraulic Conductivity from 3.0 to 7.60 m/day and Storativity value ranging from $2.1x10^{-4}$ to $5.1x10^{-4}$.

Water table contour map of NAQUIM 2.0 area shows that ground water flow direction is from north-west (NW) and west north-west (WNW) to south-east (SE) and east south-east (ESE). Depth to water level in respect of Group-I(A) aquifer during pre-monsoon 2023 ranged from 8.75 to 42.51 m bgl (Average: 23.47 m bgl) and the block wise average water level varied from 16.55 m bgl to 28.98 m bgl, whereas during post-monsoon water it varied from 5.87 to 34.25 m bgl and block wise average water level is from 16.24 m bgl to 26.53 m bgl. Seasonal fluctuation varied from (-3.40 m) to (+15.54 m) and for major area except Pilana block, it is from 0 to (+)2 m. Long term (2014-2023) trend of water level in Aquifer-I(A), as reported from only two stations available, shows the decline @0.75 m/year at Khekra and @0.80 m/year at Pilana. For Aquifer Group-I(B), water level ranged from 21.12 to 28.80 m bgl during pre-monsoon and from 20.20 to 27.25 m bgl during post-monsoon with block wise average seasonal fluctuation of piezometric surface is from 0.80 to 1.83 m.

The Group-I(A) aquifers are extremely stressed and the topmost aquifer of Group-I(A) is experiencing a continuous decline in ground water level over the years due to heavy indiscriminate withdrawal of ground water by huge numbers of shallow irrigation tube wells tapping this aquifer group for cultivation of sugarcane, the chief cash crop usually occupying more than 71% of sown land in NAQUIM 2.0 area for 10 to 12 months with crop water requirement (CWR) around 2.40 m. Consequently, the shallow unconfined aquifers are constantly and alarmingly being de-watered.

As per the Dynamic Ground Water Resource Estimation for unconfined aquifer of Group–I(A) as on March 2023 by GEC 2015 methodology, the Annual Extractable Ground Water Resource in NAQUIM 2.0 area is 335.5058 MCM and the Current Annual Ground Water Extraction for all uses is 325.8521 MCM. Administrative block wise Stage of Ground Water Extraction (SoE) ranges from 74.41% (Chhaprauli block) and 130.59% (Pilana block) and Stage of Ground Water Extraction for whole NAQUIM 2.0 area is 98.02%. Chhaprauli, Baraut and Baghpat are categorized as 'semi-critical' whereas Khekra, Pilana and Binauli are categorized as 'over-exploited'. Bagpat block has been elevated from previous 'Critical' category as per GWRE 2022 to present 'Semi-Critical' category as per GWRE 2023 due to the improvemnt of SoE from 93.30% to 88.34%. Ground water resources available for future irrigation and industrial uses in Chhaprauli, Baraut and Baghpat blocks are 16.05, 17.13 and 5.63 MCM respectively.

The static ground water resource of shallow unconfined Group–I(A) aquifers in NAQUIM 2.0 area is calculated as 294.13 MCM taking the annually saturated thickness of this aquifer in consideration. On the basis of Storativity or Storage Co-efficient and the height of pre-monsoon piezometric head measured from the bottom of the confining layer overlying the concerned confined aquifer, the in-storage/static ground water resource of the confined Group- I(B) aquifer has also been estimated to be 44.525 MCM with a seasonal fluctuation of only 0.588 MCM as a result of very small seasonal change in piezometric head of this aquifer.

In the NAQUIM 2.0 area of Baghpat district ground water of Aquifer Group-I is of mixed type and mostly of Magnesium Bi-Carbonate type ($Mg - HCO_3$) and slightly alkaline in nature with the average pH value 7.83. Ground water in both the Aquifers of Group-I(A) and I(B) is generally fresh and potable except a very sporadic occurrence of Fluoride, Iron and Uranium with concentration slightly above the maximum permissible limit. No significant seasonal variation in chemical quality of ground water in any of the group of aquifers is observed. Ground water qualities of Group-I(A) and Group-I(B) aquifers do not differ significantly, except sporadic iron contamination in Group-I(A) aquifers. Uranium content ranging from 0.004 to 0.057 mg/lt in pre-monsoon and from 0.003 to 0.08 mg/lt in post-monsoon period has been detected in ground water from some Indian Mark-II hand pumped tube wells with 30 to 65 m depth at some isolated locations. Ground water is free from any sodium hazard as it has very low SAR (< 10) and is also having very low salinity hazard as the water mostly falls in S1-C2 and S1-C3 category. So, ground water in shallow aquifer groups I(A) and I(B) all over NAQUIM 2.0 area is generally suitable for irrigation.

As the measures of proper management of ground water in drinking water sector, it is estimated that in order to cater a population of 912196 (63.64 % of projected population as in 2021), remained uncovered before implementation of Jal Jeevan Mission (JJM), through piped water supply scheme @40 lpcd, 13.318 MCM water is required (40% i.e. 5.3272 MCM from Aquifer Gr-I(A) with available static resource of 294.13 MCM and 60% i.e. 7.9907 MCM from Aquifer Gr-I (B) with the available in-storage resource of 44.525 MCM). For this work, 41 nos. of shallow tube wells tapping Group-I(A) aquifers up to 80 m bgl and 49 nos. deep tube wells tapping Group-I(B) aquifers up to 150 m bgl are to be constructed, which may cause a decline of water level in Group-I(A) aquifers ranging from 0.032 to 0.135 m and that of piezometric surface in Group-I(B) aquifers from 5.006 to 21.235 m. However, if it is planned to cover the projected human population @70 lpcd in 2031, the additional requirement of drinking water would be 0.073887176 MCM per day, which can be extracted through 165 deep tube wells of maximum 200 m depth in Aquifer Group-I(B) with a total estimated cost of Rs. 16.50 Crore.

For ground water management in irrigation sector, 'Supply-Side Intervention' such as Re-Excavation of Existing Tanks (REET) with Recharge Shafts, Injection Well and Conservation Tanks/Ponds in rural areas and Roof-Top Rain Water Harvesting structures along with Injection Wells in urban as well as rural areas are the feasible structures.

Total 102.53993 MCM of Non-Committed Surface Run-Off, as estimated by the Dhruvanarayana'93 methods, is available for recharging the ground water bodies present in shallow aquifer groups. For fully filling up the storage space amounting 481.0802 MCM, available in between 15 m bgl and post-monsoon water level in Group-I(A) aquifer, an amount of 641.4402 MCM water is required, which is to be collected through 11882748 nos. of Roof Top (each of 100 sq. mt. area) Rain Water Harvesting (RTRWH) structures and injected through equal numbers of injection wells with 75% recharge efficiency. On the other hand, the storage space amounting 6.1394 MCM, available in between 15 m bgl and post-monsoon piezometric surface in confined aquifer Group-I(B), can be fully filled up by 8.1858 MCM of source water, which is to be collected through 151644 nos. of Roof Top Rain Water Harvesting system fitted with similar number of injection wells. If it is possible to fill up the respective target storage spaces fully, then the water level in unconfined Group-I(A) aquifer may rise in the range from 1.24 m to 11.53 m, whereas in confined Group-I(B) aquifer, the rise in piezometric surface may range from 5.20 to 12.25 m.

As per the proposed Model-I of 'Supply Side Intervention' if the net non-committed surface runoff as source water amounting 102.53993 MCM is to be allocated to Re-excavated Existing Tanks (REET), injection Wells and Surface Storage cum Irrigation Tanks i.e. Farm Ponds in the percentage of 35%, 30% and 35% respectively then 271 REETs, 79 Injection Wells (IW) and 360 Farm Ponds (FP) have to be constructed all over the NAQUIM 2.0 area with a total expenditure of Rs. 54.43 Crore @ Rs. 5.31/- per 1 CuM of source water to be recharged. On the other hand, as per Model-II of intervention, out of 102.53993 MCM of net Non-Committed Surface Run-Off, 70.900 MCM and 13.508 MCM water may be allocated in an appropriate ratio to the injection wells for partly recharging Group-I(A) and Group-I(B) aquifers respectively and the residual amount of 18.13193 MCM may be stored in surface conservation cum irrigation tanks/ponds. In this scheme under Model-II, a total 285 nos. of injection wells {Group- I(A) –239, Group-I(B) –46} have to be constructed with a total expenditure of Rs. 16.55 Crore and 184 nos. of irrigation tanks/farm ponds have to be constructed with an expenditure of Rs. 14.72 Crore and thus a total amount of Rs. 31.27 Crore has to be spent @ Rs. 3.05/- per 1 CuM of source water. Moreover, with 13.59895 MCM water remaining in 184 nos. of surface conservation cum irrigation tanks/farm ponds after undergoing a 25% evaporation loss, an additional 4532.986 Ha (taking CWR/Delta Factor as 30 cm per crop) agricultural land can be brought under assured irrigation.

Under 'Demand Side Intervention' activities a two-fold effort may be made for improving the ground water scenario in shallow aquifers of NAQUIM 2.0 area and increasing the area of irrigation as well as making additional agricultural income viz. (i) change in cropping pattern by partial reduction of highest water requiring (CWR) local crop and (ii) gradual shrinkage of traditional irrigation practices like flooded/spread irrigation and adopting modern micro-irrigation techniques like drip and sprinkler irrigations. Cropping pattern change may be accomplished by two alternative methods: Method – 1 : ground water saved through 10% reduction of sugarcane cultivation may be fully utilized for growing lower CWR crops like wheat, 'boro' rice, mustard and vegetables by which 35749.76 Ha of alternative irrigation area may be created with an effective increase of irrigation area by 28340.66 Ha and a considerable increase of sown/cropped area during the dry season/lean period (winter, spring and summer), eventually which may result in an effective gain in agricultural income by Rs. 580.3849 Crore after compensating the loss by 10% reduction of Sugarcane cultivation. Method-2 : distribution of the agricultural land released from reduction of 10% sugarcane cultivation area, two times in a year, to the lower water requiring crops, first in

Kharif season absolutely for rice cultivation and then in Rabi season for mustard, wheat and vegetables in equal proportion can effectively save 101.2577 MCM of ground water in shallow Gr.-I(A) aquifers resulting in improvement of district wise Stage of Extraction (SoE) from 97.12% (2023) to 74.61% i.e. from 'critical' to 'semi-critical' category with a considerable rise of water level (1.25 m) in Gr-I(A) aquifer and at the same time a profit of Rs. 48.9608 Crore.

Artificial Recharge of shallow Group-I (A) aquifers over the whole NAQUIM 2.0 area by injection tube wells utilising non-committed surface run-off amounting 70.90 MCM, as a 'Supply Side Intervention' singly may increase the ground water reserve by 53.1750 MCM and reduce the district wise Stage of Ground Water (Dynamic Resource) Extraction (SoE) from 97.12% to 83.84%. Change in Cropping Pattern by releasing 10% sugarcane area and using that area first in Kharif season absolutely for Rice and then distributing that area equally among three low CWR crops mustard, wheat and vegetables in Rabi season as a 'Demand Side Intervention' alone may save 101.2577 MCM of ground water and reduce the district wise SoE from 97.12% to 74.61%. Ultimately a significant cumulative increase of dynamic Ground Water resource by 154.4327 MCM and an improvement of district wise SoE from 97.12% to 66.51% may take place as a combined effect of 'supply side intervention' through artificial recharge by injection wells and 'demand side intervention' through cropping pattern change for saving the ground water resource.

As a collective outcome of both the 'supply side intervention' through irrigation from conservation cum irrigation tanks/ponds and 'demand side intervention' through allocation of ground water saved by 10% curbing of sugarcane cultivation to other low CWR crops a total 32873.6457 Ha agricultural land can be irrigated additionally.

In Part-II of this report, block wise aquifer management plans of Baghpat district including supply side and demand side interventions have been presented separately by incorporating the salient technical data and information regarding the existence of aquifers, their thickness, disposition, individual characteristics, aquifer-wise ground water resources and chemical quality.

कार्यकारी सारांश

केंद्रीय भूमि जल बोर्ड (CGWB), उत्तर क्षेत्र, लखनऊ **द्वारा** वार्षिक कार्ययोजना 2023-24 में राष्ट्रीय राजधानी क्षेत्र (NCR) और उत्तर प्रदेश राज्य के अंतर्गत बागपत जिले के 1,350 वर्ग किमी क्षेत्र में राष्ट्रीय जलभृत मानचित्रण एवं प्रबंधन 2.0 (NAQUIM 2.0) का कार्य किया गया है, जिसमें जिले के सभी छह अतिदोहित और अर्ध-संकटपूर्ण (OCS) श्रेणी के विकास खंड शामिल हैं।

उद्देश्य

- जलभृत प्रणालियों की ज्यामिति और संरचना को क्षैतिज और लंबवत दिशा में स्पष्ट करना।
- अलग-अलग और समूह के जलभृतों का विश्लेषण और विशेषताएँ पहचानना।
- पुनर्भरण और निर्वहन क्षेत्रों का सीमांकन करना।
- जलभृत मानचित्र तैयार करना, जलभृत प्रबंधन योजनाओं को निरूपित तथा सिफारिश करना।

भौगोलिक और जनसांख्यिकीय विवरण

- **स्थान**: भारतीय सर्वेक्षण डिग्री शीट्स 53G&H; **टॉपोशीट्स** 53G/3, 53G/7, 53G/4, 53G/8, 53H/1,53 H/5
- **निर्देशांक**: 28.7833˚ और 29.2976˚ उत्तर अक्षांश, और 77.1376˚ और 77.5055˚ पूर्व द्राघिमांश ।
- **जनसंख्या**: जनगणना-2011 के अनुसार कुल आबादी 13,03,048 है और जनसंख्या घनत्व 965 व्यक्ति/वर्ग किमी है, जबकि 2001 से 2011 तक औसत जनसंख्या बृद्धि की अनुपात है 11.94%

जलवायु

- **प्रकार**: उप-शुष्क से उप-उष्णकटिबंधीय, शुष्क हवा, अत्यधिक गर्मी और अत्यधिक सर्दियों के साथ।
- **ग्रीष्मकालीन तापमान**: अधिकतम 40°C, न्यूनतम 24.8°C
- **शीतकालीन तापमान**: अधिकतम 20.6°C, न्यूनतम 7.9°C
- **औसत वार्षिक वर्षा** (2013-2022): 540.46 मिमी; **सामान्य वार्षिक वर्षा**: 674.76 मिमी।
- **मासिक औसत सुबह की सापेक्ष आर्द्रता**: 67%

मिट्टी और भूमि उपयोग

- **मिट्टी का प्रकार**: मुख्य रूप से हल्की दोमट, रेतली दोमट और रेतली मिट्टी, जिसमें अच्छी जलनिकासी और उपजाऊता होती है।
- **भूमि उपयोग एवं भूमि आवरण**
  - **कृषि योग्य क्षेत्र** (2020-21): 1,11,573 हेक्टेयर (NAQUIM 2.0 के कुल क्षेत्रफल का 82.66%)
  - **शुद्ध खेती किया गया क्षेत्र**: 1,07,553 हेक्टेयर (कुल कृषि योग्य क्षेत्र का 96.40%)
  - **कृषि योग्य बंजर भूमि**: NAQUIM 2.0 क्षेत्र का 1.84%
  - **गैर-कृषि उपयोग**:NAQUIM 2.0 क्षेत्र का 14.11%; **वर्तमान परती भूमि**: NAQUIM 2.0 क्षेत्र का 1.13%
  - **वन भूमि:** NAQUIM 2.0 क्षेत्र का 1.20%

ध्यातृवाद

ध्यातृवादी दृष्टिकोण से, जलभृत मानचित्रण एवं प्रबंधन क्षेत्र को मुख्य तीन भौमित्रिणत्रासिक इकाइयों में विभाजित किया जा सकता है: पुरानी जलोढ़ समतल, यमुना और हिंडन नदियों की पुरानी बाढ़ समतल तथा इन नदियों की सक्रिय बाढ़ समतल। पुरानी जलोढ़ समतल सबसे पुराना भुआकृतिक इकाई है जो NAQUIM 2.0 क्षेत्रफल का लगभग 80% में फैला हुआ है, जहां कई ताल और झील पाई जाती है। यह क्षेत्र यमुना और हिंडोन नदी की 'दोआब' इलाका का हिस्सा होने के कारण, समतल समजातीय स्थलाकृति दिखाता है, जिसमें भूमि सतह की ऊंचाई 218 से 233 मीटर amsl तक और साधारण औसत ढलान 0.15 मीटर/किमी है। जिले के मध्य भाग में थोरा ज्यादा ऊंचाई पाई जाती है, जो यमुना और हिंडन नदियों के बीच जल विभाजन के रूप में कार्य करती है।

जल निकासी

यमुना, हिंडन और कृष्णी इस क्षेत्र की प्रमुख जल निकासी नदियाँ हैं। पूरा क्षेत्र जलोढ़ विन्यासों की एक मोटी स्तर से ढका है, जिसमें क्वाटरनरी (Quaternary) युग के दौरान में स्थानीय रूप से गंगा नदी की सहायक नदियों यमुना और हिंडन **द्वारा** बाढ़ समतल के निक्षेप के रूप में और क्षेत्रीय रूप से केंद्रीय गंगा जलोढ़ समतल के निक्षेप के रूप में जमा हुईं तलछट सामग्री शामिल हैं।

NAQUIM 2.0 क्षेत्र में, 50% से अधिक आबादी सीधे खेतीबारी के काम और 70% आबादी प्रत्यक्ष या अप्रत्यक्ष रूप से कृषि और संबंधित कार्यकलाप पर निर्भर है। गन्ना, गेहूं, धान, सरसों, आलू, सब्जियां इत्यादि प्रमुख फसलें हैं। कृषि भूमि जो गन्ने की खेती से मुक्त है, उसमें साल में 3 फसलें उगाई जाती हैं, जिसमें फसल चक्र '(खरीफ चावल/दालें/चारा फसलें) - (गेंहू/सरसों/रबी सब्जियां/आलू/दालें)- (दालें/सब्जियां/चारा फसलें)' शामिल है। फसल की औसत गहनता 160.43% है।

भूजल आधारित सिंचाई मुख्य रूप से गहरे नलकूप (DTW), मध्यम गहराई नलकूप (MDTW) और उथले नलकूप (STW) से की जाती है, जिससे कुल सिंचित क्षेत्र 105794 हैक्टर है (शुद्ध सिंचित क्षेत्र का 98.55%)। सतही जल आधारित सिंचाई केवल 1556 हेक्टेयर क्षेत्र में 486 किमी नेटवर्क लंबाई वाली पूर्व यमुना नहर से होती है। भूजल और सतही जल से सिंचित कुल क्षेत्र 107350 हेक्टेयर है, जो कुल कृषि योग्य क्षेत्र का 96.21% और कुल बोयी गयी क्षेत्र का 99.81% है।

भूवैज्ञानिक दृष्टिकोण से, यह क्षेत्र क्वाटरनरी युग के असंपिंडित तलछटों की एक बहुत मोटी स्तर (473 मीटर की गहराई तक) से ढका हुआ है जो प्री-कैम्ब्रियन भूतल (basement) (दिल्ली सुपरग्रुप के क्वार्टजाइट) के उपर जमा हुआ है और जिसमें बिभिन्न आकार के बालू (बहुत बारीक से मोटी), बजरी, कंकड़ और चिकनी मिट्टी भिन्न अनुपात में शामिल होते हैं एवं जिनकी मोटाई द्रोणी (basin) विन्यास के अनुसार पश्चिम से पूर्व की ओर (अर्थात यमुना से हिंडोन की ओर) बढ़ जाती है। बड़े पैमाने पर दो अलग-अलग भूवैज्ञानिक इकाइयों की पहचान की गई है: (i) पुराना

जलोढ़/वाराणसी जलोढ़/ ऊंचा भूभाग (Upland) क्षेत्र - यमुना और हिंडन के बीच का अंतर-नदीय क्षेत्र; (ii) नई जलोढ़ - पुरानी बाढ़ समतल के एक छोटे क्षेत्र एवं यमुना और हिंडन के प्रवाह मार्गों पर अवस्थित वर्तमान के सक्रिय बाढ़ समतल के साथ साथ नदी के संकीर्ण निक्षेपण/जमाव छतों।

बागपत जिले की इस जलभृत मानचित्रण और प्रबंधन क्षेत्र में भूजल अप्रतिबंधित से अर्ध-प्रतिबंधित और प्रतिबंधित स्थितियों के अंतर्गत रहता है। शीर्ष पर स्थित जलभृत कभी-कभी गाद (सिल्ट) या गादयुक्त मिट्टी की परतों **द्वारा** अर्ध-प्रतिबंधित हो जाते हैं। 100 मीटर की गहराई तक बालू की परतों की संचित मोटाई उत्तरपूर्व और दक्षिणपूर्व की दिशा में बढ़ जाती है, जबकि चिकनी मिट्टी की बिस्तरों की मोटाई उत्तरपश्चिम और दक्षिणपश्चिम की ओर बढ़ती है। प्रत्येक जलभृत की मोटाई नदी हिंडन की दिशा में यानी पश्चिम से पूर्व की ओर बढ़ जाती है। 100 - 200 मीटर की गहराई तक, पश्चिमी हिस्से में बालू 40% से कम है, जबकि यह उत्तर-पूर्वी हिस्से में अधिकतम (60%) है, और 300 - 400 मीटर की गहराई में दानेदार भूगर्भीय स्तरों में बालू 40% से कम है।

बाघपत जिले में अबतक के अधिकतम अन्वेषणमुलक छेदन गहराई 473 मीटर तक 4 जलभृत समूहों की पहचान की गई है, जिन्हें तीन प्रमुख मिट्टी (clay) के स्तरों **द्वारा** अलग किया गया है।

- **जलभृत समूह - I**: 0.0 से 59 मीटर तक (न्यूनतम) और 166 मीटर (अधिकतम)
- **जलभृत समूह - II**: 84 मीटर (न्यूनतम) से 301 मीटर (अधिकतम)
- **जलभृत समूह - III**: 215 मीटर (न्यूनतम) से 404 मीटर (अधिकतम)
- **जलभृत समूह - IV**: 316 मी (न्यूनतम) से 473 मीटर (अन्वेषण छेदन की अधिकतम गहराई)

जलभृत समूह - I में दानेदार परतों आमतौर पर मोटे वाले होते हैं, क्षेत्रीय रूप से विस्तारित होते हैं और गहरे जलभृत समूहों की तुलना में अधिक मोटे दानेवाले होते हैं। जलभृत समूह - II, III और IV में दानेदार परतों अपेक्षाकृत पतले वाले होते हैं, कभी-कभी लेंसॉइड आकार के होते हैं, जिनमें तलछट महीन, और मुख्य रूप से गादयुक्त और मिट्टी वाले पदार्थ होते हैं। जलभृत समूह-I को दो भागों में विभाजित किया गया है - I(A) (0.00 से 80 मीटर अधिकतम) और I(B) (न्यूनतम 55 मीटर से अधिकतम 166 मीटर)। जलभृत समूह - II, III और IV के बीच की मिट्टी की परतें जलभृत समूह - I(A), I(B) और II के बीच की मिट्टी की परतों की तुलना में अपेक्षाकृत मोटी होती हैं। जलभृत समूह - I में सबसे उच्च विद्युतीय प्रतिरोधकता होती है, जो लगभग 35 से 40 ओहम.मी. होती है, जबकि जलभृत समूह - II की प्रतिरोधकता 15 से 25 ओहम.मी. होती है और जलभृत समूह - III और IV की प्रतिरोधकता 15 से 20 ओहम.मी. होती है। जलभृत समूहों की प्रतिरोधकता सामान्यतः गहराई के साथ घटती जाती है, जो गाद (सिल्ट) और मिट्टी के मिश्रण के कारण गहराई के साथ दानेदारता में सामान्य रूप से कमी को दर्शाता है। यह निष्कर्ष निकाला गया है कि जलभृत समूह-I की पार्श्व प्रतिरोधकता/दानेदारता परिवर्तन गहरे जलभृत समूहों की तुलना में अधिक होते हैं।

प्रारंभिक सांध्रव (infiltration) गति 169.7 मिमी/घंटा और अंतिम सांध्रव गति 13.3 मिमी/घंटा पाई गई हैं, जबकि सभी चरणों के लिए औसत सांध्रव गति 91.5 मिमी/घंटा अनुमानित की गई है। उच्च सांध्रव गति आसरा, कश्यामपुर खेरी, माकर, ओसिका और पूरा जैसे विभिन्न गाँव में पाई गई हैं, जो स्थानीय मिट्टी के रेतीले स्वभाव को इंगित करती हैं।

NAQUIM 2.0 क्षेत्र के उत्तरी, उत्तर-पश्चिमी और पश्चिमी किनारों को प्राकृतिक पुनर्भरण क्षेत्र माना जा सकता है, विशेष रूप से यमुना नदी के साथ वाले क्षेत्र, जहां बहुत मोटी और समूह-I(A) की जलभृतें प्रचुर मोटे दानेदार सामग्री के साथ मौजूद हैं। NAQUIM 2.0 क्षेत्र की सीमा-वर्ती यमुना नदी अपने अधिकांश भाग में अंत:प्रवाही (influent) है और इस कारण से उसकी बायीं तट के समीप का क्षेत्र उथले भूजल भंडार के प्रेरित (induced) पुनर्भरण के लिए उपयुक्त है। NAQUIM 2.0 के अवशिष्ट क्षेत्र उथले अप्रतिबंधित जलभृतों के संदर्भ में भूजल निकालने वाला (discharge) क्षेत्र माना जा सकता है। हिंडन नदी, जो अत्यधिक प्रदूषित है और NAQUIM 2.0 क्षेत्र की पूर्वी सीमा को चिह्नित करती है, आमतौर पर बहिर्वाही स्वभाव दिखाती है। हालांकि, पिलाना और खेकरा विकास खंड के प्रमुख भागों और बिनौली विकास खंड के दक्षिणी भाग में एक लम्बी विस्तारित भूजल गर्त बना हुआ है और इसका परिणामस्वरूप हिंदोन नदी का दक्षिणी भाग अंत:प्रवाही हो गया है। इसलिए भविष्य में हिंडन के पश्चिमी तट के समीप उथले अप्रतिबंधित जलभृतों को दोहित करने वाले नलकूप का निर्माण तथा प्रेरित पुनर्भरण को प्रतिषिद्ध किया जाना चाहिए, क्योंकि इस कार्य से उथले जलभृतों का संदूषण हो सकता है। जलभृतों - I(B), II, III और IV का पुनर्भरण क्षेत्र उत्तर और उत्तर-पश्चिम की ओर और NAQUIM 2.0 क्षेत्र के बाहर काफ़ी दूर स्थित है। हालांकि, बागपत जिले की इस पूरा NAQUIM 2.0 क्षेत्र ही समूह - I(A) के जलभृतों की कृत्रिम पुनर्भरण के लिए उपयुक्त है।

NAQUIM 2.0 क्षेत्र में जलभृत समूह - I की पानी की उपज (yield) सामान्यत: 1557 से 3458 लिटर प्रति मिनट (lpm) होती हैं, जबकि जलस्तर गिरावट 4.53 से 7.15 मीटर तक होती है।

- **उदिक संचालकता (K):** एक स्थान पर जलभृत - I(A) का उदिक संचालकता (K) की परिमाण 49 मीटर/दिन और जलभृत समूह - I(B) के लिए एक अन्य स्थान पर परिमाण 19.5 मीटर/दिन है।
- **संप्रेषणीयता/परला-संवहनशीलता (T)**: जलभृत समूह - I(A) की परला-संवहनशीलता 1712 से 2458 वर्ग मीटर/दिन तक होती है और समूह-I(B) के लिए 474 से 1500 वर्ग मीटर /दिन तक होती है।
- **संग्रहणशीलता/भंडारण क्षमता/ भंडारण गुणांक (S)**: जलभृत-I(B) की संग्रहणशीलता 2.438×10^{-5} से 2.5×10^{-3} तक होती है, जो दर्शाता है कि ये जलभृत पूरी तरह से प्रतिबंधित हैं।

जलभृत समूह- II पानी की उपज/निकासी (yield) 1987 से 2300 लिटर/मिनट (lpm) तक होती हैं, जलस्तर गिरावट 6.30 से 14.44 मीटर और परला-संवहनशीलता 270 से 837 वर्ग मीटर /दिन तक होती है, उदिक संचालकता 4.38 से 12.50 मीटर/दिन एवं संग्रहणशीलता 7.75×10^{-4} से 1.26×10^{-3} तक है।

जलभृत समूह - III के लिए सीमित रूप से उपलब्ध तथ्य दर्शाता है कि इसकी पानी की उपज 1360 से 2200 लिटर प्रति मिनट होती हैं, जबकि जलस्तर गिरावट 9.22 से 25.55 मीटर के बीच होता है। परला-संवहनशीलता 345 से 2285 वर्ग मीटर /दिन तक होती है और उदिक संचालकता 3.5 से 23 मीटर/दिन तक होती है जबकि संग्रहणशीलता $7.70x10^{-4}$ से $5.63x10^{-3}$ तक होती है।

जलभृत समूह - IV का सीमित तथ्य पुष्टि करता है कि इसकी निकासी दरें 2100 से 2200 लिटर प्रति मिनट होती हैं, जबकि जलस्तर गिरावट 12.52 से 22.62 मीटर के बीच होता है। परला-संवहनशीलता का मान 301 से 763 वर्ग मीटर /दिन तक जो कि अपेक्षाकृत कम होती है, उदिक संचालकता 3.0 से 7.60 मीटर/दिन तक होती है और संग्रहणशीलता $2.1x10^{-4}$ से $5.1x10^{-4}$ तक होती है।

NAQUIM 2.0 क्षेत्र के पानी की मेज (Water Table) का समोच्च रेखा मानचित्र दर्शाता है कि भूजल प्रवाह की दिशा उत्तर-पश्चिम (NW) और पश्चिम उत्तर-पश्चिम (WNW) से दक्षिण-पूर्व (SE) और पूर्व दक्षिण-पूर्व (ESE) की ओर है। समूह - I(A) जलभृत के संदर्भ में 2023 के मानसून पूर्व के दौरान जल स्तर ज़मीन से नीचे 8.75 से 42.51 मीटर (औसत: 23.47 मीटर) तक और ब्लॉक वार औसत जलस्तर ज़मीनी स्तर से 16.55 मीटर नीचे से 28.98 मीटर नीचे तक था, और मानसून के बाद यह 5.87 से 34.25 मीटर ज़मीनी स्तर से नीचे और विकास खंड स्तर पर औसत जलस्तर ज़मीनी स्तर से 16.24 मीटर से 26.53 मीटर नीचे तक था। मौसमी उतार-चढ़ाव (-)3.40 मीटर से (+)15.54 मीटर तक और पिलाना विकास खंड को छोड़कर अध्ययन क्षेत्र का अधिकांश इलाका में यह 0 से (+) 2 मीटर तक पाया गया था। जलभृत - I(A) में जलस्तर का दीर्घकालिक (2014-23) प्रवृत्ति केवल दो स्थानों से उपलब्ध हुआ, जिसके अंतर्गत खेकरा में 0.75 मीटर प्रति वर्ष और पिलाना में 0.80 मीटर प्रति वर्ष की दर से जलस्तर में गिरावट दर्ज किया गया। जलभृत - I(B) में भूजल का स्तर पूर्व-मानसून के दौरान ज़मीनी स्तर से नीचे 21.12 से 28.80 मीटर और मानसून के बाद 20.20 से 27.25 मीटर तक था, जिसमें विकास खंड वार पीजोमेट्रिक सतह की औसत मौसमी उतार-चढ़ाव 0.80 से 1.83 मीटर तक पाया गया था।

समूह - I(A) के जलभृतों अत्यधिक तनावग्रस्त हैं और इसका सबसे ऊपरी जलभृत का जलस्तर में सतत गिरावट हो रहा है, क्योंकि गन्ने की खेती के लिए पूर्णतया जलापूर्ति भूजल से ही होती है जो की बड़ी संख्या में उथली सिंचाई नलकूप **द्वारा** भारी पैमाने पर और अंधाधुंध तरीके से निष्कासन किया जा रहा है। मुख्य फसल गन्ना सामान्यत बोई गयी भूमि की 71% को 10 से 12 महीने तक कब्जा करके रखती है और गन्ने की एक फसल की जल-आवश्यकता लगभग 2.40 मीटर होती है जिसकी परिणामस्वरूप उथले अप्रतिबंधित जलभृत की जलस्तर में अविरत वृहद पैमाने पर गिरावट और इस जलभृत की ऊपरी भाग चिंताजनक रूप से असंतृप्त अर्थात् निर्जलित हो रहा है।

जलभृत मानचित्रण एवं प्रबंधन क्षेत्र के समूह - I(A) की अप्रतिबंधित जलभृत के लिए GWRE 2015 पद्धति द्वारा की गई मार्च 2023 तक की स्थिति में गतिशील भूजल संसाधन अनुमान के अनुसार, सालाना निष्कासन योग्य भूजल संसाधन 335.5058 MCM है और सभी उपयोगों के लिए वर्तमान वार्षिक भूजल निष्कासन 325.8521 MCM है। प्रशासनिक विकास खंड वार भूजल निष्कासन का चरण 74.41% (छपरौली) से 130.59% (पिलाना) तक है और पूरे NAQUIM 2.0 क्षेत्र के लिए निष्कासन चरण 98.02% है। छपरौली, बड़ौत और बाघपत 'अर्ध-संकटपूर्ण' श्रेणी में आया, जबकि खेकरा, पिलाना और बिनौली विकास खंड 'अतिदोहित' श्रेणी में आया है। छपरौली, बड़ौत और बाघपत विकास खंड में भविष्य के सिंचाई और औद्योगिक उपयोगों के लिए उपलब्ध भूजल संसाधन क्रमशः 16.05, 17.13 और 5.63 MCM हैं।

पूरे वर्ष के लिए संतृप्त रहने वाले मोटाई को ध्यान में रखते हुए गणना की गई समूह-I(A) के उथले अप्रतिबंधित जलभृतों की स्थैतिकी/स्थिर भूजल संसाधन 294.13 MCM है। समूह - I(B) के प्रतिबंधित जलभृत का स्थैतिकी/स्थिर भूजल संसाधन 44.525 MCM है जो संग्रहणशीलता/भंडारण गुण (S) और प्रतिबंधित जलभृत के ऊपर स्थित परिसीमन परत (confining layer) के तल से पूर्व-मानसून पीजोमेट्रिक हेड की ऊँचाई के आधार पर अनुमानित किया गया है, जिसमें केवल 0.588 MCM का मौसमी उतार-चढ़ाव पाया गया, जो पीजोमेट्रिक हेड (piezometric head) में बहुत छोटे मौसमी परिवर्तन का परिणाम है।

भूजल की गुणवत्ता

बागपत जिले की समूह - I के जलभृतों का भूजल मिश्रित प्रकार का है और अधिकांशतः मैग्नीशियम बाइ-कार्बोनेट (Mg-HCO_3) प्रकार का है और थोड़ा क्षारीय प्रकृति के है क्योंकि pH का औसत मान 7.83 है। समूह - I(A) और समूह - I(B) दोनों के जलभृतों का भूजल सामान्यतः मीठा और पीने योग्य होता है, सिवाय फ्लोराइड, लोहे और यूरेनियम, जिसकी मात्रा छिटपुट रूप से कभी-कभी मानक एवं अनुमोदित/स्वीकृत सीमा से थोड़ी अधिक पाई जाती है। जलभृतों में भूजल की रासायनिक गुणवत्ता में कोई महत्वपूर्ण मौसमी परिवर्तन नहीं पाया गया। समूह - I(A) और समूह -I(B) के जलभृतों की भूजल गुणवत्ता में भी कोई विशेष अंतर नहीं है, केवल समूह-I(A) के जलभृतों में कभी-कभी लोहे का संदूषण पाया जाता है। कुछ भिन्न-भिन्न स्थानों पर 30 से 65 मीटर गहराई वाले इंडियन मार्क-II हस्तचालित नलकूप से लिए गए भूजल नमूनों में मानसून पूर्व समय यूरेनियम की मात्रा 0.004 से 0.057 मि.ग्रा./ली. और मानसून के बाद में 0.003 से 0.08 मि.ग्रा./ली. पाई गई। भूजल सोडियम के खतरे से मुक्त है क्योंकि इसका सोडियम अवशोषण अनुपात (SAR) बहुत कम (< 10) है और इसमें लवणता का संकट भी बहुत कम है क्योंकि यह मुख्यतः S1-C2 और S1-C3 श्रेणी में आता है। संपूर्ण NAQUIM 2.0 क्षेत्र के उथले जलभृतों का भूजल सामान्यतः सिंचाई के लिए भी उपयुक्त है।

भूजल प्रबंधन

पेयजल क्षेत्र में भूजल प्रबंधन

बागपत जिले की इस जलभृत मानचित्रण एवं प्रबंधन क्षेत्र में भूजल के उचित प्रबंधन के लिए यह अनुमानित किया गया कि जल जीवन मिशन (जे.जे.एम) के कार्यान्वयन से पहले अछूती रही जनसंख्या 912,196 (वर्ष 2021 के लिए अनुमानित जनसंख्या की 63.64%) की पेयजल आवश्यकताएं को पाइप लाइन जल आपूर्ति योजना **द्वारा** 40 लीटर प्रति व्यक्ति/दिन की दर से पूरी करने के लिए 13.318 MCM पानी की ज़रूरत है, जिसका अनुशंसित स्रोत इस प्रकार है:

- 40% (5.3272 MCM) समूह-I(A) के जलभृतों से, जिसमें उपलब्ध स्थिर/स्थैतिक संसाधन 294.13 MCM है।
- 60% (7.9907 MCM) समूह-I(B) के जलभृतों से, जिसमें उपलब्ध स्थिर/स्थैतिक संसाधन 44.525 MCM है।

इस कार्य के लिए 80 मीटर गहराई तक उपलब्ध समूह - I(A) के जलभृतों को दोहन करने वाले 41 उथले नल कूप और 150 मीटर गहराई तक उपलब्ध समूह - I(B) के जलभृतों को दोहन करने वाले 49 गहरे नल कूप का निर्माण किया जाना है, जिससे समूह - I(A) जलभृतों में जल स्तर में 0.032 से 0.135 मिटर तक और समूह-I(B) जलभृतों में पीजोमेट्रिक सतह में 5.006 से 21.235 मिटर तक की गिरावट हो सकती है। हालांकि, यदि वर्ष 2031 के संदर्भ में अनुमानित मानव जनसंख्या 1576688 की पेयजल आवश्यकताएं को 70 लीटर प्रति व्यक्ति/दिन की दर से पूरी करने की योजना है, तो अतिरिक्त पेयजल की आवश्यकता प्रति दिन 0.0738872 MCM होगी। यह 165 गहरे नल कूप (अधिकतम 200 मी. गहराई) के माध्यम से समूह - I(B) जलभृतों से निकाला जा सकता है, जिसकी अनुमानित कुल लागत 16.50 करोड़ रुपये होगी।

सिंचाई क्षेत्र में भूजल प्रबंधन

आपूर्ति-संबंधित हस्तक्षेप

उपयुक्त/व्यवहार्य संरचनाएं:

- ग्रामीण क्षेत्रों में पुनःउत्खनित मौजूदा जलाशय (Re-excavated Existing Tanks: REET) रिचार्ज शाफ्ट्स के साथ जहां यह संभव है, अन्तःक्षेपण नल कूप (Injection Well: IW) और सतही संरक्षण जलाशय/तालाबों अथवा सिंचाई के लिए खेत तालाब (Farm Pond: FP)।
- शहरी और ग्रामीण क्षेत्रों में अन्तःक्षेपण नलकूप के साथ छत वर्षा जल संचयन संरचनाएं।

भूजल पुनर्भरण के लिए उपलब्ध पानी: बागपत जिले की पूरे जलभृत मानचित्रण एवं प्रबंधन क्षेत्र में उत्पन्न हुआ 102.53993 MCM गैर-प्रतिबद्ध सतही बहाव (ध्रुवनारायण'93 विधियों **द्वारा** अनुमानित)।

समूह - I(A) के जलभृत में पुनर्भरण:

ज़मीन की सतह से 15 मीटर गहराई और मॉनसून के बाद की भूजल स्तर के बीच स्थित 481.0802 MCM भंडारण स्थान को पूरी तरह से भरने के लिए 641.4402 MCM पानी की आवश्यकता है, जिसे 11882748 छत वर्षा जल संचयन (एक छत की क्षेत्रफल 100 वर्ग मीटर) संरचनाओं और समसंख्यक 75% पुनर्भरण दक्षता वाले अन्तःक्षेपण नलकूप के माध्यम से संग्रहीत कर सकते हैं।

समूह - I(B) के जलभृत में पुनर्भरण:

ज़मीन की सतह से 15 मीटर गहराई और मॉनसून के बाद की पीजोमेट्रिक सतह के बीच मौजूद 6.1394 MCM भंडारण स्थान को पूरा भरने के लिए 8.1858 MCM पानी स्रोत की आवश्यकता है, जिसे 151644 छत वर्षा जल संचयन प्रणाली (एक छत की क्षेत्रफल 100 वर्ग मीटर) और समसंख्यक 75% पुनर्भरण दक्षता वाले अन्तःक्षेपण नल कूप के माध्यम से संग्रहीत कर सकते हैं।

अगर लक्षित भंडारण स्थानों को पूरा भरना संभव हो जाता है, तो समूह - I(A) जलभृत में जल स्तर 1.24 मीटर से 11.53 मीटर तक ऊपर आ सकता है, जबकि समूह - I(B) जलभृत में पीजोमेट्रिक सतह 5.20 मीटर से 12.25 मीटर तक ऊपर आ सकता है।

आपूर्ति-संबंधित हस्तक्षेप: मॉडल-I

- 102.53993 MCM शुद्ध गैर-प्रतिबद्ध सतही बहाव को स्रोत जल के रूप में पुनःउत्खनित मौजूदा जलाशय (REET), अन्तःक्षेपण नल कूप (IW) और सतही संरक्षण/सिंचाई जलाशय/तालाब (खेत तालाब) में क्रमशः 35%, 30% और 35% के प्रतिशत में आवंटित किया जा सकता है।
- इस कार्य के लिए 271 पुनःउत्खनित मौजूदा जलाशय (REET), 79 अन्तःक्षेपण नल कूप (IW) और 360 खेत तालाबों (FP) का निर्माण करना होगा, जिसका कुल खर्च 54.43 करोड़ रुपये और प्रति 1 घन मीटर (CuM) स्रोत जल की पुनर्भरण के लिए खर्च होगा 5.31 रुपये/-

आपूर्ति-संबंधित हस्तक्षेप: मॉडल-II

- 102.53993 MCM गैर-प्रतिबद्ध सतही बहाव में से 70.90 MCM और 13.508 MCM पानी को क्रमशः समूह - I(A) और समूह-I(B) जलभृतों का आंशिक पुनर्भरण के लिए अन्तःक्षेपण नलकूपों को आवंटित और शेष 18.13193 MCM सतही संरक्षण/सिंचाई जलाशय/तालाबों में संग्रहीत करना।
- इस में समूह - I(A) के लिए 239, समूह-I(B) के लिए 46, कुल 285 अन्तःक्षेपण नल कूपों का निर्माण करना होगा जिसके लिए 16.55 करोड़ रुपये खर्च होगा। 184 संरक्षण/सिंचाई जलाशय/खेत तालाबों का निर्माण करना होगा जिसकी लागत होगी 14.72 करोड़ रुपये। अंततः कुल खर्च 31.27 करोड़ रुपये और प्रति 1 घन मीटर स्रोत जल की पुनर्भरण के लिए खर्च होगा 3.05/- रुपये।

- 25% वाष्पीकरण नुकसान के बाद 184 संरक्षण व सिंचाई जलाशय/खेत तालाबों में शेष 13.59895 MCM पानी से 4532.986 हेक्टेयर अतिरिक्त कृषि भूमि को सुनिश्चित सिंचाई के सुविधा मिलेगी।

(क) मांग-संबंधित हस्तक्षेप

जलभृत की स्थिति सुधारने और सिंचाई क्षेत्र में वृद्धि के लिए दोतरफा प्रयास-

(i) सबसे अधिक पानी की मांग वाली (High CWR) और स्थानीय रूप से सबसे ज़्यादा उगने वाली फसल की खेती में आंशिक कमी करके फसल-पद्धति (Cropping Pattern) में बदलाव करना।

फसल- पद्धति में बदलाव: विधि-1

10% गन्ने की खेती में कमी से बचाए गए भूजल का पूर्ण उपयोग निम्न जल आवश्यकता वाली (CWR) फसलों जैसे गेहूँ, 'बोरो' चावल, सरसों और सब्जियों की खेती के लिए किया जा सकता है, जिससे 35749.76 हेक्टेयर वैकल्पिक सिंचाई क्षेत्र बनाया जा सकता है, जिसमें 28340.66 हेक्टेयर सिंचाई क्षेत्र की शुद्ध/वास्तविक/यथार्थ वृद्धि और सूखा मौसम (सर्दी, बसंत और गर्मी) के दौरान बोए गए क्षेत्र में उल्लेखनीय वृद्धि हो सकती है। इस प्रणाली से गन्ने की खेती में 10% कमी के बाद भी 580.3849 करोड़ रुपये की कृषि आय में वास्तविक वृद्धि हो सकती है।

फसल- पद्धति में बदलाव: विधि-2

गन्ने की खेती में 10% कमी से मुक्त की गई कृषि भूमि को वर्ष में दो बार, पहली बार खरीफ मौसम में चावल की खेती के लिए और फिर रबी मौसम में सरसों, गेहूँ और सब्जियों के लिए बराबर अनुपात में वितरण करके कार्यसाधक रूप में 101.2577 MCM भूजल बचाया जा सकता है, जिससे जिला वार निष्कर्षण चरण (Stage of Extraction: SoE) में सुधार हो सकता है जैसे कि 2023 में परिगणित 97.12% से घट कर अब 74.61% हो सकता है, यानी यह क्षेत्र सम्पूर्ण जिला के हिसाब से 'क्रिटिकल' से 'सेमी-क्रिटिकल' श्रेणी में आ सकता है, साथ ही समूह-I(A) जलभृत के जलस्तर में 1.25 मीटर की वृद्धि हो सकती है और साथ ही साथ 48.9608 करोड़ रुपये का लाभ भी हो सकता है।

(ii) पारंपरिक सिंचाई विधियों जैसे बाढ़/फैलाव सिंचाई को धीरे-धीरे घटाकर आधुनिक सूक्ष्म-सिंचाई तकनीकों जैसे ड्रिप और स्प्रिंकलर सिंचाई को अपनाना।

आपूर्ति-संबंधित हस्तक्षेप द्वारा **भूजल पुनर्भरण एवं भूजल संसाधन की बरोतरी:**

'आपूर्ति-संबंधित हस्तक्षेप' के अंतर्गत गैर-प्रतिबद्ध सतह बहाव 70.90 MCM का उपयोग करते हुए अन्तःक्षेपण नलकूप **द्वारा** समूह - I(A) के जलभृतों में केवल कृत्रिम पुनर्भरण के माध्यम से ही

अलग से भूजल भंडार में कुल 53.1750 MCM की वृद्धि हो सकती है और गतिशील भूजल संसाधन निष्कर्षण की जिलावार चरण (SoE) 97.12% से घट कर 83.84% हो सकता है।

मांग-संबंधित हस्तक्षेप फसल-पद्धति में बदलाव द्वारा भूजल की बचत एवं भूजल स्थिति में सुधार:

'मांग-संबंधित हस्तक्षेप' के अंतर्गत केवल गन्ने के वर्तमान क्षेत्र का 10% को छुड़ाकर और उस कृषि क्षेत्र का उपयोग पहले खरीफ मौसम में पूरी तरह से धान के लिए और फिर रबी मौसम में सरसों, गेहूं और सब्जियों जैसी तीन कम जल-आवश्यकता (CWR) वाली फसलों के बीच समान रूप से वितरित करके ही अलग से 101.2577 MCM भूजल को बचाया जा सकता है और साथ में जिला वार गतिशील भूजल संसाधन निष्कर्षण चरण को 97.12% से घटाकर 74.61% किया जा सकता है।

आपूर्ति-संबंधित हस्तक्षेप तथा मांग-संबंधित हस्तक्षेप के सामूहिक प्रभाव द्वारा भूजल भंडार में वृद्धि और भूजल परिदृश्य में सुधार:

कृत्रिम भूजल पुनर्भरण **द्वारा** 'आपूर्ति-संबंधित हस्तक्षेप' और फसल-पद्धति परिवर्तन **द्वारा** 'मांग-संबंधित हस्तक्षेप' के संयुक्त प्रभाव के रूप में भूजल संसाधन में कुल 154.4327 MCM की महत्वपूर्ण संचयी **वृद्धि** हो सकती है और साथ ही साथ बागपत जिले का गतिशील भूजल संसाधन निष्कर्षण चरण (SoE) 97.12% से घट कर 66.51% हो सकता है।

आपूर्ति-संबंधित हस्तक्षेप तथा मांग-संबंधित हस्तक्षेप के सामूहिक प्रभाव **द्वारा आश्वस्त/निश्चित सिंचाई क्षेत्र की** वृद्धि

'आपूर्ति-संबंधित हस्तक्षेप' के रूप में गैर-प्रतिबद्ध सतह बहाव को भंडारण/संरक्षण सह सिंचाई सिंचाई जलाशय/तालाबों/खेत तालाबों में संरक्षण और सिंचाई के लिए उपयोग के माध्यम से और 'मांग-संबंधित हस्तक्षेप' के रूप में गन्ने की खेती को 10% कम करके बचाए गए भूजल को अन्य कम जल-आवश्यकता वाली फसलों को आवंटित करने का संयुक्त परिणाम के रूप में अतिरिक्त 32873.6457 हेक्टेयर कृषि भूमि को सिंचाई के तहत लाया जा सकता है।

रिपोर्ट के पार्ट-II में बागपत जिले के विकास खंड वार जलभृत प्रबंधन योजनाओं के अंतर्गत आपूर्ति-संबंधित और मांग-संबंधित हस्तक्षेप को अलग-अलग से उपस्थापित किया गया है जिसमें जलभृतों की स्थिति, उनकी मोटाई, भौगोलिक वितरण, उनकी अलग विशेषताएँ, जलभृत-वार भूजल संसाधन और रासायनिक गुणवत्ता इत्यादि संबंधित तकनीकी आँकड़े एवं जानकारी शामिल हैं।

Technical Report on NAQUIM 2.0 in OCS Blocks

Baghpat district, Uttar Pradesh

(Chhaprauli, Baraut, Baghpat, Khekra, Pilana and Binauli blocks: 1350 sq. km.)

{Whole/Parts of Toposheets: Toposheet nos. 53 G/3, 53 G/7, 53 G/4, 53 G/8, 53 H/1 and 53 H/5}

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PART - I

1. INTRODUCTION

Under Annual Action Plan 2023-24 Central Ground Water Board, Northern Region, Lucknow has taken up the NAQUIM 2.0 study for Aquifer Mapping and Ground Water Management work in a water-stressed area of 1350 sq. km. covering all six blocks of Baghpat district, Uttar Pradesh. This NAQUIM 2.0 area is lying between latitudes 28.7833˚ and 29.2976˚ North and longitudes 77.1376˚ and 77.5055˚ East and comes under National Capital Region (NCR). The NAQUIM 2.0 area in Baghpat district is bordered by the Yamuna River as well as Sonipat district of Haryana in the west, Muzaffarnagar and Shamli districts in the north, Meerut district as well as Hindon River in the east and by Ghaziabad district in the south. Baghpat district is administratively divided into three tehsils namely Baghpat, Baraut and Khekra, which is further divided into six development blocks namely Baghpat, Binauli, Chhaprauli, Baraut, Pilana and Khekra. Total population is 13,03,048 (Census 2011). Economy of the NAQUIM 2.0 area is mainly agrarian and sugar mill is the main industry.

The whole NAQUIM 2.0 area is covered by thick alluvial formation composed of fluvial sediments deposited during Quaternary period as flood plain deposits by Yamuna and Hindon rivers, the right bank tributaries of mighty River Ganga. 80% of the area is covered by Older Alluvium Plains, the oldest geomorphic unit, and the remaining area is covered by Newer Alluvium. The unconsolidated sediments occurring in the alluvial plains are admixtures of clay and sand of different grades. Principal crops are sugarcane, wheat, paddy, pulses, potato and maize. Cropping intensity is 167%, which indicates that a huge volume of ground water is constantly being extracted for irrigation through a very large number of shallow irrigation tube wells. Major water bearing granular formation is fine to medium sand. Sporadic pollution of ground water due to Iron, Uranium and brackishness is observed though it is not alarming.

The findings of previous National Aquifer Mapping and Management (NAQUIM) by CGWB and other several studies by the academic institutions and State Govt. departments have revealed that the ground water level in the NAQUIM 2.0 area is constantly declining at an alarming rate. All 6 administartive blocks are under OCS (Over-Exploited/Critical/Semi-Critical) category in terms of ground water extraction as per the Dynamic Ground Water Resource Estimation-2023 by GWRE Methodology 2015, out of which, Binauli, Pilana and Khekra blocks are Over-Exploited (OE) and Baghpat, Baraut and Chhaprauli blocks are Semi-Critical (SC).

1.1 Objectives of NAQUIM 2.0

Broad objective of this work is to decipher the geometry of underlying aquifer systems in horizontal and vertical directions, to find out its resource potential relating to quality and quantity, aquifer characterization and scope for further development, to delineate the recharge and discharge areas, to prepare block-wise aquifer maps and finally to formulate aquifer-wise and block wise ground water management plans. Specific objectives are to do/find out:

(1) Aquifer Disposition; (2) Aquifer wise water level; (3) Recharge areas; (4) Assesment of ground water resources; (5) Ground water quality, management intervention and demarcation of safer aquifers; (6) Artificial recharge plans; (7) Identification of potential aquifers for drinking water; (8) Plan for source sustainability.

1.2 Approach and Methodology

(i) Compilation of Existing Data

(a) Exploratory Drilling and Pumping Test Data of CGWB (lithology, granular zones/aquifers,T, S)

(b) Geophysical Data-VES/TEM/ERI, Electrical Logging along with Gamma Log of Bore Holes.

(c) Water Level and Temperature Data from NHNS Wells and Key Wells of NAQUIM 1.0.

(d) Ground Water Quality Data from NHNS Wells/Quality Monitoring Wells/ Exploratory and Observation Wells/Wells established for Special Study/Key Wells of NAQUIM 1.0.

(e) Ground water draft data and parameters of GW Estimation and Available GW Resource

(ii) Identification of Data Gaps related to all kinds of technical data vital for NAQUIM 2.0

(iii) Data Generation based on Data Gaps

(a) Establishment of new Key Wells distinctly tapping different groups of aquifers existing at different depths for measurement of water levels/piezometric heads, for ascertaining ground water quality/pollution and for estimation of water resource related to various aquifers in unification with existing data of CGWB and related State Govt. Departments.

(b) Ground Water and Surface Water Sampling from various types of sources for Basic and Heavy Metals Analysis in CGWB Laboratory and then reporting water pollution, if any.

(c) Carrying out Geophysical Survey (VES, TeM, ERI) for deciphering the depth, geometry and disposition of sub-surface granular zones/aquifers and the quality of ground water.

(iv) Preparation of thematic maps of the NAQUIM 2.0 area on GIS platform and 2D/3D aquifer disposition and geometry maps and isopach maps of aquifers.

(v) Preparation of aquifer wise & administrative block wise ground water management plans.

1.3 Location, Extent and Accessibility of NAQUIM 2.0 Area

Present NAQUIM 2.0 area has an extent of 1350 sq. km. covering sixnos. of administrative blocks named Chhaprauli, Baraut, Baghpat, Khekra, Binauli and Pilana of Baghpat district and is located in the north-western part of the country and western part of Uttar Pradesh. The areais confined between 28.7833° N and 29.2976° N and 77.1376° E and 77.5055° E, falls in the Survey of India Toposheet nos. 53 G/3, 53 G/7,53 G/4, 53 G/8, 53 H/1 and 53 H/5 and is well connected with state capital Lucknow by road and rail.

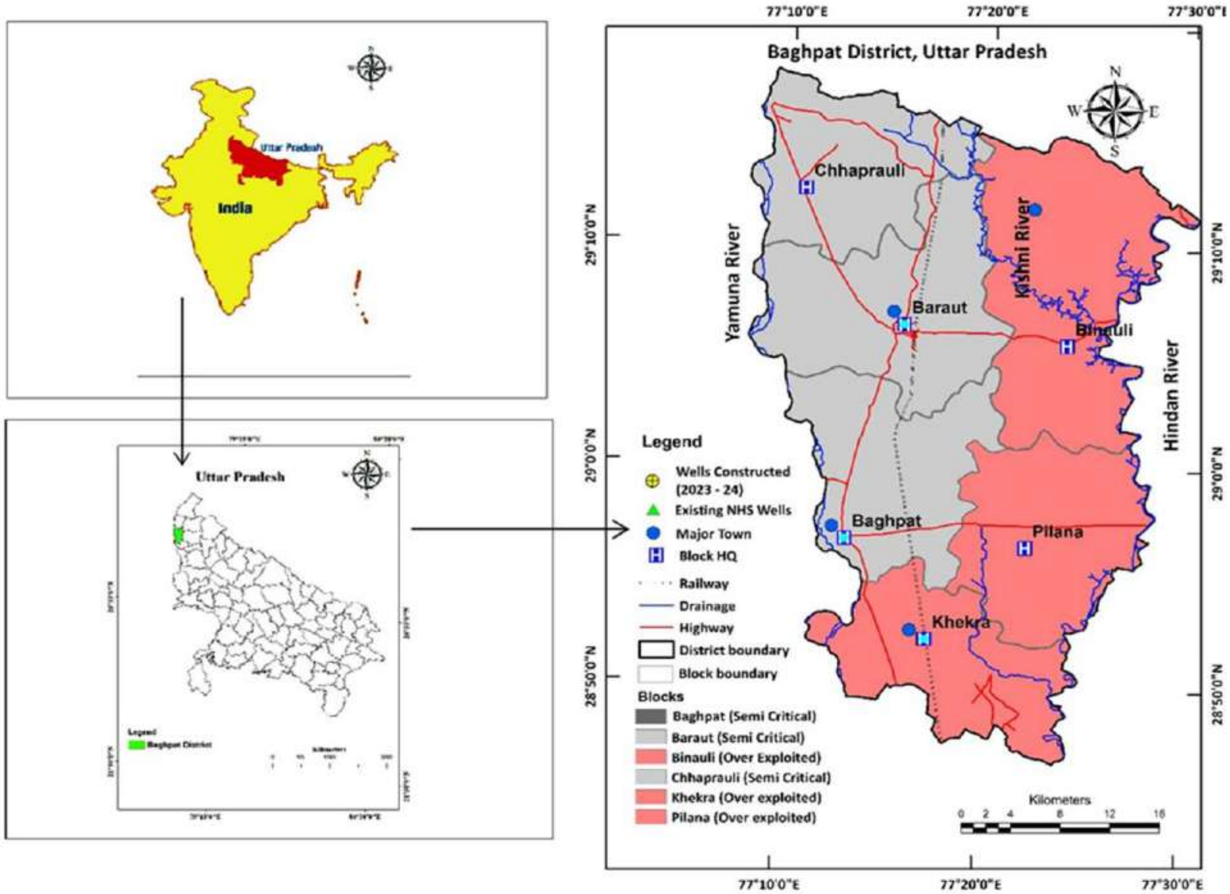


Fig. - 1.1 : Base Map of NAQUIM 2.0 Area in Baghpat district

1.4 Demography

According to Census 2011, the total population is 1303048 out of which 1028023 (~ 78.89%) persons reside in rural and 275025 (~ 21.11%) persons reside in urban areas. Male population is 700070 (~53.72%) and Female population is 602978 (~46.29%). The district has an average population density of 965 persons per sq. km. (Rural - 807, Urban - 3647)

Table - 1.1 : Block wise Population (Census 2011) of NAQUIM 2.0 Area in Baghpat district

Block	Area (sq. km.)	Population			Population Density (Person per sq. km.)
Chhaprauli	205.32	172120			839
Baraut	276.86	279430			1010
Baghpat	210.63	228208			1084
Khekra	160.37	223619			1395
Pilana	207.14	167776			810
Binauli	290.00	231895			800
NAQUIM 2.0 Area Total	**1350.32**	Total:**1303048**	Male: **700070**	Female: **602978**	**965**
Total Rural	1274.43	Total:**1028023**	Male: **553807**	Female: **474216**	**807**
Total Urban	75.89	Total:**275025**	Male: **146263**	Female: **128762**	**3624**

1.5 Climate and Temperature

Climate of NAQUIM 2.0 area in Baghpat district is sub-humid to sub-tropical and it is characterised by dryness of the air with an intensely hot summer and an extremely cold winter. May is the hottest month with mean daily maximum temperature at 40°C and mean daily minimum temperature at 24.80°C. The maximum temperature may be as high as 46°C. With the onset of monsoon an appreciable drop in day temperature is noticed. January is the coldest month with mean daily maximum temperature at 20.60°C and mean daily minimum temperature at 7.90°C. The air remains dry during the greater part of the year except the monsoon period and April and May are usually the driest months. Mean monthly morning relative humidity is 67%. Winds are generally gentle in post-monsoon and winter months, whereas stronger in the summer and monsoon months. (Source: https://mausam.imd.gov.in/)

1.6 Rainfall

Normal annual rainfall is about 674.76 mm where 86% of the rainfall takes place during the period from June to September due to South-West monsoon. The annual rainfall in the year 2022 is 405.6 mm (monsoon-235.0mm and non-monsoon-170.6 mm).

Rainfall data are mainly used for artificial ground water recharge study as well as design and construction of water conservation projects. (Source: https://mausam.imd.gov.in/)

Table - 1.2 : Decadal Annual Rainfall of NAQUIM 2.0 Area in Baghpat district

Year	Annual	Monsoon (June to Sept)	Non-Monsoon (Oct to May)	Year	Annual	Monsoon (June to Sept)	Non-Monsoon (Oct to May)
2013	681.70	624.20	57.50	**2018**	707.80	691.50	16.30
2014	272.90	211.80	61.10	**2019**	527.00	466.40	60.60
2015	522.00	373.90	148.10	**2020**	545.20	436.30	108.90
2016	517.80	493.40	24.40	**2021**	828.9	688.4	140.5
2017	395.70	367.70	28.00	**2022**	405.6	235	170.6
	2390.1				**3014.5**		

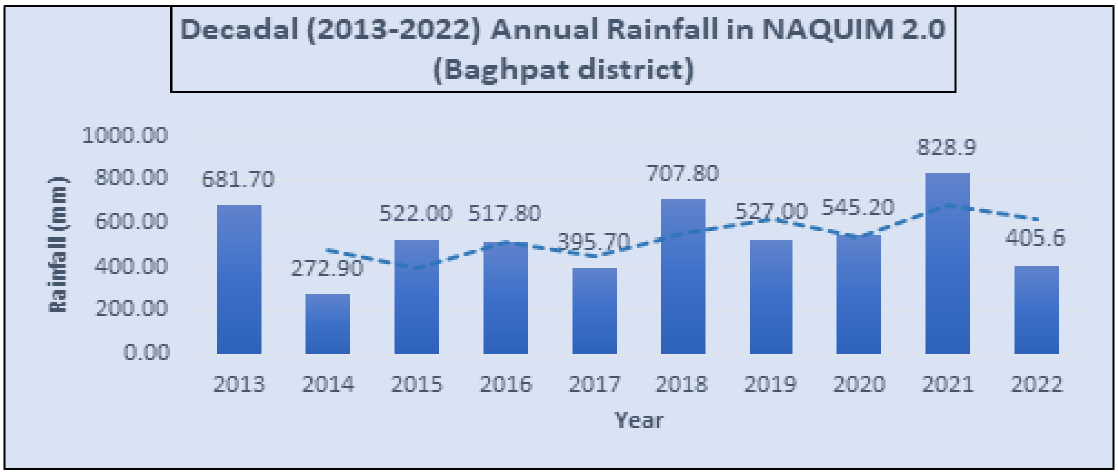


Fig. - 1.2 : Decadal (2013 - 22) Annual Rainfall of NAQUIM 2.0 Area in Baghpat district

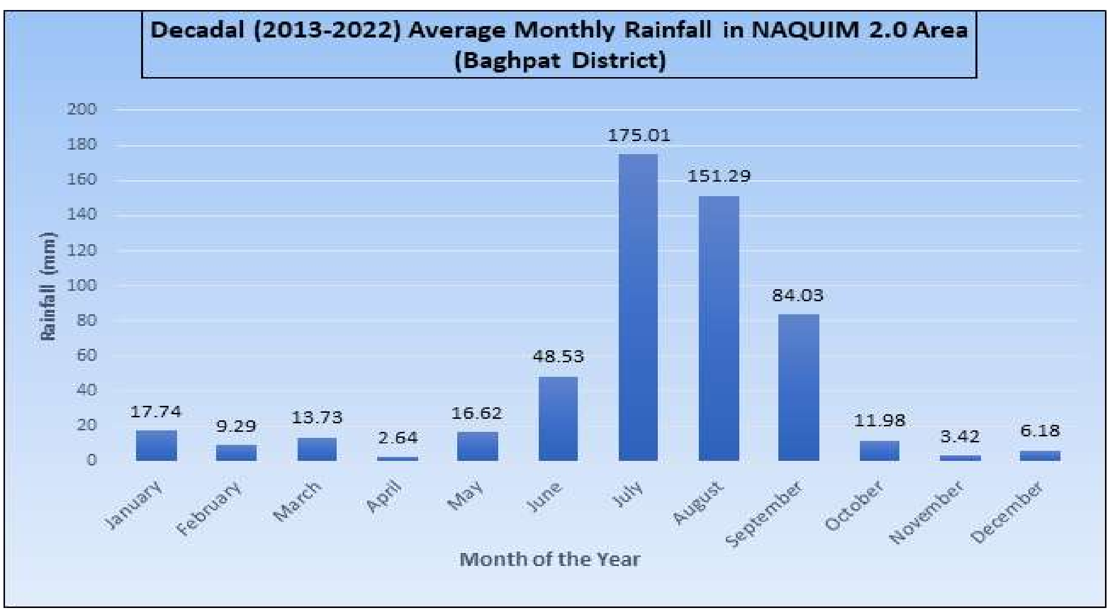


Fig. - 1.3 : Decadal (2013 - 22) Average Monthly Rainfall in NAQUIM 2.0 Area

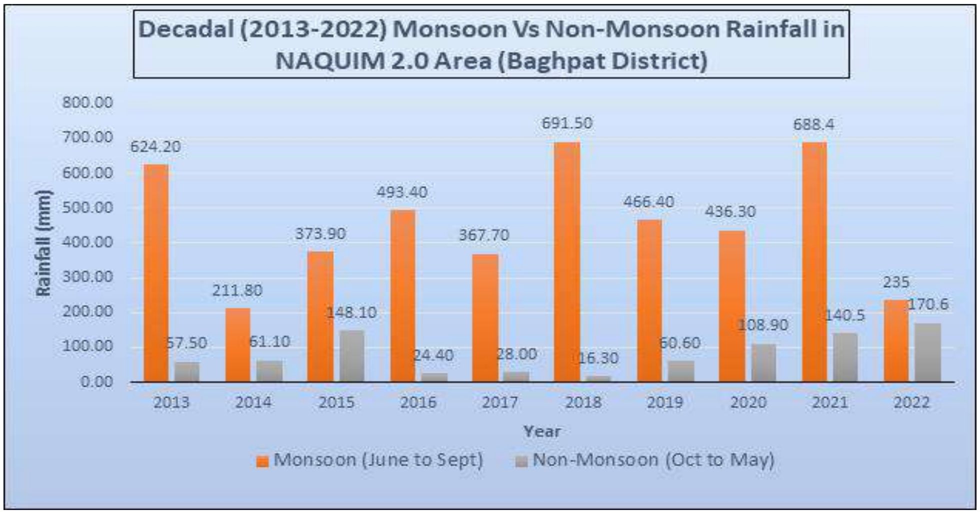


Fig. - 1.4 : Monsoon & Non-Monsoon Rainfall over Last Decade (2013-22) in NAQUIM 2.0 Area

1.7 Geomorphology

Geomorphologically, the area can be divided into three broad morpho-stratigraphic units - Older Alluvial Plain; Older Flood Plain and Active Flood Plain of Yamuna and Hindon rivers.

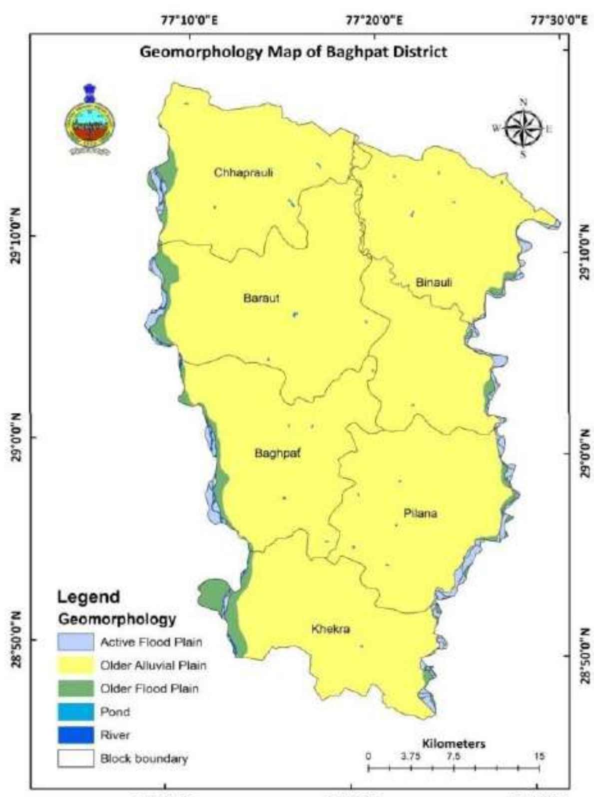


Fig. - 1.5 : Geomorphology Map of NAQUIM 2.0 Area in Baghpat District

Older Alluvial Plain is the oldest geomorphic unit, which covers about 80% of the NAQUIM 2.0 area, where a number of Tals, Lakes occur. Bad land and ravines are developed along the banks of Yamuna, Hindon and Krishi rivers. The Older Flood Plains of Yamuna and Hindon rivers are limited to their higher zones and occur as narrow curvilinear, lenticular patches along the course of these rivers and represented by either one or two terraces. The Active Flood Plain is restricted to the present-day active channel regimes of Yamuna, Hindon and Krishni.

1.8 Land Use and Land Cover

In 2020-2021, out of the total NAQUIM 2.0 area, about 82.66% area is cultivable whereas 79.67% of study area is actually cultivated, about 1.84% area is occupied by cultivable waste land, about 14.11% area under non-agricultural use and almost 1.20% area is under forest land. The average cropping intensity is 160.43%. About 96.21 % of total cultivable area and 99.81% of cultivated or sown area (in 2020-21) has been irrigated by different sources of water. Block-wise land use and land cover is given in Table -1.3. (Source:https://bhukosh.gsi.gov.in/Bhukosh/Public)

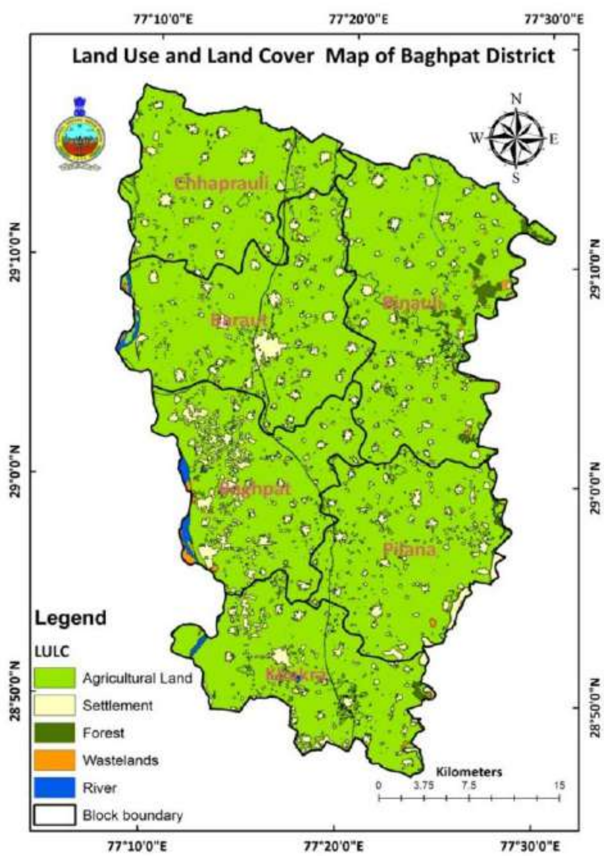


Fig. - 1.6 : Land Use & Land Cover Map of NAQUIM 2.0 Area in Baghpat district

Table - 1.3 : Block wise Land Use (2020 – 21) of NAQUIM 2.0 Area in Baghpat district

Name of Block	Geographical Area (Ha)	Forest Area (Ha)	Area under Non-Agricultural Use	Barren& Uncultur-able Land (Ha)	Pasture Land (Ha)	Land of Misc. Tree Garden& Bush	Culturable Waste Land (Ha)	Other Fallow Land (Ha)	Current Fallow (Ha)	Cultivable area (Ha)	Net Cultivated/ Net Sown Area (Ha)	Gross Sown Area (Ha)	Cropping Inten - sity (%)	Net Irrigated Area (Ha)	Gross Irrigated Area (Ha)
Chhaprauli	20030	132	2143	234	17	23	556	101	162	**17380**	16662	27425	164.60	16626	27365
Baraut	24457	186	3180	305	15	15	353	92	189	**20664**	20122	28384	141.06	20098	28314
Baghpat	20875	203	3257	286	10	16	338	101	216	**17002**	16448	25148	152.89	16215	25133
Khekra	16878	188	2444	219	10	16	421	125	210	**13876**	13245	22141	167.16	13214	22131
Pilana	20349	358	2273	308	18	15	286	103	223	**17274**	16765	25945	154.76	16753	25936
Binauli	24854	442	3473	248	17	15	337	165	365	**20494**	19792	35769	180.72	19724	35733
Total Rural	127443	1509	16770	1600	87	100	2291	687	1365	**106690**	103034	164812	159.96	102630	164612
Total Urban	7540	120	2271	215	12	24	199	15	165	**4883**	4519	7741	171.30	4720	7738
Total	**134983**	**1629**	**19041**	**1815**	**99**	**124**	**2490**	**702**	**1530**	**111573**	**107553**	**172553**	**160.43**	**107350**	**172350**

Source: https://updes.up.nic.in (SPIDER: Sankhyikiya Patrika)

1.9 Soil

The NAQUIM 2.0 area occupies more or less a levelled upland tract lying between Yamuna and Hindon rivers, which is covered mainly by older alluvium soils consisting broadly of 'Bhur'/sandy soil occupying high mounds/undulating surface, 'Matiar'/clay rich soil in depressions and 'Domat'/loam in plains.

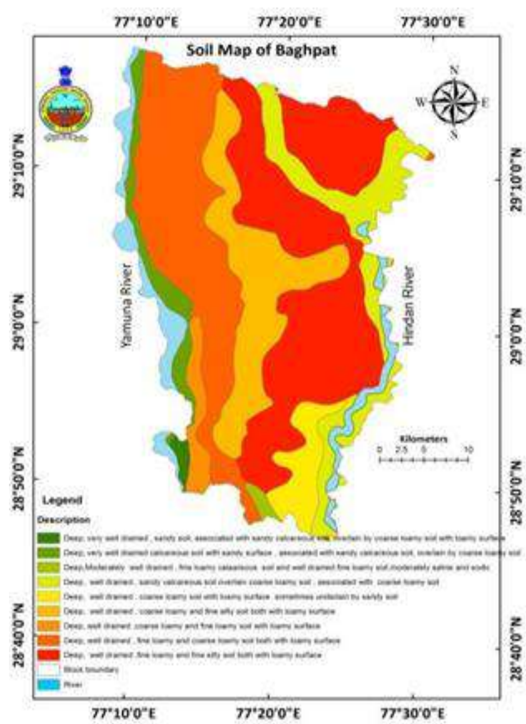


Fig. - 1.7 : Soil Map of NAQUIM 2.0 Area in Baghpat district

Major parts of the area are covered by minor loam, sandy loam and sandy soils, which are well draining and very fertile. The area is also marked by development of ravines and bad land at places along banks of Yamuna, Hindon and Krishni rivers. Soils occurring in ravine and bad land area are normally rich in iron (Fe) and alluvium (Al). (Source:https://bhukosh.gsi.gov.in/Bhukosh/Public)

Soils are sandy, silty and clayey in varying proportions depending upon the local drainage characteristics. Two broad units are (i) Sandy ridges and Sand Dunes: occur close to drainage way sand correspond to 'Bhur'. Isolated sandy ridges and sand dunes are indicative of changing drainage pattern. (ii) Central upland/interfluvial area (Older Alluvial Plain): Major unit of the area isdissected by drainage ways. Top sediments being clayey with minor sand and silt. Occurrence of alkaline soils is restricted to this unit only.

1.10 Drainage

The drainage is controlled by Yamuna River, its tributary Hindon River and sub-tributary Krishni River, all perennial in nature. Rivers Yamuna and Hindon form the western and eastern boundaries of NAQUIM 2.0 area respectively. River Krishni enters into the area form northern side near village Asara in Chhaprauli block and after flowing for a short distance towards southeast, joins the Hindon river near village Laksha Mandap in Binauli block. The drains/streams Daula, Budher, Tera, Kandhal and at places, some small nalas are developed near the rivers.

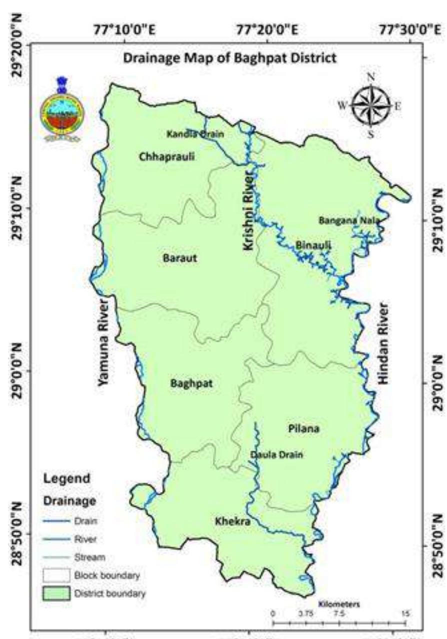


Fig. - 1.8 : Drainage System of NAQUIM 2.0 Area in Baghpat district

1.11 Cropping Pattern and Cropping Intensity

The principal kharif crops are Rice, Arhar, Urad, Bajra etc. whereas the principal Rabi crops are Wheat, Vegetables, Mustard, and Potato etc. The fodder crops are grown in all seasons i.e. Rabi, Kharif and Zaid. Sugarcane is chief cash crop in the area, which occupies around 71 % of the agricultural land almost over the whole agricultural year (10 months) across all the three seasons. Excluding Sugarcane cultivation, the usual cropping pattern is Kharif Rice/Pulses/ Fodder Crops– Wheat/Mustard/Rabi Vegetables/Potato/Pulses – Pulses/Vegetables/Fodder crops. Cropping Intensity for whole area is 160.43% and it varies from 141.06% (Baraut block) to 180.72% (Binauli block). Mostly cultivated main crops are Sugarcane and Wheat. Paddy, Vegetables and Mustard are also grown but in smaller scale. (**Source:** https://updes.up.nic.in/spideradmin/Hpage1.jsp)

Table - 1.4 : Season wise Area occupied by Crops and Irrigation Status (in Ha.) (2021-22)

Block Name	Net sown area	Area sown more than once	Gross Sown Area				Land prep-ared for Sugar-cane	Net irrig-ated area	Gross irrig-ated area	Area under Kharif Crop (%)	Area under Rabi Crop (%)	Area under Zaid Crop (%)
			Total	Kharif	Rabi	Zaid						
Chhaprauli	16662	10763	27425	18863	7655	832	60	16626	27365	68.78	27.91	3.03
Baraut	20122	8262	28384	16737	10654	907	70	20098	28314	58.97	37.54	3.20
Baghpat	16448	8700	25148	14953	9384	846	15	16215	25133	59.46	37.32	3.36
Khekra	13245	8896	22141	12274	9104	742	10	13214	22131	55.44	41.12	3.35
Pilana	16765	9180	25945	14013	11108	867	9	16753	25936	54.01	42.81	3.34
Binauli	19792	15977	35769	24257	10776	735	36	19724	35733	67.82	30.13	2.05
Total Rural	103034	61778	164812	101097	58681	4929	200	102630	164612	61.34	35.60	2.99
Total Urban	4519	3222	7741	5797	1442	404	3	4720	7738	74.89	18.63	5.22
Total	**107553**	**65000**	**172553**	**106894**	**60123**	**5333**	**203**	**107350**	**172350**	**61.95**	**34.84**	**3.09**

Table - 1.5 : Block wise Sown Area of Major Crops in NAQUIM 2.0 Area (in Ha)

Block Name	Sugar -cane	Whe -at	Rice	Vege-tables	Mus-tard	Ara-har	Urad	Pot-ato	Baj -ra	Oni -on	Moo -ng	Bar -ley	Mas-soor	Mat -ar	Cot-ton	Jow -ar	Mai -ze	Gram
Chhaprauli	12416	1414	736	434	175	87	44	10	62	5	4	4	4	6	2	1	0	0
Baraut	15492	3690	745	533	242	65	62	29	112	8	5	7	3	4	5	1	1	1
Baghpat	10958	1493	672	553	375	98	62	27	77	12	5	7	8	5	5	1	1	1
Khekra	11463	370	791	463	397	63	70	45	114	9	6	4	1	2	6	1	1	0
Pilana	7834	3362	1089	437	228	97	48	31	122	12	14	8	7	4	4	1	0	0
Binauli	15928	6609	708	516	378	84	64	53	101	14	11	5	9	9	4	1	1	0
Total rural	74091	16938	4741	2936	1795	494	350	195	588	60	45	35	32	30	26	6	4	2
Total Urban	2296	3824	727	498	168	42	30	7	67	9	0	2	1	2	3	1	0	0
Total	**76387**	**20762**	**5468**	**3434**	**1963**	**536**	**380**	**202**	**655**	**69**	**45**	**37**	**33**	**32**	**29**	**7**	**4**	**2**

(**Source:** https://updes.up.nic.in/spideradmin/Hpage1.jsp)

1.12 Irrigation

Irrigation in this NAQUIM 2.0 area is carried out by the ground water structures such as tube wells and surface water irrigation system like canals. East Yamuna Canal and its branches irrigate a very small part of the cultivated land in the NAQUIM 2.0 area measuring only 1556 Ha, which constitute only 1.45% of the net irrigated area (107350 Ha) whereas 105794 Ha i.e. 98.55% area of net irrigated area is irrigated by ground water.

Fig. - 1.9 : Percentage of Net Area Irrigated by different sources in NAQUIM 2.0 Area

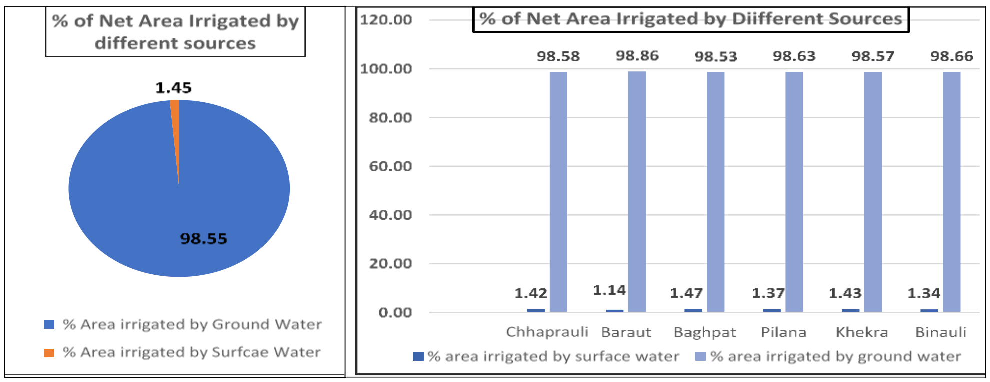


Table - 1.6 : Block wise Area (in Ha) irrigated by different sources in NAQUIM 2.0 Area

Block	Net Irrigated Area (Ha)						Gross Irriga-ted Area	Irriga-tion Inten-sity (%)	Irriga-tion by Surface Water	Irriga-tion by Ground Water	% of Net Irrigated Area by G. Water	% of Net Irrigated Area by S.Water
	Canal	State Govt.TW	Private Tube Well	Dug Well	Pond	Total						
Chhaprauli	236	57	16333	0	0	16626	27365	164.59	236	16390	98.56	1.42
Baraut	230	87	19781	0	0	20098	28314	140.88	230	19868	98.86	1.14
Baghpat	238	83	15894	0	0	16215	25133	155.00	238	15977	98.53	1.47
Khekra	189	85	12940	0	0	13214	22131	167.48	189	13025	98.57	1.43
Pilana	229	52	16472	0	0	16753	25936	154.81	229	16524	98.63	1.37
Binauli	265	70	19389	0	0	19724	35733	181.17	265	19459	98.66	1.34
Total Rural	1387	434	100809	0	0	102630	164612	160.39	1387	101243	98.65	1.35
Total Urban	169	73	4478	0	0	4720	7738	163.94	169	4551	96.42	3.58
Total	**1556**	**507**	**105287**	**0**	**0**	**107350**	**172350**	**160.55**	**1556**	**105794**	**98.55**	**1.45**

Source: https://updes.up.nic.in/spideradmin/Hpage1.jsp

Table - 1.7 : Numbers of Surface Water and Ground Water Structures for Irrigation

Block	Length of Canal Network (Km)	State Govt. Tube Well	Shallow Tube Well (STW)			Medium Depth Tube Well (MDTW)	Deep Tube Wells (DTW)
			Electric Powered	Diesel Powered	Total		
Chhaprauli	81	20	2855	1238	4093	135	6
Baraut	163	44	3578	1738	5316	140	10
Baghpat	68	27	2850	1581	4431	142	11
Khekra	62	38	2419	819	3238	140	4
Pilana	48	57	2860	827	3687	137	38
Binauli	64	94	4029	210	4239	156	140
Total	**486**	**280**	**18591**	**6413**	**25004**	**850**	**209**

2. DATA COLLECTION AND DATA GENERATION

Table - 2.1 : Existing Data of Baghpat district before NAQUIM 2.0 Work

Nos. of EW/OW/PZ /SH	Pump-ing Test	T	S	VES	TEM	ERI (line-km)	Bore Hole Electrical Logging	Nos. of WL Monitoring Wells	GW Quality Monitoring Wells	Soil Infil-tration
EW– **16**, OW– **07** PZ – **04**, SH – **03**	**11**	**11**	**11**	**43**	**0**	**31.2**	**9**	**13 Aq–I(A)**	**6 Aq–I(A)**	**54**

Table - 2.2 : New Data Generation under NAQUIM 2.0 Work (2023-24)

EW/ OW/PZ drilled	Pum-ping Tests	VES	TEM	Water Quality Samples Collected	Water Samples Analysed	Number of User Feedback Collected	New GW Level Monitoring Wells established
EW- 04 OW- 04 PZ-1	1	13	93	**Pre-Monsoon:** BASIC- 82, HM- 82 GW-61, SW-21 **Post-Monsoon:** BASIC-128, HM-128 GW-108, SW-20	**Pre-Monsoon:** BASIC- 82, HM- 82 GW-61, SW-21 **Post-Monsoon:** BASIC-128, HM-128 GW-108, SW-20	04	109

2.1 Hydrogeological Data Collection and Data Generation

2.1.1 Geology

The NAQUIM 2.0 area regionally lies in Ganga-Yamuna doab, a part of Central Ganga Plain. Precisely the area is located on the left bank of river Yamuna occupying a part of Yamuna-Hindon Doab. The area is underlain by a thick pile of alluvial formation consisting unconsolidated sediments (thickness > 450 m) of Quaternary age deposited over Precambrian basement, which comprises silt, clay, sand of various grades, gravels and kankar in varying proportions. Thickness of alluvium increases from west to east (from Yamuna to Hindon).

Table - 2.3 : Geological Sequence of NAQUIM 2.0 in Baghpat district

Group	Age	Formation		Lithology
Quaternary	Recent to upper Pleistocene	Younger Alluvium Recent:0.01m.a.	Neogene Sediments	Sand, silt and clay mainly along the flood plains
	Middle to Upper Pleistocene	Older Alluvium Holocene: 0.01-1.0 m.a.		Mainly clay and kankar in uplands and sand of different grades
------- Disconformity --------				
Tertiary	Pleistocene(1m.a.)	Upper Siwalik		Conglomerate, Sandstone, Shale
	Pliocene to Middle Miocene	Middle and Lower Siwalik		Shale and Sandstone
-------- Unconformity ------				
Pre-Cambrian Basement				

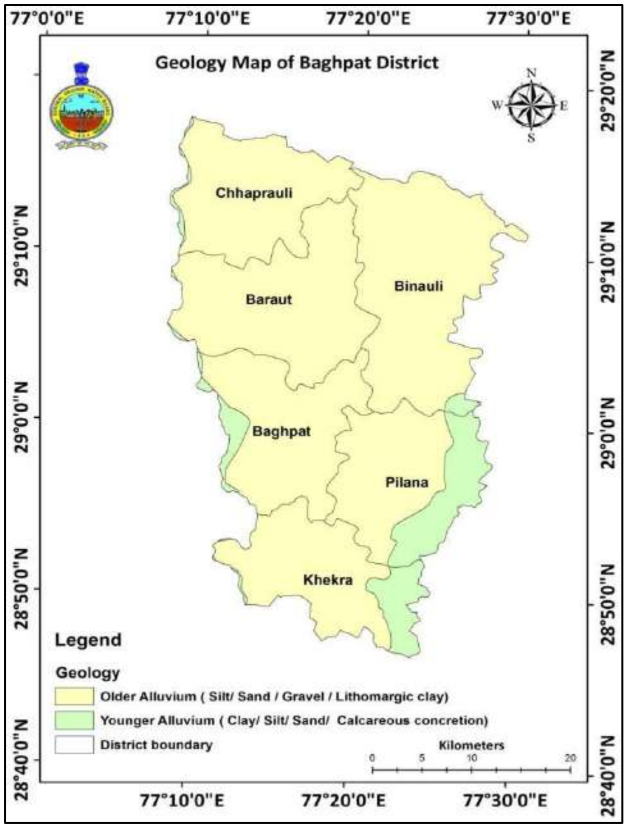


Fig. - 2.1 : Geological Map of NAQUIM 2.0 Area in Baghpat district

Broadly, two distinct geological units : (i**)** Older Alluvium or Varanasi Alluvium or Upland area; (ii**)** Younger Alluvium in Older Flood Plain areas and Active Flood Plains of Yamuna and Hindon.

Older Alluvium occupies entire upland and inter fluvial area occurring between drainages Yamuna and Hindon, which covers about 80% ofarea and is represented by a polycyclic sequence of oxidised, reddish, brownish silt, clay with interbeds of grey to brown sand. Dissemination of 'kankar' (mainly calcareous) is frequent and at places ferruginous granules are associated. Sequence broadly exhibits two litho-facies viz. silt-clay facies and sandy facies.

Younger Alluvium is confined to narrow depositional terraces of rivers and active flood plains, comprising cyclic sequences of grey silt-clay and grey micaceous sand. Sediments of are normally loose, unconsolidated, non-oxidised and free from kankar dissemination. Occurring close to drainage and corresponding to 'Bhur' soil, the area is marked with presence of isolated sandy ridges and sand dunes, indicating a change in drainage pattern. Younger alluvium exists along Yamuna and Hindon flood plains. Abandoned channels, sand dunes can also be seen in these flood plains. Flood plains can be further divided into two units: (a) Older flood plain and (b) Active flood plain

Active Flood Plain: River channel and adjacent terraces subjected to periodic flooding consisting of sand, silt and silty clay and with clay pockets constitutes the active flood plain.

Older Flood Plain: Flood plains of Yamuna also locally knownas 'Khadar', which constitutes older floods plains, characterized by presence of fluvial land forms-mender scars, cuts and meanders and palaeo-channels. Sediments are fine to medium sand, silt with thin clay horizons. The zone is separated from uplands/older alluvium by occurrence of sharp break at places, discontinuous natural levees, occurrence of sand dunes and abrupt change in slope.

2.1.2 Hydrogeology

Hydrogeology is mainly controlled by the geology, geomorphology and rainfall. Rainfall is the main source of the ground water, which is utilized for irrigation, domestic and industrial purposes. Rate of rainfall infiltration and ground water storage potential mainly depends on geomorphic set-up as well as geological formations. As per the information from the boreholes drilled, the area between Yamuna and Hindon rivers is occupied by thick alluvial sediments composed of different grades of sand (very fine to coarse), sandy clay, silt, clay and kankar (mainly calcareous concretion). Sand horizons form the potential aquifers, which are sometimes dissected by clay inter- beds. Water table is generally 20 to 30 m deep.

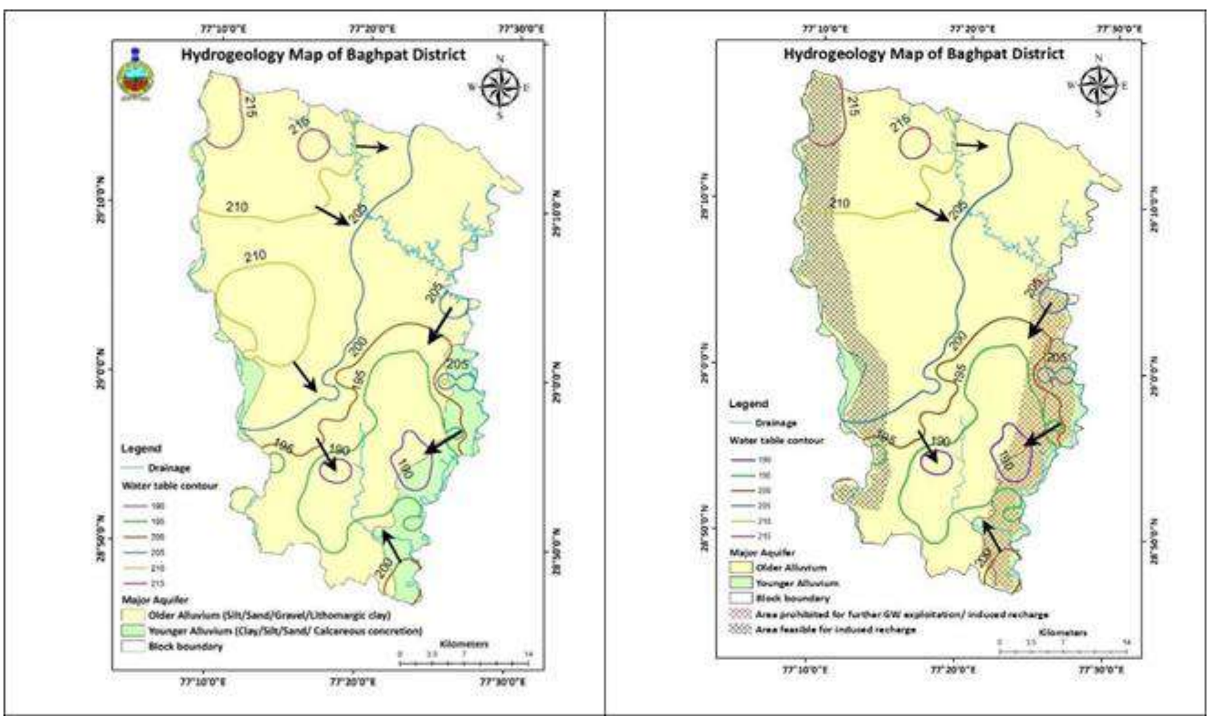


Fig. - 2.2 : Hydrogeology Map with Water Table Contours and Ground Water Flow Directions

From the exploratory drilling programme of Central Ground Water Board, generally a 3-tier aquifer system exists in the NAQUIM 2.0 area where Aquifer-IV was encountered at some places (2013-14). Granular zones in Aquifer Group–I are generally thick-bedded, very extensive and are consisting of comparatively coarser material than deeper Aquifer Group–II & III, where the aquifers are relatively thin-bedded, sometimes lensoid in nature and consisting of finer sediments with the domination of silty and clayey material.

As per available exploration data and its interpretation, Quaternary alluvium attains significant thickness ranging up to 473 mbgl and more. Bedrock composed of Quartzite belonging to Delhi Supergroup was encountered at different depths, progressively shallower towards Yamuna–Firozpur (399 m bgl). Sediments are more argillaceous below 50 m to 60 m.

Water Table elevation map for the phreatic aquifer has been prepared keeping the contour interval 5 meter. Perusal of the map shows that the water table follows the topography and major flow direction is from NW to SE. Water table slope becomes gradually steeper towards south-east.

2.1.3 Recharge of Ground Water

2.1.3.1 Soil Infiltration Test:

Soil infiltration is the process by which water on the ground surface enters in to the soil. Infiltration rate in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation water. Infiltration rate defined the volume flux of water flowing into the soil profile per unit of soil surface area and measured in inches per hour or millimeters per hour. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. The infiltration rate decreases as the soil becomes saturated. Infiltration rates decline to a steady or quasi-steady state as soil becomes increasingly moist over the period of a storm or experimental wetting. Infiltration rate usually shows a sharp decline with time from the start of the application of water. The constant rate approached after a sufficiently large time is referred as the steady-infiltration rate. In dry soil, water infiltrates rapidly in initial phases and called as the initial infiltration rate. As more water replaces the air in pores, water from the soil surface infiltrates more slowly and eventually reaches at steady state rate. This is called basic infiltration rate or steady state infiltration rate. Determination of infiltration rates is essential for prediction of surface runoff amount, saturated hydraulic conductivity of the surface layer, ground water recharge potential and in developing or selecting the most efficient and suitable irrigation methods.

Soils with low and reduced infiltration have potential to increase the overall amount of runoff water and flooding and become saturated at the surface during rain events, which, in turn, decreases soil strength, increases detachment of particles thus erosion probability, generate anaerobic conditions and can also cause nutrient deficiencies in plants. However, soils that transmit water freely throughout the entire profile or into tile lines need proper chemical management to ensure the protection of ground water and surface water resources.

Class	Rate of Infiltration (mm/hr)	Remarks
Very Slow	< 2.5	Soil in this group has very high percentage of clay
Low	2.5 – 12.5	Most of these soils are shallow, high in clay and low in organic matter contents
Medium	12.5 – 25.0	Soils in this group are loams and silts
High	>25	These soils are deep sands, deep well aggregated silt loams and some tropical soils with porosity.

Soil infiltration tests (54 Nos. under NAQUIM 1.0 study) in the Baghpat district shows variation in the infiltration rate over the entire district. The initial infiltration rate varies between 30 mm/hr to 450 mm/hr and the final infiltration rate varies between 3 mm/hr to 90 mm/hr. The average initial and final infiltration rate for the district is found to be 169.7 mm/hr and 13.3 mm/hr respectively. The average infiltration rate for the Baghpat district is estimated as 91.5 mm/hr. The higher infiltration rates are observed at sites Asara, Kashampur Kheri, Makara, Osika and Pura indicating sandy nature of local soils. Sandy loam soil is known to have high infiltration rates while clay loam and sandy clay soils are known to have very low infiltration rates.

2.1.3.2 Recharge and Discharge Zones:

Shallow aquifers adjacent to river Yamuna and Hindon are very thick and prolific due to existence of courser granular materials. Northern, north-western and western fringe areas may be considered as natural recharge areas and especially the stretch along Yamuna i.e. western boundary is a very good recharge zone where water level in Group - I(A) aquifer ranges from 12 to 15 m bgl, whereas rest of the area may be treated as natural discharge area.

Yamuna River, flowing along western boundary of NAQUIM 2.0 area, shows influent nature for major portion of its length. It is feasible to construct a series of shallow tube wells on the left bank of Yamuna to facilitate the induced recharge process for balancing between storage and extraction of ground water from shallowest unconfined Group - I(A) aquifer.

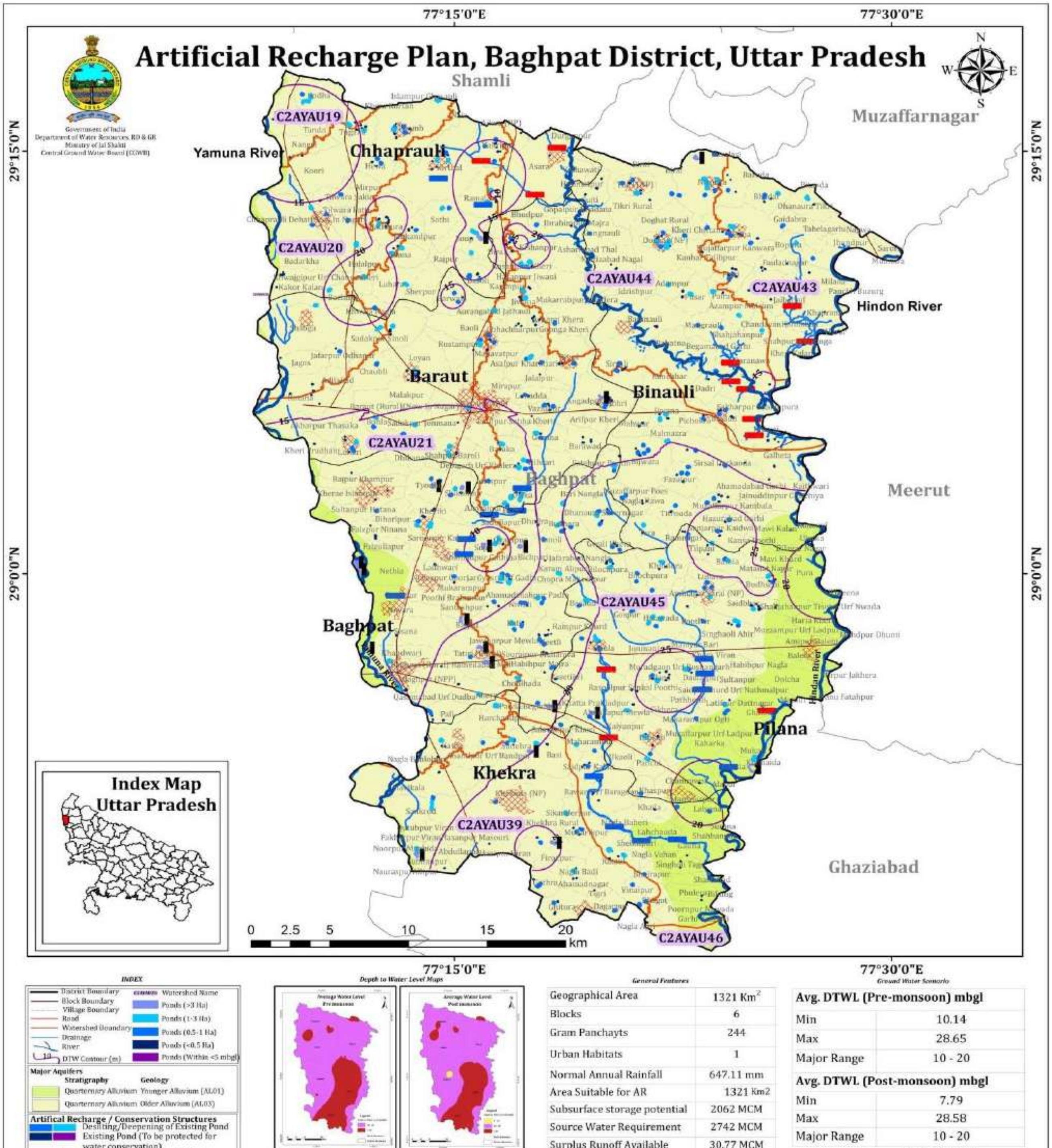


Fig. - 2.3 : Map showing Artificial Recharge Plan of NAQUIM 2.0 Area in Baghpat district

Hindon, flowing along the eastern boundary, is a highly polluted river owing to continuous discharge of massive industrial wastes into it, which shows its effluent nature for major section of its length in the north. A large ground water trough area covering major parts of Pilana and Khekra blocks and southern part of Binauli block has been created due to excessive indiscriminate withdrawal of ground water locally for irrigation and so the adjacent section of Hindon river course situated in the south has become influent. Therefore, this ground water trough area elongated roughly south-southwest to north-northeast direction has become vulnerable in terms of pollution of ground water in phreatic aquifers as the river may contribute contaminated water to these neighbouring aquifers, which are sometimes extending even up to the ground surface. Thus, the construction of any kind of tube wells for induced recharge purpose or further construction of large numbers of shallow tube wells for irrigation purpose in this locality near the right bank of Hindon, especially in the southern section, should be prohibited as the induced recharge due to shallow tube wells proposed, if any, may pollute the ground water presently being extracted by drinking water tube wells and other shallow tube wells as apprehended/reported by the villagers.

The major part of the recharge area for the Aquifers-I (B), II, III & IV i.e. the lower litho-system is situated far away from the NAQUIM 2.0 area towards north and north-west and outside the NAQUIM area. The rate of spot recharge of ground water in aquifers underneath is moderately high due to existence of well drained soil and the silty and sandy upper formation below the soil cover occurring all over the NAQUIM area. For the Aquifer–I (A) housed in the upper litho-system in Older Alluvium the recharge area lies in the western, north-western and northern part.

2.1.4 Aquifer Disposition and Geometry

The aquifers in the study area were mapped through lithology (exploratory drilling) geophysical investigations (VES, ERT and Borehole logging) and aquifer characteristics. The methods and techniques adopted for aquifer mapping areas under:

1. ExploratoryDrilling - (i) Litholog and (ii) Pumping Test
2. Geo-Physical Study – (i) Surface Geophysical Method – (a) Vertical Electrical Sounding (VES)
(b) 2D Electrical Resistivity Imaging (ERI)
(ii) Sub-Surface Geophysical Study (Borehole Logging)– (a) Self-Potential (SP)
(b) Electrical Resistivity (N16" and N64") (c) Natural Gamma Radioactivity

Exploration including Drilling, TW construction and Geophysical Survey under NAQUIM-I

EW	OW	SH	Total	Aquifer Group-I	Aquifer Group-II	Aquifer Group-III	Aquifer Group-IV	VES	Electrical Logging of bore holes	Resistivity Imaging (line-km)
6	5	3	14	1 EW	2 EW	1 EW	2 EW	43	9	7.2

The aquifer disposition maps have been prepared on the basis of lithological and geophysical log information obtained from existing exploratory drilling and geophysical data of CGWB, data of Jal Jeevan Mission, UP Jal Nigam with the data of exploratory drilling and constructed tube wells and also of current geophysical survey for further hydrogeological and geophysical data generation under NAQUIM-2.0.Aquifers with varied resistivities were picked up from the interpretations of electrical resistivity and gamm alogs of boreholes.

Existing before NAQUIM 1.0			**Data Generation during NAQUIM 1.0**			**Data Generation during NAQUIM 2.0**		
EW	Pz	SH	EW	OW	SH	EW	OW	PZ
7	**1**	**-**	**6**	**5**	**3**	**4**	**4**	**1**

Disposition of various Aquifers deciphered in previous studies is furnished in Table-2.4. To obtain a three-dimensional generalized view of the aquifer dispositions 3-D multi-logs and fence diagrams (aquifer group and stratigraphical) have been prepared in different orientations on the basis of integrated lithologs and geophysical logs (Electrical Log and Gamma Log).

These logs and the fence/panel diagrams prepared thereby reveal the presence of a thick pile of alluvial sediments with alternation of various grades of sand, clay and silt. Principal aquifers in the area have been delineated by grouping the fine to medium sand, coarse sand and gravelly sand as aquifers. Litho-Stratigraphic fence diagram prepared joining different exploratory wells shows four groups of aquifers along with three distinct clay horizons. There is variation in thickness of aquifer groups but in regional scale they are making different groups on the basis of aquifer characteristics like grade of sand and clay. The area is characterized by occurrence of fairly thick sands of various grades forming prolific aquifers. Thickness of the sand layer is more towards northeast and southeast, whereas the thickness of clay layer is more towards northwest and southwest. Thickening of the aquifers is towards river Hindon i.e. from west to east. Location map of the tube wells, 2D lithological and stratigraphical cross-section, fence diagram and 3-D stratigraphic models are presented in Fig.- 2.4, 2.5 and 2.6.

Table - 2.4 : Disposition of the Aquifer Groups of NAQUIM 2.0 area in Baghpat district

Location	Bottom Aq-I	Top Aq-II	Bottom Aq-II	Top Aq-III	Bottom Aq-III	Top Aq-IV	Bottom Aq-IV
Koordi	91	109	252	306	358	401	450 and Continued
Tabelagarhi	166	184	260	282	383	316	450
Sanjarpur Kaidwa	95	120	189	215	278	325	425 and Continued
Firojpur	88	100	192	230	230	316	399
Sherpur	84	94	206	226	314	422	
Baraka	102	136	204	232	312	352	442 and Continued
Guripur	115	132	213	232	282	338	Continued
Kakripur	92	142	309	326	394	407	Continued
Pilana	101	116	239	288	404	421	Continued
Tikri	119	133	207	237	252	370	
Aminagar Sarai	126	195	250	-	-	-	
Kekhra	130	215	250	265	350		
Mitili	70	80	168	230	265	281	
Baraut	74	88	183	266	364	393	
Beleni	59	68	142	279	380	391	

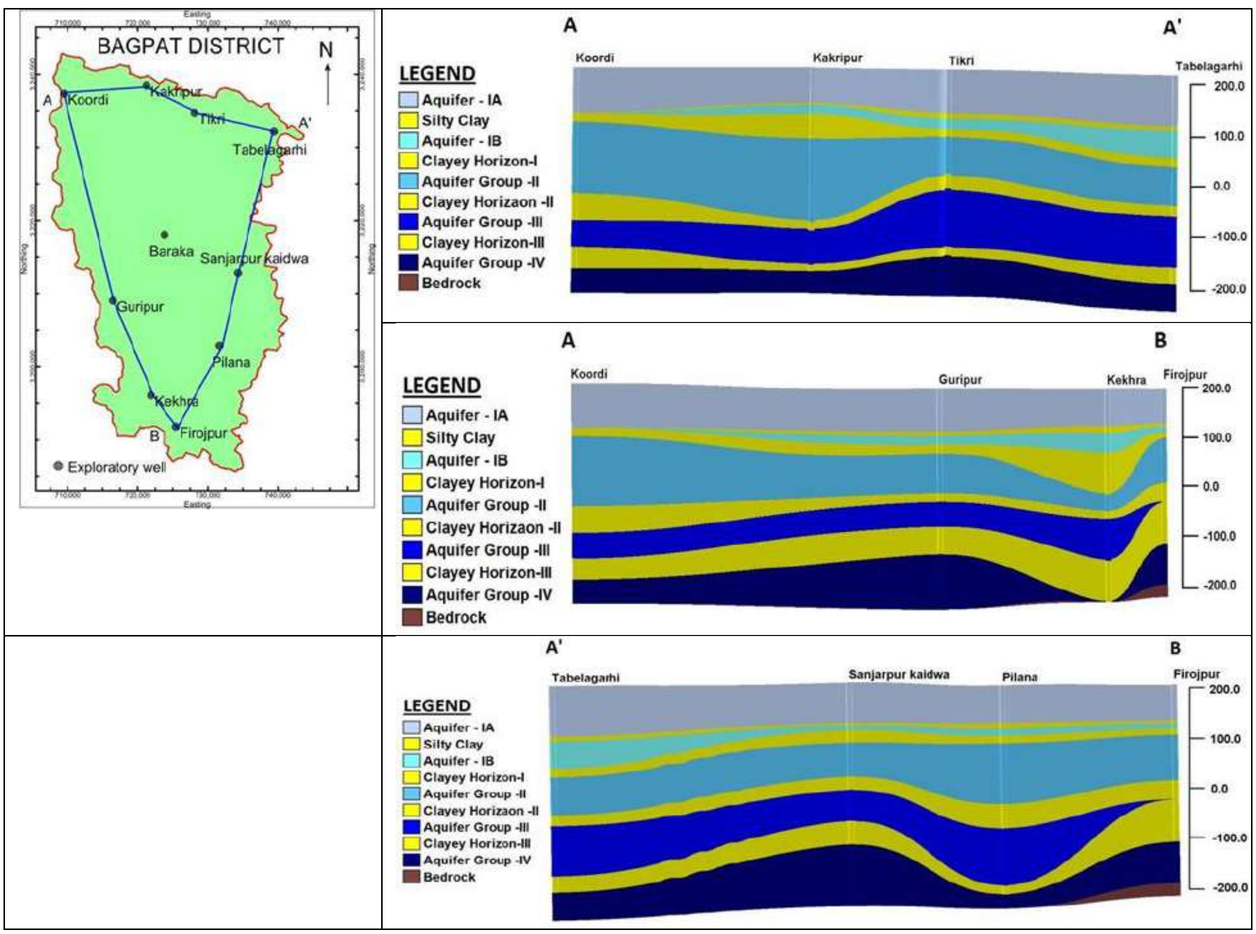


Fig. - 2.4 : Stratigraphical 2D Cross-Section of NAQUIM 2.0 Area in Baghpat district

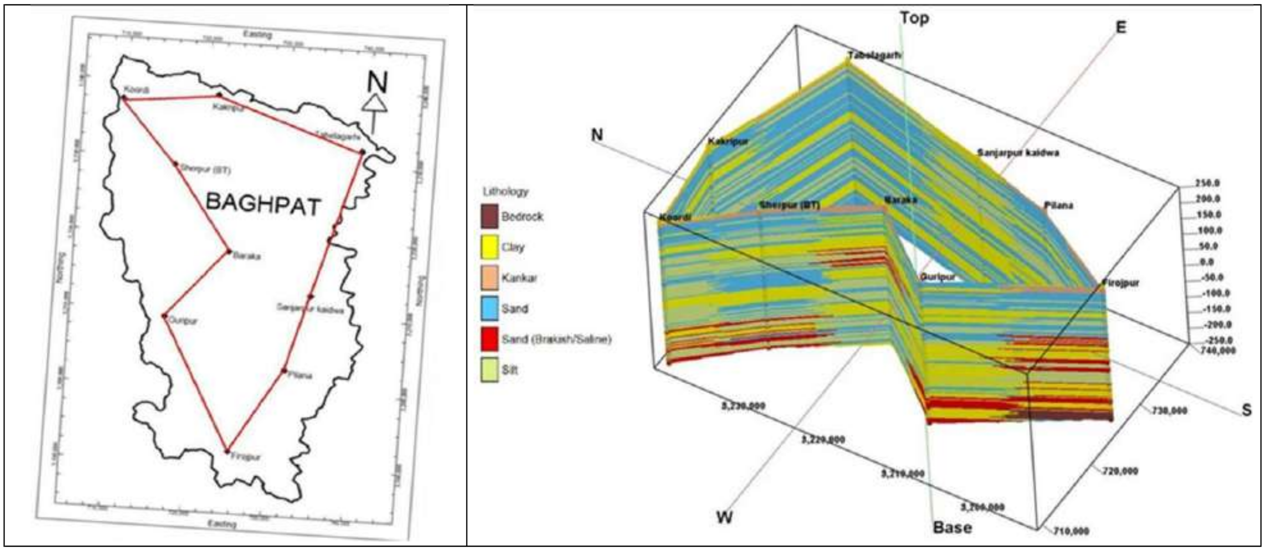


Fig. - 2.5 : Lithological Fence Diagram of NAQUIM 2.0 Area in Baghpat district

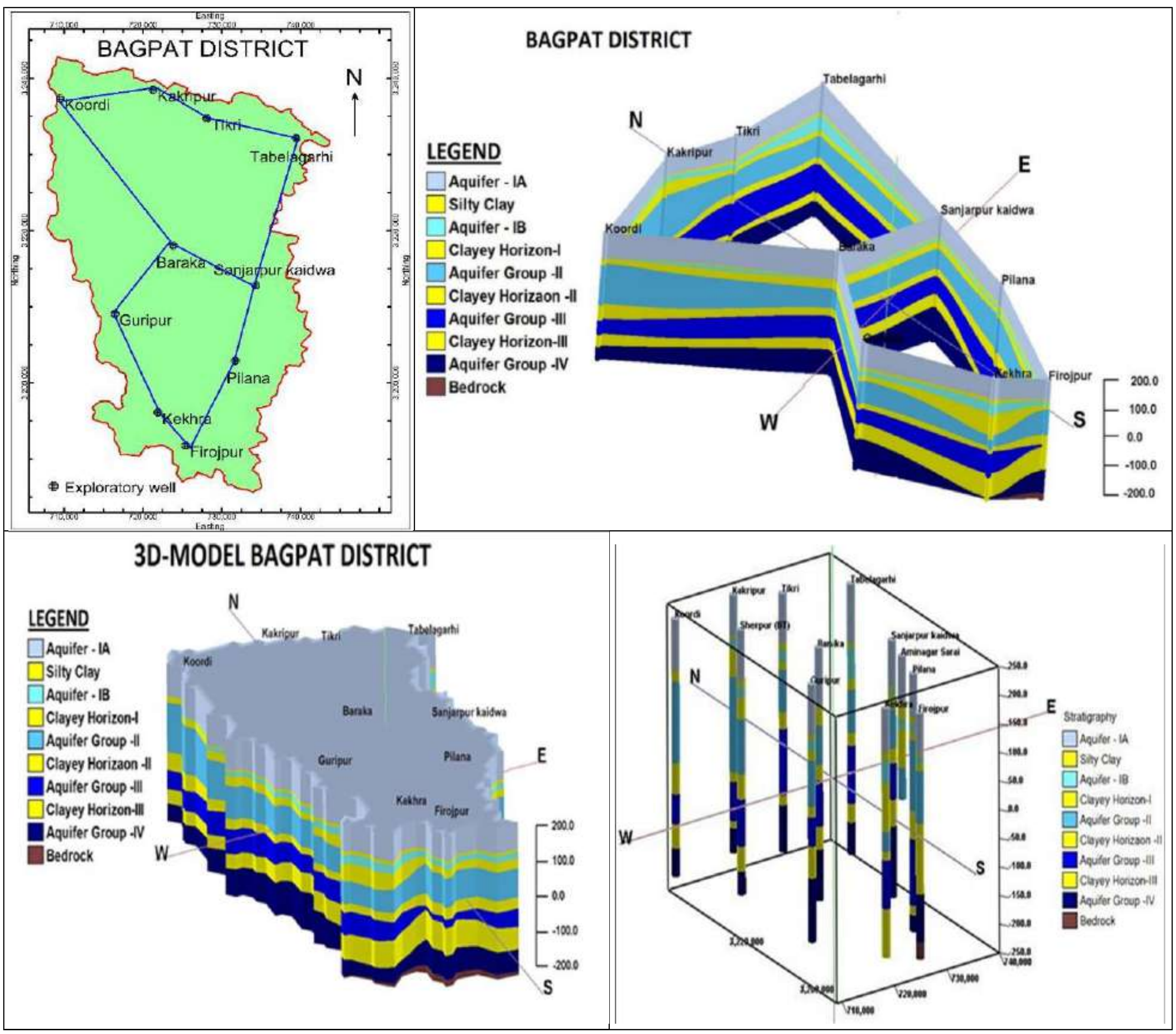


Fig. - 2.6 : Pannel Diagram, Strip Log & 3D Model of Aquifer Groups in NAQUIM 2.0 Area

The aquifer diagrams reveal that sand percentage decreases west wards from river Hindon to Yamuna. Granular zone thickness down to 100 m depth shows alesser cumulative thickness in the western part and a general increase towards east. In western part, in the depth range 100-200 m, sand percentage is less than 40%, whereas it is maximum (60%) in northeastern part of the NAQUIM 2.0 area. Actually, the sand percentage decreases towards west and south. The granular zone thickness in depth range of 300-400 m indicates less than 40% sand percentage. As per previous study, aquifer material thickness varies from 40 to 60% in both Aquifer Group-I & II.

2.1.5 Demarcation of Aquifer Groups

Demarcation of different aquifer groups area has been done on the basis of lithological character, geophysical characteristics, hydraulic properties and chemical quality ascertained by exploratory drilling, vertical electrical soundings, geophysical logging and pumping tests.

Under NAQUIM 2.0, geophysical data were generated though 13 VES, 93 TEM and 4 borehole loggings. Depthwise down to 450 m bgl, the aquifers have been grouped as Aquifer Group-I, AquiferGroup-II, Aquifer Group-III and Aquifer Group-IV, which are separated by confining clay layers of thickness more than 10 m and also consist of several thin aquifers separated by clays and silts. The resistivity of these aquifer groups in generally decreases with depth. Aquifer Group-I is characterized by the highest resistivity around 35 to 40 ohm. m with a local lowering (16 to 22 ohm.m) in the central part, whereas the underlying aquifers have resistivities as low as 15 ohm.m. It indicates a general decrease in granularity with depth as well as mixing of silts and clays. The Aquifer Group-II is characterized by a resistivity range of 15 to 25 ohm.m, while Aquifer Groups-III and IV are characterized by a resistivity range of 15-20 ohm.m. The lateral resistivity variations or granularity of Aquifer Group-I is much higher as compared to deeper aquifers. Variations in aquifer thicknesses and trend in their occurrences are the indicatives of variations in depositional palaeo-environment and the influences of structural controls at different geological times.

Under NAQUIM 2.0 (AAP 2023-24) in Baghpat district, exploratory drilling was carried out for further data generation in data-gap areas to decipher the occurrence, depth, geometry and hydrogeological characteristics of aquifers and then to demarcate the aquifer groups. Exploratory drilling was carried out 4 sites located in 3 blocks Pilana, Binauli & Chhaprauli by 2 in-house drilling rigs (150 m and 300 m capacity) and 4 EWs, 4 OWs and 1 PZ were constructed. Various aquifer parameters were determined by preliminary yield test and pumping test (Table - 15).

Under NAQUIM 2.0 in Baghpat district, 4 groups of aquifers have been identified within the explored depth of 473 m. Aquifer Group-I : from 0.0 down to 59 m (min.) and to 166 m bgl (max.); Aquifer Group–II : starts from 84 m (min.),extends up to 301 m bgl (max.); Aquifer Group–III : starts from 215 m (min.),extends up to 404 m bgl (max.) and Aquifer Group–IV : starts from 316 m (min), extends up to 473 m bgl (maximum explored depth). Aquifer Group-I is again divided into two parts- I(A) (occurrence from 0.00 to 80 m bgl max.) and I(B) (occur from 55 m bgl min. to 166 m max.). The aquifers are generally separated from each other by prominent and regionally extensive thick clay beds. The Aquifer Group-I(A) is mostly under unconfined condition. Sometimes it becomes semi-confined at the bottom portion due to presence of thin intervening silty clay layer in the middle. However, all other underlying aquifers are purely confined in nature.

Table - 2.4 : Ground Water Exploration Data Availability before NAQUIM 2.0 (Aq. Gr. - I)

Sl. No.	Village	Block	Well Type	Latitude (N)	Longitude (E)	Drilling Depth	Well Depth	Granular Zones Encountered (m bgl – m bgl)	Zones Tapped (m bgl – m bgl)
1.	**Malakpur**	Baraut	EW	29.1193	77.2252	202	190		15 - 27, 35 - 40, 44 - 54 70 - 72, 74 - 82, 121-126 158 - 166, 179 - 185
2.	**Johari**	Baraut	EW	29.1083	77.3417	451	256		39-57, 67-80, 91.4-95.4 103-106, 123-135, 145-152, 157-165, 171-177 188-194, 237-250
3.	**Jafarpur**	Baraut	STW	29.1433	77.1803	84.4	82.6	30.50-64, 73.15-80.50	32.6 - 62.5, 73.7 - 79.7
4.	**Baghpat**	Baghpat	PZ	28.9427	77.2276	55	51		43.50 - 49.50
5.	**Gauripur** (WAPCOS)	Baghpat	SH	77.2216	28.9913	460		14 - 22, 35 - 40.6, 43 - 53, 55 - 61.3 166 - 172.7, 254 - 258	
6.	**Budhera**	Baghpat	STW	29.0275	77.3130	88.3	78	12.20-33.53, 42.67-76.20	29.1 - 32.6, 43.9 - 74.7
7.	**Ferozpur** (WAPCOS)	Khekra	EW& OW	28.8338	77.3104	404	76	22-32, 32-47, 54.5-70.5, 78- 84, 101-105 107.5-111, 125.5-134, 137-140.5, 148.5-157.5, 162.5-167, 172-173.5,178-182,185 -191, 259-273, 358-363, 389-392, 394-397	32 - 38, 42 - 48, 54 - 58 60 - 70
8.	**Khekra**	Khekra	EW	28.8645	77.2806	442	69		42 - 48, 54 - 66
9.	**Bandpur**	Khekra	STW	28.9063	77.2664	79.2	76.2		40 - 43, 50 - 57, 61-75
10.	**Gauma**	Khekra	STW	28.8431	77.3870	108.2	103.1		33.80 - 60.60
11.	**Singoli**	Khekra	STW	28.8286	77.3794	75	73.1		33.8 - 52.7, 54.2 - 69.7
12.	**Aminagar**	Pilana	EW	28.9800	77.3833	130	130		64-76,112-118,121-127
13.	**Pilana**	Pilana	PZ	28.9400	77.3692	64	60.8		52.15 - 58.20
14.	**Hariya Khera**	Pilana	STW	28.9691	77.4552	100	99	7.62-16.80, 45.10-57.90, 68.30-80.20 85.30-98.70	46.6 - 57.00, 68.30-76.20, 86.20 - 98.10
15.	**Dolcha**	Pilana	STW	28.9401	77.4444	86.9	74.7	18.3-24.1,32.3-66.1,68.3-71.9, 75.3-77.7	30.50-71.60
16.	**Baghpat**	Pilana	STW	28.8704	77.3716	91.4	75.3	24.3-31.7, 42.7-59.4, 63.7-74.4	26.5-31.6, 37-49, 63-75
17.	**Gangauli**	Binauli	STW	29.2042	77.3274	83.8	82.3	9.18 - 18.30, 27.43 - 64, 73.10 - 79.80	31.1 - 35, 39.30 - 63.40 72.80 - 78.60
18.	**Kanhar**	Binauli	STW	29.1870	77.3927	83.2	75	6.10 - 9.15, 27.50 - 35, 44.20 - 74.10	28.0 - 34.0, 46.0 - 70.0
19.	**Tikri**	Binauli	EW	29.2208	77.3467	455	159		63 - 69, 75 - 87, 99-111 135 - 141, 147 - 153
20.	**Bamnauli**	Binauli	STW	29.1452	77.3496	91.5	83.8	24.40 - 30.50, 41.15 - 45.70 48.16 - 80.16, 81.69 - 86.26	39.6-46.3, 52.42-55.50 61.6-64.3, 70.10-79.80
21.	**Barnawa**	Binauli	STW	29.1146	77.4287	109.7	108.5	13.70-18.30, 27.40-36.60, 42.70-57.90 64.00 - 83.20, 86.90 - 109.70	52.3-57.7, 64.0 - 83.2 88.9-91.2, 100.6 -107.3
22.	**Galetha**	Binauli	STW	29.0725	77.4348	102.8	102.8	46.30-56.40, 67.7-84.1, 92.6-101.80	45.7-55.8, 70.1 - 84.1 92.6-97.2, 99.4 - 102.1
23.	**Bijwara**	Binauli	STW	29.0736	77.3567	85.3	84.1	27.40 - 80.80	39.8 - 60.8, 67.4 -79.5
24.	**Gaidbara**	Binauli	STW	29.2060	77.4349	97.5	91.4	37.5 - 67.90, 75.30 - 91.40, 94.20-96.90	51.80 -64, 74.70 - 91.40

Table - 2.5 : Ground Water Exploration Data Availability before NAQUIM 2.0 (Aq. Gr.-II)

Sl. No.	Village	Block	Well Type	Latitude (N)	Longitude (E)	Drilling Depth(m)	Well Depth(m)	Granular Zones Encountered (m bgl – m bgl)	Zones Tapped (m bgl–m bgl)
1.	**Koordi** (WAPCOS)	Chhap-rauli	EW & OW	29.2477	77.1556	473	214	23-31.3, 33-37.5, 39.5-47, 52.5-72 74.5-77, 80.5-82, 87-90.5, 108.5-122 140.5- 43.5, 146-151, 156.8-159,181-186 192-197.2, 205-207.2, 250-252, 332-335 342-345, 350-357, 374.5-377,390- 392.5 401.5-404.5 410-416, 422-423.5 438-441, 444- 448.5	110-122 141-144 147-159 181-187 191-197 205-208
2.	**Sherpur** (WAPCOS)	Chhap-rauli	EW & OW	29.1721	77.2253	462	228	23.5-31, 37-62, 63.7-67, 73-77, 79 - 86 110.8-115, 156-159, 161.6-178, 207-222, 295-311, 319 - 324, 332.5 - 339	156 - 159 162 - 178 207 - 219
3.	**Daha**	Binauli	EW	29.1958	77.4194	456	251		187-196, 215-218, 233-245

Table-2.6: Ground Water Exploration Data Availability before NAQUIM 2.0 (Aq. Gr.-III)

Sl. No.	Village	Block	Well Type	Latitude (N)	Longitude (E)	Drilling Depth (m)	Well Depth (m)	Granular Zones Encountered (m bgl – m bgl)	Zones Tapped (m bgl – m bgl)
1.	**Tabela-garhi** (WAPCOS)	Binauli	EW	29.1958	77.4625	473	389	30-40, 54-91.5, 91.5-103 111-134,139-166,195-206.5 213.5-229, 235-243 245- 250, 289-310, 322-327 345.5-356.5, 365-383 416.5-429.5, 433-446	290-299, 301-310 322-328, 345-357 365-371, 374-383
2.	**Barnawa**	Binauli	PZ	29.1117	77.4250	452	416		360-372, 383-395 398-410
3.	**Meetli**	Baghpat	EW	28.9597	77.3042	451	375		289-300, 304-310 325-328, 332-335 345-358, 362-370

Table - 2.7 : Ground Water Exploration Data Availability before NAQUIM 2.0 (Aq. Gr.-IV)

Sl. No.	Village	Block	Well Type	Latitude (N)	Longitude (E)	Drilling Depth(m)	Well Depth(m)	Granular Zones Encountered (m bgl – m bgl)	Zones Tapped (m bgl- m bgl)
1.	**Badaka** (WAPCOS)	Baraut	EW & OW	29.0711	77.2992	451	448	23-34, 40.5-45, 51.5-54, 56-61.5 67-79.5, 89-93, 139-143, 152-160 173-181, 187-193.5, 199-203 233-236.5, 267-278, 305.5-310.5 352.5-358, 369-370.5, 387-396 399.5-406.5, 416.5-421, 433-441	389-395 401-407 418-421 434-440
2.	**Sanjarpur Kaidwa** (WAPCOS)	Binauli	EW & OW	29.0221	77.4058	456	426	30-35, 40-52, 60-74, 122-130 156-161, 226-231, 255-264, 339-348 354-362, 368-379, 416-422	339-348, 354-362, 367-379, 414-420
3.	**Kakripur** (WAPCOS)	Chhaprauli	SH	29.2559	77.2769	473	434	25-33, 36-41, 43-47.5, 55-70, 83-93 124.5-128.5, 134.8-137.8, 159.5-165, 176.7-182, 195-199.5, 219-225 230.2-235, 264-269, 290-294, 336-348, 384 - 394, 413 - 423	336-348 384-393 413-422 SWL:16 m bgl
4.	**Pilana** (WAPCOS)	Pilana	SH	28.9328	77.3769	473	452	27.5-33, 36.8-57.5, 65.5- 74.5 118-132.7, 135.5-138.5, 148-154 170.4-174, 218.8-223.8, 289-304 369-378, 388-98, 431-441.5	SWL: 18 m bgl

Table - 2.8 : Ground Water Exploration Data Generated under NAQUIM 2.0 in 2023 - 2024

Sl. No.	Village	Block	Well Type	Latitude	Longi-tude	Drilling Depth (m)	Well Depth (m)	Granular Zones Encountered (m bgl – m bgl)	Zones Tapped (m bgl – m bgl)	T (m^2/ day)	S
1.	**Titroda**	Binauli	EW	29.04106	77.37598	300	279	26-39, 45-59 65-75, 86-102 111-121, 125-131 137-145, 151-158 165-169, 175-179 213-217, 221-244 251-257, 266-275	213-216 224-242 265-274 **(Aquifer - II)**		
2.	**Titroda**	Binauli	OW	29.04106	77.37598	298	279	26-39, 45-59 65-75, 86-102 111-121, 125-131 137-145, 151-158 165-169, 175-179 213-217, 221-244 251-257, 266-275	213-216 224-242 265-274 **(Aquifer - II)**		
3.	**Titroda**	Binauli	PZ	29.04106	77.37598	150	79	26 - 39, 45 - 59 65 - 75	46-58, 65-74 **(Aquifer - IA)**		
4.	**Shobhapur**	Pilana	EW	28.9897	77.36345	157.50	154	30-50, 59-75 83-88, 110-126 132-137, 146-150	113-125 132-138 147-150 **(Aquifer - IB)**	473.91	2.438×10^{-5}
5.	**Shobhapur**	Pilana	OW	28.9897	77.36345	157.50	154	30-50, 59-75 83-88, 110-126 132-137, 146-150	113-125, 132-138, 147-150 **(Aq - IB)**	473.91	2.438×10^{-5}
6.	**Shahpur Banganga**	Binauli	EW	29.13854	77.44756	150.75	138	16-20, 22-25, 36-56, 60-78, 92-104 122-134, 144-150	92-104 122 -134 **(Aquifer - IB)**		
7.	**Shahpur Banganga**	Binauli	OW	29.13854	77.44756			16-20, 22-25, 36-56, 60-78, 92-104 122-134, 144-150	92-104 122 -134 **(Aquifer - IB)**		
8.	**Chhaprauli**	Chhap-rauli	EW	29.20540	77.16555	301.50	244	38-46, 48-69 82-88, 102-114 128-134, 141-146 162-170, 174-180 180-192, 200-206 236-242	163-169 175-178 184-190 200-206 236-239 **(Aq- II)**		
9.	**Chhaprauli**	Chhap-rauli	OW	29.20540	77.16555	250.00	244	38-46, 48-69 82-88, 102-114 128-134, 141-146 162-170, 174-180 180-192, 200-206 236-242	163-169 175-178 184-190 200-206 236-239 **(Aq- II)**	270.51	

Table - 2.9 : GW Exploration Data generated by CGWB for Aquifer Group-I(A) & I(B)

Sl. No	Location	Block	Type of Well	Lati-tude	Longi-tude	Year of Dr-illing	Dril-ling Depth	Well Depth	Granular Zones Deciphered (mbgl)	Zones Tapped (mbgl)	SWL mbgl	Disch-arge (lpm)	Draw-down (m)
1.	**Baghpat**	Baghpat	EW	28.9365	77.2178	2006	137.15	115.83	30.1-45.7, 48.95-57.90, 61.30-64.30, 95.10-110.40,	49-58, 61-64 95-110	13.7	2082	5.3
2.	**Jiwana**	Baraut	EW	29.1648	77.2886	2006	97.6	88.34	3-9.1, 12-18.3, 24-33.5, 36.6-64, 70.1-82.8	70-83	11.1	809	4.85
3.	**Mukkarpur**	Chhaprauli	EW	29.2394	78.1871	2006	98	90.65	9.2-21.3, 24.4-33.5, 39.6-64, 70.1-79.25, 82.3-85.35	56-64, 71-77 82-85	11.1	809	5.10
4.	**Makhar**	Pilana	EW	28.9090	77.4238	2006	98	89.53	21.35-25.9, 28.95-35, 39.6-86	65-84	22.8	850	4.85
5.	**Achraj kheda**	Baraut	EW	29.1402	77.3237	2006	97	89.9	7.1-27.9, 30.7-43.3, 53.2-84.6	65-84	21	850	4.95
6.	**Baraut**	Baraut	EW	29.1221	77.1659	2006	99	87.86	45.73-77.74, 81.7-85.97	47-74, 81-85	10.5	2952	5.90
7.	**Kakaur**	Chhaprauli	EW	29.1912	77.1565	2006	91.46	82.25	39.63-54.88, 61-64, 67-82.32	40-53, 67-80	13.71	2309	4.50
8.	**Daha**	Binauli	EW	29.1944	77.4173	2008	118.5	97.57	15.25-19.8, 29-35.1, 44.2-47.25, 51.8-61.9, 75.6-92	51-54, 53-62 76-92	28	3458	6.25
9.	**Khekada, Fakrpur**	Baghpat	EW	28.9492	77.2285	2009	78.35	72.72	33.53-39.63, 52.43-67.07	54-67	21.5	424	6.70
10.	**Baraut, Chhaprauli Rd**	Baraut	EW	29.0999	77.2606	2009	82.31	78.41	3.04-15.24, 30.48-39.63, 42.68 - 45.73, 48.78-60.93, 64-76.21	53-60, 66-76	13.7	636	7.90
11.	**Khekada, Tehsil**	Baghpat	EW	28.9492	77.2285	2009	84.45	62.39	4.57-9.14, 27.43-56.8	44-57	15.5	795	9.10
12.	**Baraut, Kotana**	Baraut	EW	29.1221	77.1659	2009	80.79	72.9	9.14-15.24, 33.53-36.58, 39.63-51.82, 64.02-73.17	39-52, 63-70	9.5	675	7.50
13.	**Baghpat, Bye Pass**	Baghpat	EW	28.9492	77.2285	2009	138.07	72.1	24.4-27.43, 30.48-67.07	44-66	15.85	2950	6.50
14.	**Baghpat, Bye Pass**	Baghpat	EW	28.9492	77.2285	2009	125	117.06	32.62-36.58, 41.15-56.4, 60.97-71.64, 92.98-114.32	48-55, 62-65 101-114	18.5	2955	6.35
15.	**Khatta Prahaladpur**	Pilana	EW	28.9177	77.3296	2010	140.15	120.37	18.3-30.5, 33.5-79.3, 79.3-115.85	63-70, 82-95 96-115	27.5	2953	6.50
16.	**Koordi, Near Banquet**	Chhaprauli	EW	29.2454	77.1741	2010	141.76	132.81	30.48-42.68, 60.97-82.31, 85.36-97.56, 125-132.62	63-82, 86-97 124-132	18.9	2953	6.25
17.	**Rataul-1**	Khekra	EW	28.8297	77.3424	2010	137	128.08	12.7-21.3, 24.15-30.1, 39.6-57.9, 60.9-78.35, 94.5-106.7, 115.85-121.95	53-58, 61-77 95-107, 115-122	18.5	2954	6.10
18.	**PHC, Pawala Beghumbad**	Baghpat	EW	28.9333	77.3082	2010	125.91	88.64	18.29-70.12,	33-36, 44-54, 61-70, 79-82	17.8	2954	6.80
19.	**Rataul-2**	Khekra	EW	28.8316	77.3425	2010	140.24	127.34	12.19-15.24, 24.39-30.48, 39.63-57.92, 60.97-73.17, 97.56-109.75, 118.9-121.95	49-58, 64-74 98-110 119-122	18.5	2954	6.05
20.	**Aminagar Sarai**	Pilana	EW	28.9809	77.3927	2010	153.96	136.03	10.67-16.76, 38-61, 65.54-77.74, 103.65-112.8, 119.81-130.8	52-56, 67-78 104-113 121-131	28.15	2954	6.90
21.	**Agrawal Mandi Baghpat**	Baghpat	EW	28.9526	77.2718	2010	160.06	150.1	7.62-16.76,29-38, 41.15-71.64, 111.28-114.32, 134.14-144.81	50-56, 62-72 135-145	21.8	2954	6.95
22.	**Tikri**	Binauli	EW	29.2255	77.3559	2010	153.96	134.49	47.25-68.59, 77.74-89.93, 102.13-129.57	53-66,79-90, 108-111, 116-120, 126-129	31	2594	7.15
23.	**Binauli**	Binauli	EW	29.0949	77.4028	2010	157.01	148.97	29-54.87, 59.45-85.36, 100.6-105.8, 108.73-111.3, 131.1-143.3	51-55, 66-85,101 -106, 134-144	29	2954	6.55
24.	**Dhikauli**	Pilana	EW	28.9109	77.3678	2010	144.81	139.91	25.91-32.01, 50.36-59.45, 70.12-77.74,118.96-134.14	52-59, 70-77, 122-134	21.85	2954	6.25
25.	**Sunhera**	Baghpat	EW	28.9114	77.2881	2010	147.86	42	10.67-16.76, 41.15-53.35, 59.45-67.07	42-53, 60-67	24.7	2073	6.60
26.	**Baghpat (RB)**	Baghpat	EW	28.9522	77.2465	2010	146.34	39	24.38-45.73, 48.78-64.02	39-46, 51-64	13.85	2954	6.90
27.	**Baraut (RB)**	Baraut	EW	29.1000	77.2667	2010	155.48	48	39.6-64, 67-76.21, 91.46-100.6	57-61, 67-76, 92-99	16.1	2954	6.85
28.	**Daula**	Pilana	EW	77.3310	77.3310	2011	155.48	43.5	18.3-24.4, 39.63-56.4, 61-74.7	43-56, 61-74	16.25	2954	6.95
29.	**Baghpat**	Baghpat	EW	28.9500	77.2167	2011	152.43	121.13	24.39-39.63, 42.68-82.31, 85.26-88.41, 91.46-94.51, 112.8-115.85	43-48, 60-72, 79-82, 85-88, 91-94,113-116	19.2	2954	6.85
30.	**Aasra**	Chhaprauli	EW	29.2382	77.3073	2011	158.53	96.72	9.14-33.53, 36.58-82.31, 85.36-91.46	51-75, 79-82, 88-91	19.3	2954	6.65
31.	**Baranawa**	Binauli	EW	29.1143	77.4375	2011	125	115.74	30.48-51.82, 54.87-60.92, 64.02-76.21, 91.46-111.28	40-47,64-75, 92-111	18.3	2303	6.20
32.	**Baghpat**	Baghpat	EW	28.9365	77.2178	2011	103.65	64.73	21.34-42.68,45.73-59.45	35-42, 46-58	12.5	795	2.90
33.	**Khekra**	Khekra	EW	28.8814	77.2884	2005	93	77.56	30.00-32.00, 36.00-56.20, 60.50-72.25,83.00-85.00	39.85-55.29, 61.34-71.46	20	3500	

2.1.6 Aquifer wise Ground Water Levels

Ground water level in respect of Aquifer Group–I(A) is very deep. During pre-monsoon period (2023) water level ranges from 8.75 to 42.51 m bgl (Average - 23.47 m bgl; WL < 20 m in 48%, 20 to 30 m in 24% and > 30 m in 28% of key wells monitored) whereas during post-monsoon period it ranges from 5.87 to 34.25 m bgl. Long term (10 years – 2014 to 2023) trend of ground water level in respect of Group-I(A) aquifer shows a continuous decline in all 6 blocks of NAQUIM 2.0 area (Baghpat district) at an alarming rate (such as at Khekra, Khekra block @ 0.75 m/year and at Pilana, Pilana block @ 0.80 m/year) and this Aquifer Group–I(A) is also being permanently and irrecoverably de-watered. As per water level trend of period (2004-2013) shows declining trend in most of the area. In Baghpat district Pilana Pizometer shows pre-monsoon decline of 1.4 m/year whereas inpost monsoon period is 0.57 m/year.

Table - 2.10 : Pre-monsoon Ground Water Level Monitoring Data (CGWB : 2023)

Block	Total Moni-toring Station	Type of Structure				Aquifer Group		Depth to Water Level (DTWL) (Pre-Monsoon - 2023)					
		DW	PZ	HPTW	DTW	Gr. I	Gr. II	Min	Max	Average	No. of station showing WL < 20 m (%)	No. of station showing WL 20-30 m (%)	No. of station showing WL>30 m (%)
Chhaprauli	6	0	6	0	0	6	0	10.73	22.02	15.29	5 (83 %)	1 (17 %)	0
Baraut	9	0	9	0	0	9	0	10.59	28.37	19.21	6 (67 %)	3 (33%)	0
Baghpat	23	1	22	0	0	23	0	8.75	41.51	18.55	16 (70 %)	4 (17 %)	3 (13 %)
Binauli	6	0	6	0	0	6	1	9.02	34.64	28.38	1 (17 %)	3 (50 %)	2 (33 %)
Pilana	28	1	27	0	0	28	1	9.71	42.51	30.15	6 (21 %)	5 (18 %)	17 (61 %)
Khekra	6	0	6	0	0	6	0	12.1	27.7	20.75	3 (50 %)	3 (50 %)	0
TOTAL	**78**	**2**	**76**	**0**	**0**	**78**	**2**	**8.75**	**42.51**	**23.47**	**37 (48 %)**	**19 (24 %)**	**22 (28 %)**

Ground water abstraction structures tapping Aquifer Group–I(B) are very rare in NAQUIM 2.0 area. Only two tube wells tapping this aquifer were found and monitored at Pilana, block–Pilana (27.53 m bgl) and Tikri, block–Chhaprauli (33.24 m bgl) during pre-monsoon period. However, no structure has been located/identified in this NAQUIM 2.0 area as tapping Aquifer Group–II, III or IV except the tube wells constructed by CGWB under exploration and NAQUIM activities and thus could not be monitored for appropriately knowing the magnitude and fluctuation of water levels (piezometric surfaces) i.e. water level behaviour related to the deeper aquifers. The pre- monsoon and post-monsoon water level data were recorded in the year 2023 from the NHNS wells (Pz), key wells established for NAQUIM 2.0 and UPGWD Wells (Pz) to study the water level behaviour.

Depth to Water Level in Pre-Monsoon 2023 {Aquifer Group–I(A)}

During pre-monsoon period in 2023, the depth to water level ranged from 8.75 to 42.51 m bgl. The eastern half of the NAQUIM 2.0 area i.e. major parts of Khekra, Pilana and Binauli blocks, exhibited a deeper water level ranging from 20 to 42 m bgl. Conversely, the western part i.e. major parts of Baghpat, Baraut and Chhaprauli blocks showed a shallower water level ranging from 8 to 20 m bgl. Two patches elongated in N-S direction, one in central part and another near eastern fringe part of the NAQUIM 2.0 area, showed a moderately deeper water level ranging from 20 to25 m bgl, whereas in two isolated and localised patches falling separately in Khekra and Pilana blocks on the eastern border of the area a shallow water level ranging from 10 to 20 m bgl was recorded.

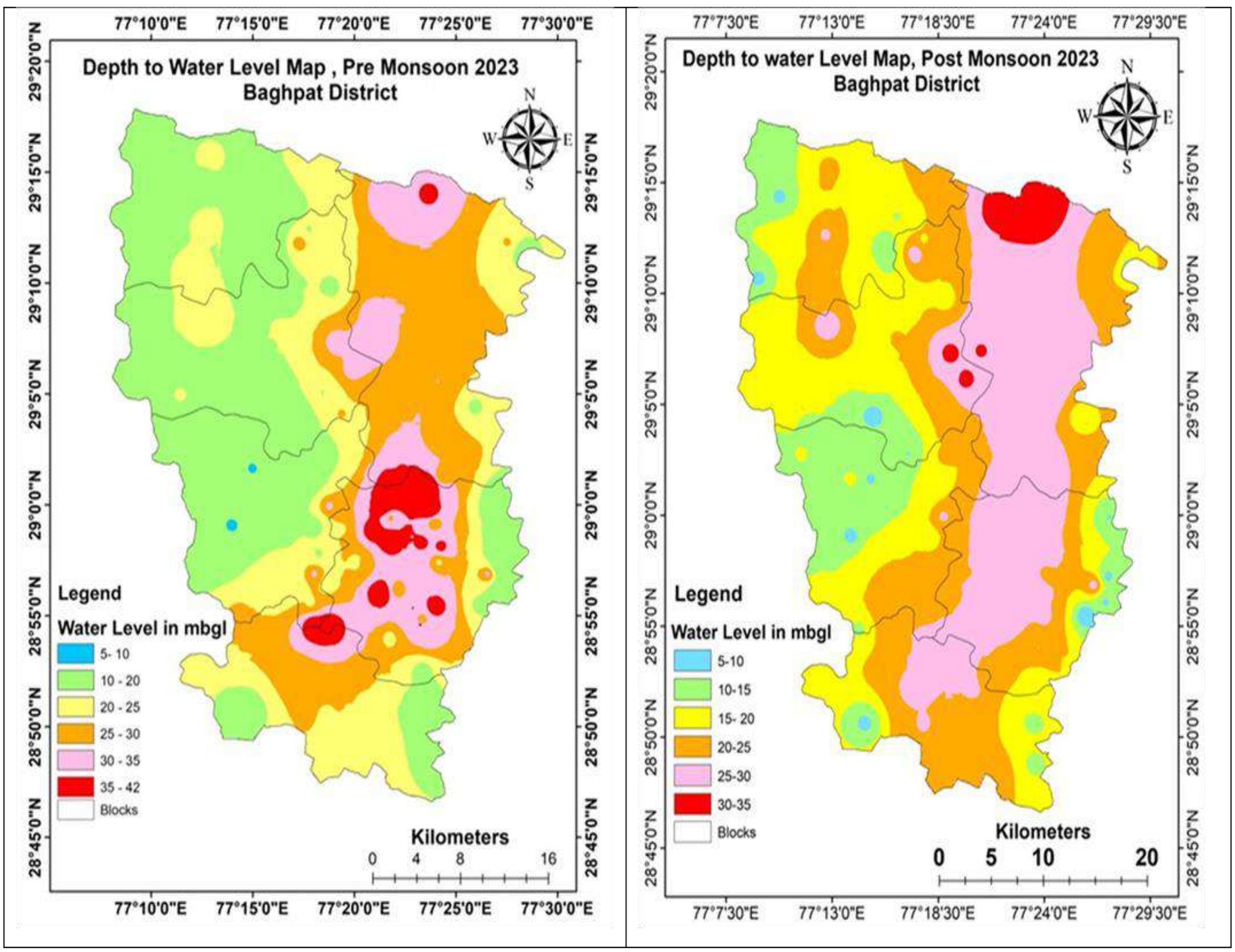


Fig. - 2.7 : Depth to Water Level Map of Pre-Monsoon & Post-Monsoon Period (2023)

Depth to Water Level in Post-Monsoon 2023 {Aquifer Group–I(A)}

During post-monsoon period in 2023, depth to water level ranged from 5.87 to 34.25 m bgl. Eastern half of the NAQUIM 2.0 area i.e. major parts of Khekra, Pilana and Binauli blocks had a deeper water level ranging from 20 to 35 m bgl, whereas the western and north-western parts i.e. vast areas of Baghpat, Baraut and Chhaprauli blocks and relatively smaller areas falling in Pilana blocks near eastern fringe and also in western and eastern ends of Khekra block showed a shallower water level majorly ranging from 10 to 20 m bgl.

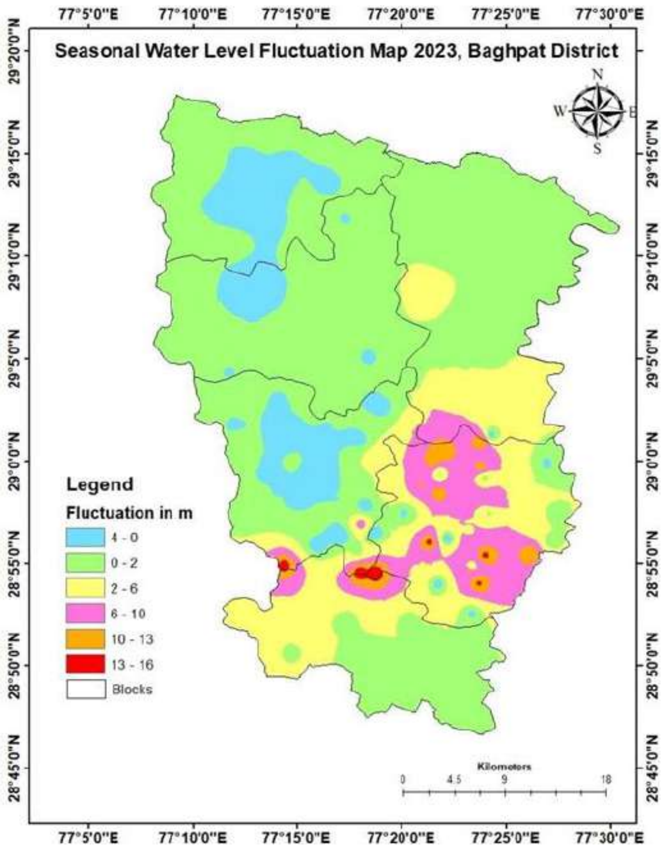


Fig. - 2.8 : Seasonal Water Level Fluctuation Map (Pre to Post-Monsoon 2023)

Seasonal Water Level Fluctuation (Pre-Monsoon to Post-Monsoon 2023){Aquifer Gr.–I(A)}

Water level rises during rainy season and stabilizes after monsoon season and generally becomes deepest during pre-monsoon season. In most of the water level monitoring wells, water level has risen in post-monsoon season with respect to pre-monsoon but at some places it has significantly gone down even up to around 4 m below the pre-monsoon water level in some areas of Chhaprauli, Baraut and Baghpat blocks. This lowering of water level during post-monsoon period is due to heavier withdrawal of ground water specifically for irrigation of the chief crop sugarcane.

However, in major part of the NAQUIM 2.0 area lying in the north and north-west, and falling in Chhaprauli, Baraut, Baghpat, Khekra and Binauli blocks, the water level has risen with a magnitude from 0 to 2 m, whereas in western half of Khekra block, almost whole area of Pilana block and southern part of Binauli block the seasonal fluctuation is measured in the tune of 2 to 10 m. A seasonal water level fluctuation map of NAQUIM 2.0 area in Baghpat district depicting annual fluctuation between pre-monsoon and post-monsoon water levels has been presented in Fig. - 2.8.

2.1.7 Aquifer Characteristics

From the old exploratory drilling data of CGWB and drilling data of UP Jal Nigam (JJM and other schemes), four major aquifer groups could be delineated within 473mbgl and named as Aquifer Group–I, II, III and IV. Aquifer Group-I may be further subdivided in to Aquifer Group–I(A) and aquifer Group–I(B). Only the Aquifer Group–I(A) is under un-confined at the top and becomes semi- confined condition with the increase of depth of occurrence. All the other three groups of aquifers are fully confined. All the aquifer groups are being recharged in north-western and northern foothill areas of the mighty Himalaya. The Bhabar zone plays a vital role in recharging the deeper aquifers of this area. All the groups of aquifers are fairly potential, although the Aquifer Group–I, specially I(A) is the most potential in terms of ground water yield owing to its considerable thickness, homogeneity and larger grain size of the aquifer materials. Tube wells in Aquifer Group-I(A) are mostly private ones and are used for individual drinking water purpose and indiscriminately for irrigation of crops specially sugarcane. However, govt. tube wells of shallow and intermediate depths tapping either or both Aquifers–I(A) and I(B) are also available for drinking water (spot source -Indian Mark-II and community supply- large diameter Deep TW) and irrigation purpose, which are generally constructed within 150 m. The drinking water tube wells for community supply under Jal Jeevan Mission (JJM) are being constructed by UP Jal Nigam in both urban and rural areas through tapping mostly the aquifers of Group I(B) and sometimes tapping both the Group-I(A) & (B) depending upon the potential of the individual aquifers.

As per the data collected under NAQUIM 2.0, it is observed that the discharge of tube wells tapping Group–I aquifers does not vary much throughout the NAQUIM area and generally restricted within 3000 lpm with an average value of 1500 lpm for a drawdown of 6 m., whereas the discharges of the tube wells tapping Group-II& III aquifers vary a lot.

As per the earlier studies, in north-western part of NAQUIM 2.0 area (Koordi, Sherpur and Gauripur) fresh ground water zone occurs down to 350 mbgl and water is brackish below 350 mbgl (Aquifer-IV). Though Aquifer Group-I is fresh, in southern area at Firozpur, ground water is brackish below 140 mbgl. In middle part at Baraka, brackish zone occurs from 139 to 198 mbgl (Aquifer Gr.-II), where the other aquifers are fresh. In northern and eastern part (Kakripur, Tabelagarhi, Sanjarpur Kaidwa and Pilana) water is fresh in all aquifers and sometimes with very slight brackishness. As per the outcome of current exploratory drilling up to 300 m, both the Aquifer Gr.-I(A) & I(B) are fresh water bearing except moderately high Iron (Fe) content in a few cases.

2.1.8 Aquifer Yield and Aquifer Parameters

Corroborating with the data and findings of the previouslarge scale NAQUIM 1.0 work in whole NCR area, the Transmissivity (T), Storativity (S) and Hydraulic Conductivity (K) values of the four groups of aquifers in NAQUIM 2.0 area of Baghpat district have been recorded under the present study. In case of deeper aquifers, a relatively higher hydraulic conductivity (K) values were obtained at sites Tyodhi (8.18 m/day), DhanuraTikri (8.72 m/day), Rasulpur, Shankarputhi (6.64 m/day) and lowhydraulic conductivity(K) value at Kirthal (0.73 m/day), and Tikri (1.11 m/day). From ground water exploration through exploratory drilling and construction of tube wells till date the following yield, drawdown and aquifer parameters data of all the aquifer groups were collected.

Group-I aquifers exist within a depth span of 0.00 to 166 mbgl over the whole NAQUIM 2.0 area with an average yield potential ranging from 1557 to 3458 lpm with the average drawdown ranging from 4.53 to 7.15 m. Hydraulic Conductivity (K) in Aquifer Group-I(A) measured at a location is 49 m/day, whereas in Aquifer Group-I(B) at another site it is 19.5 m/day. Transmissivity (T) of Group-I(A) aquifer system varies from 1712 to 2458 m^2/day and that of Group-I(B) ranges from 474 to 1500 m^2/day. Storativity(S) of Aquifer–I(B) ranges from $2.438x10^{-5}$to $2.5x10^{-3}$, which indicates that Group-I(B) aquifers in this area is confined in nature. Both Group-I(A) and I(B) aquifers are extensive and prolific in terms of yield, but the yielding capacity of Group-I(A) is better than that of Group-I(B) aquifers owing to highter hydraulic conductivity and thickness.

The tube wells constructed by tapping Group-II aquifers occurring from 84 m to 301 mbgl, have yields ranging from 1987 to 2300 lpm withdrawdown widely varying from 6.30 to 14.44 m. Transmissivity (T) ranges from 270 to 837 m^2/day with a Hydraulic Conductivity (K) value ranging from 4.38 to 12.50 m/day and Storativity (S) value varying from $7.75x10^{-4}$ to $1.26x10^{-3}$.

Very less numbers of tube wells are constructed in NAQUIM 2.0 area by tapping Group-III aquifers due to its high expenditure with depth span 215 to 404 m and availability of sufficient water in shallower Group I(B) and II aquifers. Thus, from a meagre available data it is noticed that yield of the tube wells tapping Group-III aquifers having a yield range 1360 to 2200 lpm with a drawdown from 9.22 to 25.55 m. Transmissivity here varies widely from 345 to 2285 m^2/day, hydraulic conductivity varies from 3.5 to 23m/day & Storativity from $7.70x10^{-4}$ to $5.63x10^{-3}$.

Further lesser numbers of tube wells are available in the NAQUIM 2.0 area which are tapping deepest Aquifer Group-IV occurring from 316 m to 473 m and beynd, the maximum explored depth although it is considerably potential in terms of yield, which varies from 2100 to 2200 lpm with an associated drawdown ranging from 12.52 to 22.62 m. This Group of aquifers has a comparatively lower Transmissivity (T) value extending from only 301 to 763 m^2/day with Hydraulic Conductivity (K) from 3.0 to 7.60 m/day and the Storativity value ranging $2.1x10^{-4}$ from $5.1x10^{-4}$.

Table - 2.11 : Characteristics, Potential and Parameters of Aquifer Group - I, II, III & IV

Site/ Village Name	Block	Latitude	Longi-tude	Type of well	Depth (m) of Drilling /Const-uction	Zones Tapped (mbgl to mbgl)	Aqui-fer Group	SWL (m-bgl)	Disch-arge (lpm)/ PYT/ P. Test	Drawd-own(m) /PYT/ Pump-ing Test	Hydr-aulic Condu-ctivity (m/day)	Trans-miss-ivity (m^2/ day)	Stora-tivity
Koordi	Chhap-rauli	29.24772	77.15558	EW & OW	473/ 214	110-122, 141-144 147-159, 181-187 191-197, 205-208	Gr.- II	15.6	2300	10.73	4.38/ 17.40	627	$1.26 x 10^{-3}$
Badaka	Baraut	29.07106	77.29919	EW & OW	454/ 448	389-395, 401-407 418-421, 434-440	Gr.- IV	12.87	2200	22.62	3.3/8.47	301	$2.1 x 10^{-4}$
Ferozpur	Khekda	28.83384	77.31035	EW & OW	406/ 76	32-38, 42-48, 54-58 60-70	Gr.- I	21.16	2200	6.54	49/60	2458	$1.68 x 10^{-5}$
Sanjarpur Kaidwa	Binauli	29.02214	77.40583	EW & OW	456/ 426	339-348, 354-362 367-379, 414-420	Gr.- IV	12.08	2100	12.52	7.6/ 20.70	763	$5.1 x 10^{-4}$
Sherpur	Chhap-rauli	29.17208	77.22525	EW & OW	462/ 228	156-159, 162-178 207-219	Gr.- II	21.31	2000	8.68	12.5/24	837	$1.25 x 10^{-4}$
Tabela-garhi	Binaoli	29.19582	77.46251	EW	472/ 389	290-299, 301-310 322-328, 345-357 365-371, 374-383	Gr.- III	22.50	2200	9.22	23/42	2285	
Daha	Binauli	29.19583	77.41944	EW	456/ 251	187-196, 215-218 233-245	Gr.- II	17.88	2210	6.30		350	$1.26 x 10^{-4}$
Malakpur	Baraut	29.11928	77.22523	EW	202/ 190	43-45,74-82,121-126 158.5-166, 179-185	Gr.- I	3.1	3220	6.15	19.5	1500	$2.05 x 10^{-3}$
Johari	Baghpat	29.10833	77.20555	EW	451/ 256	39-57, 67-80,157-165 171-177, 237-250	Gr.- I & II	12.26	1987	14.44	6.85	705	$7.75 x 10^{-4}$
Meetli	Baghpat	28.95972	77.30417	EW	451/ 375	289-300, 304-310 325-328, 332-335 345-358, 362-370	Gr.- III	3.98	1360	25.5	3.5	345	$7.70 x 10^{-4}$
Aminagar Sarai	Pilana	28.98	77.38333	EW	130/ 130	64-76, 112-118 121-127	Gr.- I	14.25	1557	4.84		1712	$4.17 x 10^{-4}$

2.2 Hydro-Chemical Data Collection and Data Generation

For hydro-chemical data generation water samples have been collected from 6 OCS blocks of Baghpat district during pre-monsoon as well as post-monsoon hydrogeological studies under the NAQUIM 2.0 work in 2023-24. The results of theyearly regular chemical monitoring of National Hydrograph Network Stations by CGWB and the results of chemical analysis of water samples collected under some special hydrogeological and hydro-chemical studies have also been collected. Pre-monsoon (2023) ground water samples were collected from the NHNS wells falling in Baghpat district as well as the pre-monsoon and post-monsoon ground/surface water samples from the key wells and other sources established for present NAQUIM 2.0 work were collected and had been analysed in the NABL accredited chemical laboratory of CGWB, NRfor evaluating the physico-chemical parameters and basicelementsas well as heavy metals content. Considering disposition of aquifers, the representative ground water samples were collected from Aquifer Gr.-I & II. Some surface water samples were also collected for assessing the pollution status of whole water resource.

Under NAQUIM 2.0 study a total number of 82 nos. of water samples (61 ground water samples from different hydrogeological units and 21 nos. surface water samples from river, canals and ponds) during pre-monsoon period (2023) and 128 nos. of water samples (108 nos. ground water samples from different hydrogeological units and 20 nos. surface water samples from river, canals and ponds) were collected during post-monsoon from different parts of 6 blocks of Baghpat district for Basic Chemical analysis and for Heavy Metals analysis after treating with Supra-pure HNO3. A lot of 82 nos. of samples collected during post-monsoon were from the same stations covered during pre-monsoon for observing the seasonal variation in water quality, whereas an additional 46 nos. of water samples were collected during post-monsoon as a part of further dense sampling in areas where some kind of water pollution was reported from analysis of samples collected during pre- monsoon.

Table - 2.12 : Pre-monsoon (2023) Water Samples collected from NAQUIM 2.0 Area

Block	Ground Water			Surface Water			
	HPTW(Aq.Gr.-I)	DTW (Aq.Gr.- II)	Total	River	Canal	Pond	Total
Chhaprauli	06	01	07	00	00	03	03
Baraut	09	02	11	00	01	01	02
Baghpat	07	01	08	01(Yamuna)	00	03	04
Binauli	11	02	13	03 (Hindon)	00	01	04
Pilana	11	01	12	02 (Hindon)	00	03	05
Khekra	08	03	11	01 (Hindon)	00	02	03
Total	**51**	**10**	**61**	**07**	**01**	**13**	**21**

Table - 2.13 : Post-monsoon (2023) Water Samples collected from NAQUIM 2.0 Area

Block	Ground Water			Surface Water			
	HPTW (Aq.Gr.-I)	**DTW (Aq.Gr.- II)**	**Total**	**River**	**Canal**	**Pond**	**Total**
Chhaprauli	13	01	14	00	00	03	03
Baraut	21	02	23	00	00	01	01
Baghpat	15	00	15	01 (Yamuna)	00	03	04
Binauli	16	03	19	03 (Hindon)	00	01	04
Pilana	22	03	20	02 (Hindon)	00	03	05
Khekra	06	06	12	01 (Hindon)	00	02	03
Total	**93**	**15**	**108**	**07**	**00**	**13**	**20**

2.3 Geophysical Data Collection and Data Generation

Field geophysical studies involving (i) surface geophysical survey or resistivity survey (VES and Profiling); (ii) borehole geophysical logging were carried out to delineate the subsurface geological and hydrogeological features and to analyze the hydrogeological setup and issues of NAQUIM 2.0 area with the following objectives:

1. Integration of existing geophysical data with lithology data of bore hole and preparation of inferred litho-logs
2. Locating and determining depths, thickness and lateral extent of porous and permeable formations: identifying of fresh water aquifers, regional geometry and grouping of aquifers.
3. Resolve of aquifer disposition across the basin in NAQUIM area and depth of bed rocks
4. Mapping of potential aquifers in deep buriedpaleo stream channels, if any.
5. Suggesting potential sites for the construction of water wells and demarcation of areas suitable for artificial recharge and also the areas prone to water logging
6. Estimation of hydrogeological parameters through resistivity surveys.
7. Assessment of quality of water in various aquifers, specially those being used for drinking

The geo-physical study comprising both on-surface and borehole methods focused on complete sub-surface exploration of lithology and hydrogeology of NAQUIM 2.0 area including six administrative blocks of Baghpat district, namely Baghpat, Baraut, Chhaprauli, Binauli, Pilana and Khekra. The surface geophysical methods included Vertical Electrical Sounding (VES) for depth wise resistivity profiling, Time Domain Electromagnetic Method (TeM) for assessing subsurface electrical conductivity variations and 2D Electrical Resistivity Imaging (ERI) for creating detailed resistivity distribution images in respect of different layers of subsurface formations.

On the other hand, sub-surface geophysical method of bore hole logging was carried out, which included the utilization of Self-Potential (SP) and Electrical Resistivity measurements, along with Natural Gamma Radioactivity calculation. The previous geophysical data were related to 43 Vertical Electrical Soundings, 7.2 line-km of 2D Electrical Resistivity Imaging and 9 borehole geophysical logging operations. Under the NAQUIM 2.0 work an additional 13 Vertical Electrical Soundings, 93 TEMs (at 18 sites) TeM and 4 borehole geophysical logging operations were carried out in 2023-24. So, with the help of total 56 (43+13) VES, 7.2 line-km ERI, 13 borehole loggings and 93 TeMs at 18 sites, it was attempted to unravel the geometry, disposition and spatial distribution of prevailing aquifer systems and to understand the intricate geological and hydrogeological properties of aquifers.

2.3.1 Geophysical Data Generation Plan

Methods were applied at 3 sequential stages, initiated with spot VES measurements at pre-defined 7 km x 7 km grid points yielding depth-wise, i.e., 1- dimensional information on aquifers. Efforts were made to conduct VES at the grid points. Similarly, data gap was filled by using TEM GP technique. For the grid points, where open space was not available, VES was conducted at the nearest place and near drilled boreholes. It helped standardization and validation of VES results.

It was followed by geophysical logging of the drilled boreholes to precisely identify the aquifer disposition and also standardize and refine the interpretations of surface measurements. Finally, resistivity imaging measurements were made in specific areas along profiles connecting the spot measurements and the boreholes to yield vertical as well as lateral, i.e., 2-dimensional variations in aquifer continuity. Principal aquifers have been quite successfully delineated by this approach.

2.3.2 Geophysical Methods Applied

2.3.2.1 Surface Geophysical Methods

(a) Vertical Electrical Sounding (VES): This method helps assess the thickness of subsurface layers and electrical resistivity at different depths.

(b) Transient Electromagnetic Method/Time Domain Electromagnetic Method (TEM):

Used to investigate electrical conductivity variations in subsurface by using a few basic electromagnetic (EM) principles and gives information of hydrogeological properties. TEM methods induce electric current flow in the subsurface and after the transmitted signal is shut off, it measures a voltage signal that is returned from the earth’s materials. The returning signal is measured as a function of time, and data are inverted to recover a layered earth model of resistivity.

Transient electromagnetic methods are noninvasive and do not require direct electrical contact (i.e. galvanic coupling) with the ground. Thus, it is ideal for moving or aerial surveys and for use with very resistive surface layers. Depths of investigation is tens to hundreds of meters depending on parameters like geoelectric subsurface properties, transmit/measurement time, wire loop size etc.

(c) 2D Electrical Resistivity Tomography (ERT): creates a detailed image of the subsurface resistivity distribution, aiding in identification of geological structures and aquifer boundaries. It helps to map the vertical and lateral variations in lithofacies and thus define continuity of aquifers, which is not possible by VES as the subsurface is a two-dimensional model where resistivity changes in vertical as well as horizontal directions along survey line.

2.3.2.2 Sub-Surface Geophysical (Borehole Logging) Methods:

(a) Self-Potential (SP) & Electrical Resistivity: to know electrical properties of materials and characterization of aquifers.

(b) Natural Gamma Radioactivity (NGR): to identify the composition of subsurface materials.

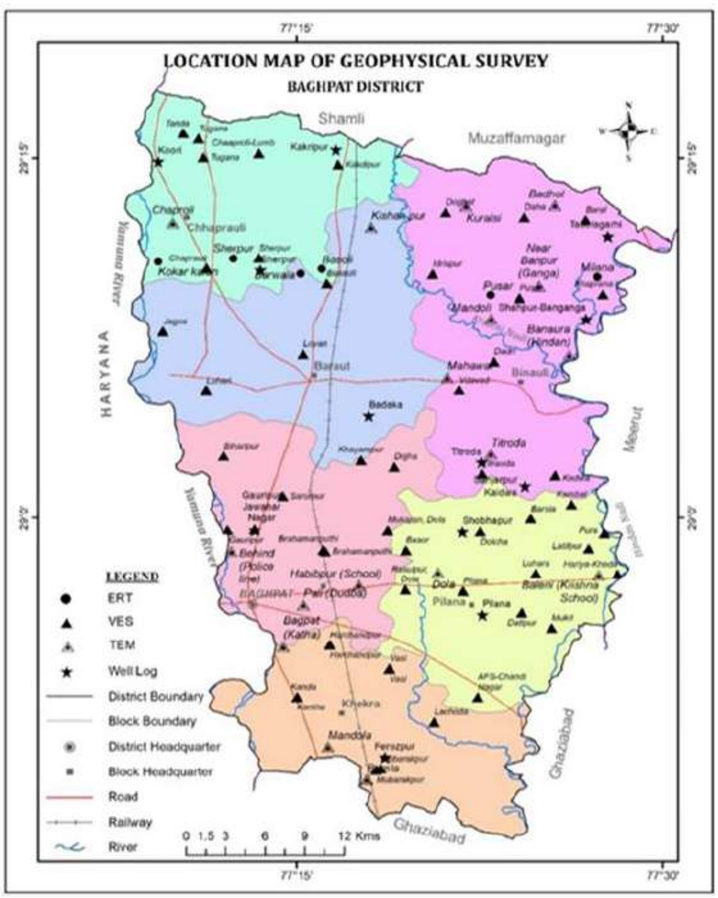


Fig.- 2.9 : Map showing locations of ERT, VES, TEM & Well Log (EW) in NAQUIM 2.0 area

General Resistivity Ranges for different lithological layers and water quality

Lithology	Resistivity Range (obtained from log in ohm.m)		
	Dry	with fresh water saturation	with brackish/ saline water saturation
Sand	> 100		2 - 9
Coarse Sand		> 60	
Coarse to Medium Sand		30 - 60	
Fine to Medium Sand		20 - 50	
Very Fine to Fine Sand		10 - 40	
Clay, Silt		10 - 20	

Table - 2.14 : Locations of 13 VES and 93 TEM (at 18 Sites) carried out in 2023-24

VERTICAL ELECTRICAL SOUNDING						TEM			
Sl. No.	**Location/ Village**	**Block**	**Latitude**	**Longi-tude**	**AB (m)**	**Sl. No.**	**Village**	**Latitude**	**Longi-tude**
1.	**Hariya-Kheda**	Pilana	28.961284	77.46889	600	1.	**Pali (Dudba)**	28.93978	77.25451
2.	**Pura**	Pilana	28.98976	77.45993	600	2.	**Behind(Police line)**	28.97702	77.20545
3.	**Kambal**	Pilana	29.01002	77.43745	500	3.	**Baleni (Krishna School)**	28.96059	77.45602
4.	**Barsia**	Pilana	28.99977	77.40959	600	4.	**Habibpur (School)**	28.95355	77.29239
5.	**Kedwa**	Binauli	29.0298	77.42651	600	5.	**Chaproli**	29.20509	77.16552
6.	**Dolcha**	Binauli	28.92926	77.7497	600	6.	**Dola**	28.96245	77.34634
7.	**Mukri**	Pilana	28.92396	77.42393	800	7.	**Titroda**	29.04474	77.38252
8.	**AFS-Chandi Nagar**	Khekra	28.876016	77.37355	600	8.	**Bagpat (Katha)**	28.91069	77.24089
9.	**Pilana**	Pilana	28.949353	77.3634	400	9.	**Mandola**	28.82124	77.27747
10.	**Basor**	Pilana	28.97793	77.3245	500	10.	**Bamla**	28.79566	77.26431
11.	**Dojha**	Baghpat	29.03579	77.31647	400	11.	**Delhi Border (Yamuna)**	28.79562	77.26431
12.	**Chaaprauli**	Chhaprauli	29.25372	77.22416	600	12.	**Banaura (Hindon)**	29.11351	77.43591
13.	**Tugana**	Chhaprauli	29.26391	77.18313	600	13.	**Shahpur BanGanga**	29.16137	77.41524
						14.	**Badhol**	29.21726	77.42621
						15.	**Mahawar**	29.09812	77.35259
						16.	**Mandoli**	29.1386	77.38281
						17.	**Kuralsi**	29.21694	77.36553
						18.	**Kishanpur**	29.20226	77.30063

3. DATA INTERPRETATION & INTEGRATION FOR AQUIFER MAPPING

3.1 Hydrogeological Data Interpretation and Integration for Aquifer Mapping

3.1.1 Aquifer Materials and Aquifer Geometry

The alluvium formation comprises sand, gravel, clay, silt, and kankar. Sands vary in grain size from very fine to coarse, which form the aquifers. Clays are mostly mixed with fine to very fine sand and silt. In general, the top 60 to 100 m column holds sand and forms the near-surface unconfined aquifer and then the semi-confined aquifer also. At deeper horizons the occurrence of sand layer diminishes towards the west, when nearing river Yamuna, whereas towards the east near river Krishni and Hindon, at places particularly in the northeastern fringe areas of NAQUIM 2.0 area, the sand horizons prevail throughout the drilled depth (473 m). The paleochannels of Yamuna, Hindon and Krishni (tributary of Hindon), also form the near-surface prolific aquifers.

The models and schematic diagrams of the aquifer groups including individual aquifers are prepared on the basis of analysis carried out and inferences drawn on technical data (hydrogeological and geophysical) collected from earlier reports and the data generated during the present field work, which have been presented below for better visual understanding of the aquifers' thickness, extent and relative disposition. The isopach (aquifer thickness) maps of Aquifer Groups-I(A), I(B) and II are presented in Fig.-3.1 &3.2.

To obtain a three-dimensional generalized view of the aquifer dispositions, 3-D Stratigraphic Model and fence diagrams have been prepared on the basis of integrated litholog and geophysical log (Electrical Log and Gamma Log) and presented in Fig.-3.3. The 3-D multi-logs depicting stratigraphical variation at individual locations has been prepared and furnished in Fig.-3.4. Principal aquifers in the NAQUIM 2.0 area are prolific due tohaving a fairly thick sands of various grades, which have been delineated by grouping the fine to medium sand, coarse sand and gravelly sand. Lithostratigraphic fence diagram prepared joining different wells shows four groups of aquifers along with three distinct clay horizons. There is a variation in thickness of aquifer groups but in regional scale they are making different groups on the basis of aquifer characteristics and grade of sand and clay. Fence and panels diagrams reveal the presence of a thick pile of alluvial sediments with alternation of various grades of sand with clay and silt. Due to unavailability of requisite data in respect of lithology and stratigraphy of Aquifer Group-III and IVfor the area, aquifer geometry, disposition and characteristics of those aquifers could not be resolved.

The NNW-SSE trending linear moderately thick sand zone parallel tothe course of river Hindon in Binauli block is indicative of a mythological palaeo-channel named Ban-Ganga.There was an exploratory drilling site at the village Sharpur BanGanga under the NAQUIM 2.0 work in 2023-24. For far deeper zones the cumulative thickness of the aquifers increases towards north eastern part of NAQUIM area near river Hindon. There is variation in thickness of aquifer groups but in regional scale they are indifferent groups on the basis of aquifer characteristics and grade of sand and clay. Isopach maps of individual Aquifers - I(A) & I(B) have been prepared to know the actual aquifer group thickness for the entire area.

3.1.2 Results of Hydrogeological Data Interpretation

(i) The general and regional ground water flow is from NW to SE and W-NW to E-SE. However, due to variation of development magnitude in a local scale, the localised flow direction has been modified by the formation of some ground water troughs.

(ii) In corroboration with the findings of NAQUIM – 1.0 study, in NAQUIM 2.0 study also 4 groups of aquifers have been identified from hydrogeological, geophysical and chemical characteristics of aquifer materials, quality of ground water and the depositional environment as wellin Baghpat district within the maximum explored depth of 473 m– Aquifer Group-I : from 0.0 down to 59 m (min.) and to 166 m bgl (max.); Aquifer Group– II : starts from 84 m (min.), extends up to 301 m bgl (max.); Aquifer Group–III : starts from 215 m (min.), extends up to 404 m bgl (max.) and Aquifer Group–IV : starts from 316 m (min), extends up to 473 m bgl (maximum explored depth). Aquifer Group-I is again divided into two parts- I(A) (unconfined to semi-confined; occur from 0.00 to 80 m bgl max.) and I(B) (confined; occur from 55 m bgl min. to 166 m max.). Aquifers are separated by prominent and regionally extensive thick claybeds (> 10 m).

(iii) For drinking water Aquifer-I(A) is used through government/private hand pumps, while Group-I(B) aquifer is used by construction of heavy-duty deep tube wells for community water supply by the State Govt. Agency. Group-I(A) aquifer is extremely stressed and being constantly depleted due to heavy indiscriminate use for cultivation of sugarcane (over 80% of cropped area) and other high water requiring crops like paddy.

(iv) Ground Water Abstraction structures tapping Aquifer Group–II are very rare in NAQUIM 2.0 area. Only two tube wells tapping this aquifer were found and monitored at Pilana, block–Pilana (27.53 m bgl) and Tikri, block–Chhaprauli (33.24 m bgl) during pre-monsoon period.

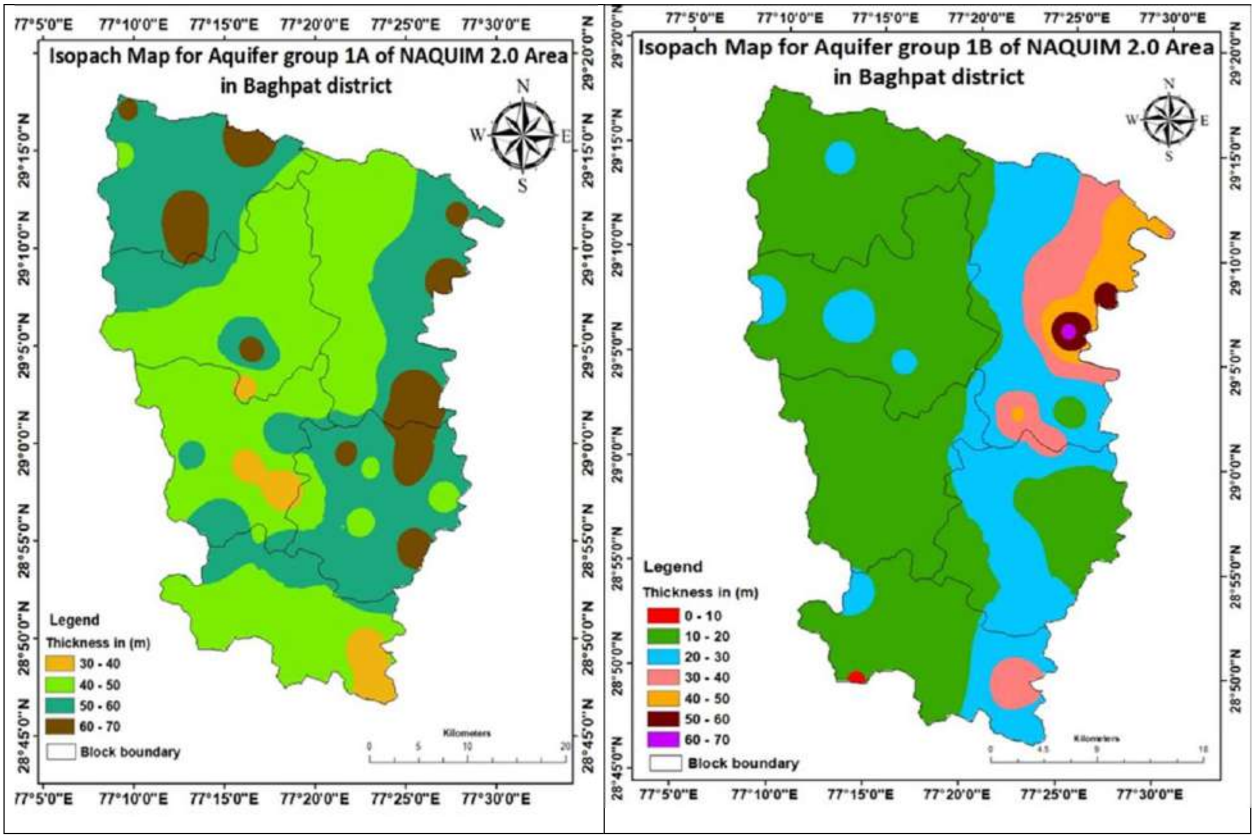


Fig. - 3.1 : Isopach Maps of Aquifer Group–I(A) & I(B) in NAQUIM 2.0 area

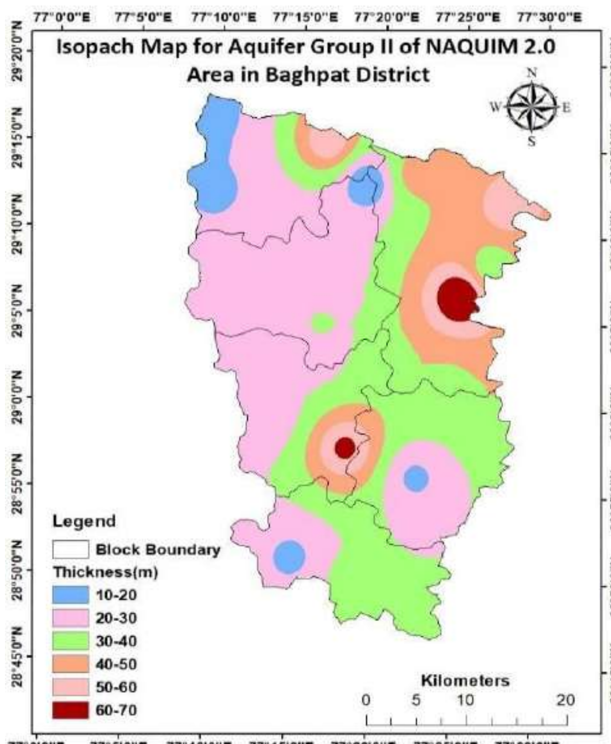


Fig. - 3.2 : Isopach Map of Aquifer Group–II in NAQUIM 2.0 area

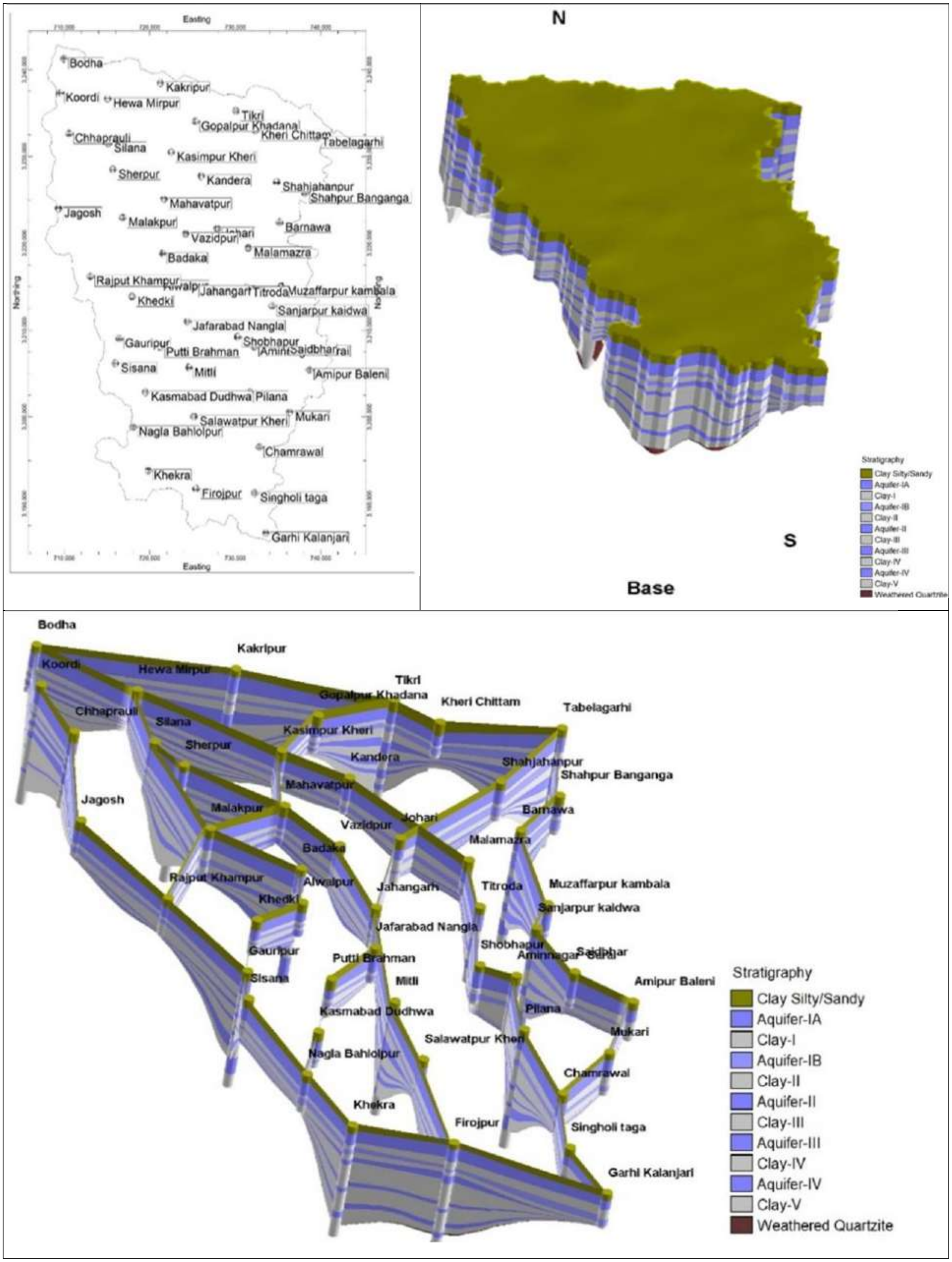


Fig. - 3.3 : Location of Exploratory Wells, 3D Stratigraphic Model and Fence Diagram

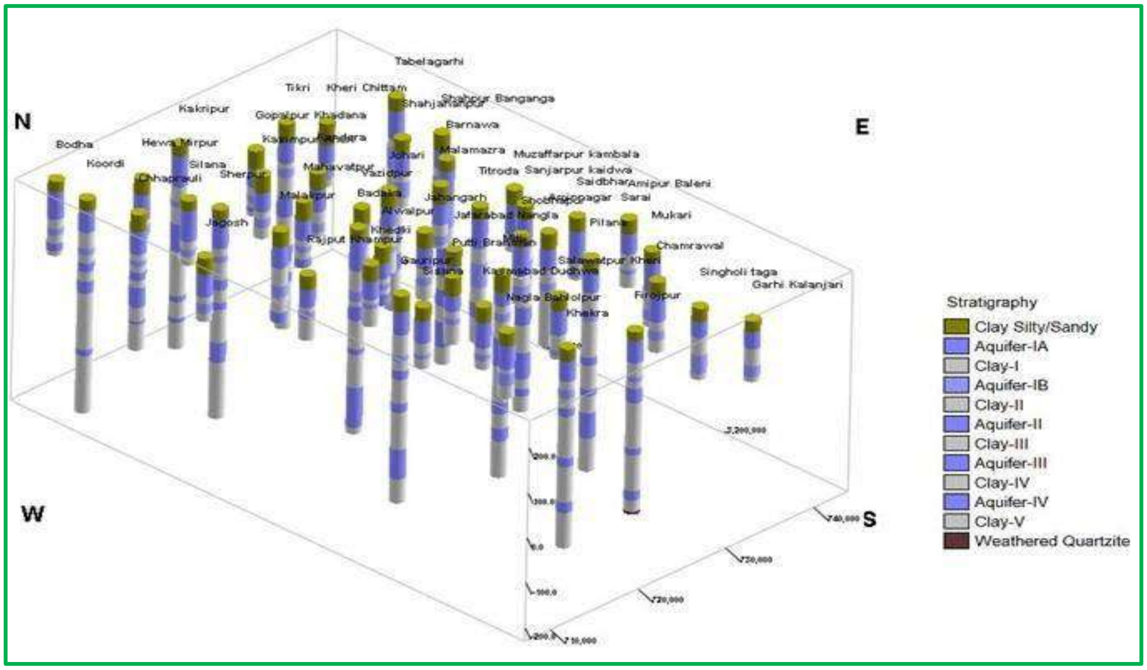


Fig. - 3.4 : 3D Multi-Log (Strip Log) showing Stratigraphical Disposition of Aquifer Groups

(v) Ground water level of Aquifer Group–I(A) is very deep. During pre-monsoon period water level ranges from 8.75 to 42.51 mbgl (Average-23.47 mbgl; WL < 20 m in 48%, 20 to 30 m in 24% and > 30 m in 28% Wells) whereas during post-monsoon period it ranges from 5.87 to 34.25 m bgl. Long term (10 years:2014-23) trend of ground water level in respect of Group-I(A) aquifer shows a continuous decline in all 6 blocks of Baghpat district at an alarming rate (at Khekra, Khekra block @ 0.75 m/yr and at Pilana, Pilana block @0.80 m/yr) and the aquifer is also being permanently de-watered.

(vi) The Dyanmic Resource (Annual Extractable GW Resource as on March 2023) of Aquifer Gr.-I(A) is **335.5058 MCM**, whereas the Static Resource of this Aquifer is **294.13 MCM**.

(vii) The shallow aquifers adjacent to the river Yamuna and Hindon are very thick and prolific due to existence of course granular materials.

(viii) Colossal and indiscriminate withdrawal of ground water from shallow unconfined aquifers for crop irrigation and continuous declining of water level along with permanent de-watering of this aquifer may have triggered the release of uranium by enhancement of its solubility and enrichment in the ground water at shallow depths under the induced oxidising condition occurring within the alluvium formation. Presence of bicarbonates chemicals in higher concentration further enhance the solubility and enrichment of uranium in ground water.

(ix) The northern, north-western and western fringe areas of Baghpat district may be considered as natural recharge area and especially the area along river Yamuna forming western boundary is locally a very good recharge zone where water table in Aquifer–I(A) ranges from 12 to 15 m bgl, whereas the rest part may be treated as natural discharge area.

(x) Yamuna River, flowing along the western boundary of NAQUIM 2.0 area, shows its influent nature in the south for the major portion of its length. Therefore, it is feasible to construct a series of shallow tube wells on the left bank of Yamuna along its course in order to facilitate the induced recharge and balancing of ground water storage with the extraction from the shallowest unconfined Group-I(A) aquifer.

(xi) Hindon, a highly polluted river due to discharge of huge industrial wastes, is flowing along the eastern boundary of the NAQUIM 2.0 area and in general it is showing its effluent nature for major portion of its length in the north.

(xii) The Aquifer Group-I(A) shows no uniform regional ground water flow direction over the whole NAQUIM 2.0 area, rather the flow path is seen to be influenced by local ground water withdrawal and a large ground water trough area has been detected in the eastern half of the mapping area during both pre and post-monsoon period. However, in general the flow lines are directed towards east and south-east.

(xiii) A large ground water trough area covering major parts of Pilana and Khekra blocks and southern part of Binauli block has been created due to excessive withdrawal of ground water locally for irrigation, due to which the adjacent portion of Hindon River course situated in the south section of eastern boundary of NAQUIM area has become influent. Consequently, this elongated stretch has become vulnerable in terms of pollution of ground water in shallow aquifers as the river may contribute contaminated water to the neighboring shallowest aquifers, which are sometimes extending even up to the ground surface. So, construction of any kind of tube well for induced recharge or further construction of shallow irrigation tube wells in huge numbers on the right bank of Hindon, especially in the southern section, should be prohibited as the induced recharge by tube wells may pollute the ground water presently available in existing drinking water tube wells and other shallow tube wells, which is occasionally being reported by the villagers.

(xiv) The whole NAQUIM 2.0 area of Baghpat district especially along a large expanse trending NNE to SSW falling in Binauli, Pilana and Khekra blocks is extremely feasible for artificial recharge in the Aquifer-I(A) as the respective ground water level in this locality invariably remains above 20 m bgl throughout the year.

(xv) Foraquifer wise management of ground water in NAQUIM 2.0 area of Baghpat district the following plan may be suitable: the total requirement of irrigation water should not be fulfilled solely from Aquifer Gr-I(A) as being done currently, only 60 % of irrigation demand should be fulfilled from Group–I(A) and the rest 40 % from Group–I(B) aquifer. All large diameter and deep heavy duty govt. tube wells for irrigation as well as for community drinking water supply should be constructed preferably by tapping the Aquifer Group–I(B) and if funds allow, then by tapping Group–II aquifers also.

(xvi) Ground water withdrawal from highly stressed Gr–I(A) aquifers should also be lessened by demand side interventions such as:

(A) changing of cropping pattern by reducing the cultivation of sugarcane and growing low CWR crops like wheat, paddy, mustard, pulses on crop land released by curtailing sugarcane
(B) practicing micro-irrigation like sprinkler and drip irrigation techniques in large scale and also by supply side interventions for enhancement of water storage on ground surface through conservation structures and below the ground surface through artificial recharge structures or through storage cum recharge structures like:

(a) construction of farm ponds in large numbers with recharge shaft wherever feasible
(b) desilting/ re-excavation/ deepening and protection of existing ponds
(c) construction of new Check Dam, 'Nala Bund', 'Merh Bundi', desilting of old Check Dam
(d) construction of recharge shaft/tube wells or induced recharge tube wells
(e) recharge shaft/tube wells attached with Roof Top Rain Water Harvesting (RTRWH) Structures on all large Govt. Buildings or Houses with roof area more than100 m^2.

3.2 Hydro-Chemical Data Interpretation and Integration for Aquifer Mapping

Quality of ground water is controlled by geogenic factors as well as anthropogenic activities, for example over-exploitation of groundwater and excessive use of fertilizers and pesticides in agriculture and improper disposal of urban/industrial waste can cause contamination of groundwater resources. It is also influenced by the contribution from the atmosphere and surface water bodies. Groundwater contains a wide variety of dissolved inorganic chemical constituents in various concentrations, resulting from chemical and bio-chemical interactions between water, soil and sub-surface geological materials through which it passes. Inorganic pollutants like salinity, chloride, fluoride, nitrate, iron, arsenic and uranium are important to check the suitability for drinking.

Ground water quality of NAQUIM area is influenced by local geology, contamination by industrial effluent and heavy withdrawal of ground water for irrigation. In major area, it is commonly withdrawn from Aquifer-I(A) through handpumps and shallow TWs. Heavy metals normally occurring in nature, not harmful to environment as they are present only in very small amounts, it becomes harmful to human when its concentrationin drinking water is more than permissible limit (BIS:2012) and is consumed for long time.

Parameters/constituents like pH, EC, TDS, TH, CO_3, HCO_3, Cl, NO_3, SO_4, F, Ca, Mg, Na, K, PO_4 and SiO_2 were evaluated by Basic analysis with the help of the instruments such as pH meter, EC meter, flame photometer, UV/Visible Spectrophotometer and titrimetric methods. For evaluatingHeavy Metals like Iron **(**Fe), Manganese (Mn), Chromium (Cr), Lead (Pb), Copper (Cu), Zinc (Zn), Arsenic (As) and Uranium (U), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS: ThermoiCAP-Q) was used at NABL Chemical Lab of CGWB, NR.

Table - 3.1 : Methods used for Chemical Analysis of Water Samples

Constituent	Method Used	Constituent	Method Used
pH	pH Meter	**Phosphate**	- do -
EC	EC Meter	**Silica**	- do -
Carbonate	Titrimetric method	**Total Hardness**	Titrimetric method
Bi-carbonate	- do -	**Calcium**	- do -
Chloride	Mohr's method	**Magnesium**	Evaluation from TH and Ca
Fluoride	Spectrophotometric method	**Sodium**	Flame emission photometric
Nitrate	- do -	**Potassium**	- do -
Sulphate	- do -	**Fe, Cr, Mn, Pb, As, U, Cu, Zn**	ICP-MS

Table - 3.2 : Results of Chemical Analysis for Heavy Metals (Pre/Post-Monsoon:2023)

Pre-Monsoon					Post-Monsoon					Desirable	Maximum Permissible (BIS : 2012)
Sl. No.	Parameters/ Constituent	Mini-mum	Maxi-mum	Ave-rage	Sl. No.	Parameters/ Constituent	Mini-mum	Maxi-mum	Ave-rage		
1.	**Cu** (mg/lt)	0.0	0.0	0.0	1.	**Cu** (mg/lt)	0.0	0.049	0.0	0.05	1.5
2.	**Cr** (mg/lt)	0.002	0.005	0.003	2.	**Cr** (mg/lt)	0.0	0.003	0.0	0.05	No Relaxation
3.	**Mn** (mg/lt)	0.034	0.897	0.143	3.	**Mn** (mg/lt)	0.0	0.498	0.0	0.1	0.3
4.	**Zn** (mg/lt)	0.069	3.904	1.036	4.	**Zn** (mg/lt)	0.0	3.746	0.562	5	15
5.	**Fe** (mg/lt)	0.013	10.125	1.150	5.	**Fe** (mg/lt)	0.0	6.803	0.364	0.3	No Relaxation
6.	**Pb** (mg/lt)	0.001	0.032	0.003	6.	**Pb** (mg/lt)	0.0	0.003	0.0	0.01	No Relaxation
7.	**As** (mg/lt)	0.001	0.0108	0.008	7.	**As** (mg/lt)	0.0	0.032	0.001	0.01	0.05
8.	**U** (mg/lt)	0.003	0.057	0.019	8.	**U** (mg/lt)	0.0	0.080	0.017	0.03	No Relaxation

Table - 3.3 : Results of Chemical Analysis for Basic Elements & Physico-Chemical Parameters (Pre/Post-Monsoon:2023)

Pre-Monsoon					Post-Monsoon					Desirable	Maximum Permissible (BIS : 2012)
Sl. No.	Parameters/ Constituents	Mini-mum	Maxi-mum	Ave-rage	Sl. No.	Parameters/ Constituents	Mini-mum	Maxi-mum	Ave-rage		
1.	**pH**	6.95	8.27	7.83	1.	**pH**	6.75	8.27	7.80	6.5 - 8.5	No relaxation
2.	**EC** (µS/cm)	269	2391	1061	2.	**EC** (µS/cm)	330	2300	1132	750	3000 (TDS – 2000)
3.	**TH**	90	610	260	3.	**TH**	60	770	316	200	600
4.	**CO3**(mg/lt)	0.0	0.0	0	4.	**CO3**(mg/lt)	0.0	0.0	0		
5.	**HCO3**(mg/lt)	110	1159	414	5.	**HCO3**(mg/lt)	146	1086	497		
6.	**Cl** (mg/lt)	7	425	57.6	6.	**Cl** (mg/lt)	7	340	52	250	1000
7.	**F** (mg/lt)	0.11	3.5	0.64	7.	**F** (mg/lt)	0.1	5.0	1.0	1.0	1.5
8.	**NO3**(mg/lt)	0.0	36	7.33	8.	**NO3**(mg/lt)	0.0	140	14	45	No Relaxation
9.	**SO4**(mg/lt)	6	380	66	9.	**SO4**(mg/lt)	0.0	400	63	200	400
10.	**PO4**(mg/lt)	0.0	17	1.28	10.	**PO4**(mg/lt)	0.0	18.6	0.84		
11.	**Ca** (mg/lt)	16	120	51	11.	**Ca** (mg/lt)	12	232	62	75	200
12.	**Mg** (mg/lt)	2	110	31.7	12.	**Mg** (mg/lt)	2	39	10.7	30	100
13.	**Na** (mg/lt)	9	480	122.5	13.	**Na** (mg/lt)	5	360	115		
14.	**K** (mg/lt)	2.4	90	13.45	14.	**K** (mg/lt)	2.4	140	14.3		

3.2.1 Hydro-Chemical Facies of Ground Water

In 1994, Arthur M. Piper, proposed an effective graphic procedure to segregate relevant analytical data to understand the sources of dissolved constituents in water. Most natural waters contain cations and anions in chemical equilibrium. It is assumed that the most abundant cations are two 'alkaline earths'Calcium (Ca) and Magnesium (Mg) and one 'Alkali' sodium (Na). The most common anions are one 'weak acid 'Bi- carbonate (HCO_3) and two 'strong acids' Sulphate (SO_4) and Chloride (Cl). To create a graph with the major constituent ions of water, Piper (1994) suggested drawing two triangles corresponding with the cations and anions respectively and one diamond that summarize both triangles. According to the location of the sample in that diamond, the hydro-chemical facies can be identified, which are the diagnostic chemical aspects of water solutions occurring in hydrologic systems.

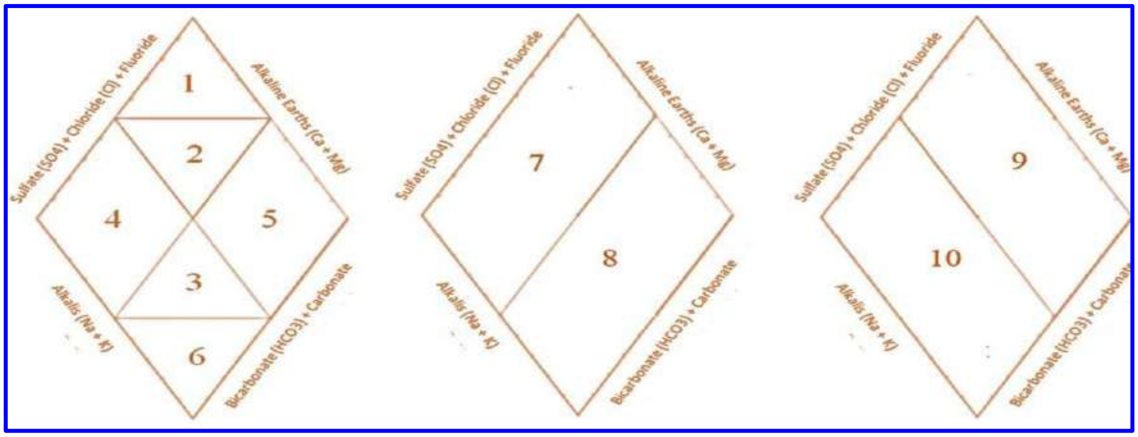


Fig. - 3.5 : General characteristics of Water in each zone of the Piper Trilinear Diagram

Zone	Characteristics of Water (Hydro-chemical Facies)
1.	Calcium-Chloride type water (Permanent Hardness)
2.	Mixed Type (Ca – Mg – Cl - SO_4)
3.	Mixed Type (Ca – Na - HCO_3)
4.	Calcium-Bicarbonate type (TemporaryHardness)
5.	Sodium-Chloride type (Saline)
6.	AlkaliBi-carbonate (Na-HCO_3)
7.	Alkaline Earths exceed Alkalis (Ca + Mg > Na + K)
8.	Alkalis exceed Alkaline Earths (Na + K > Ca + Mg)
9.	Weak Acids exceed Strong Acids (CO_3 + HCO_3 > Cl + SO_4)
10.	Strong acids exceed weak Acids (Cl + SO_4 > CO_3 + HCO_3)

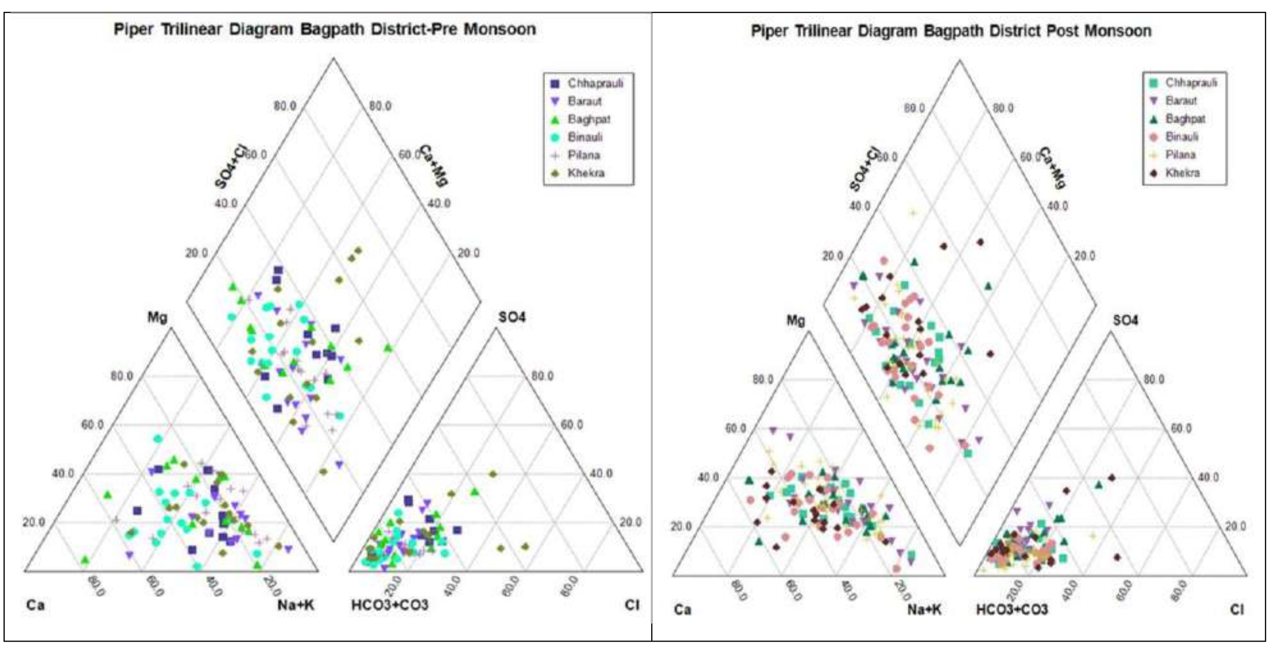


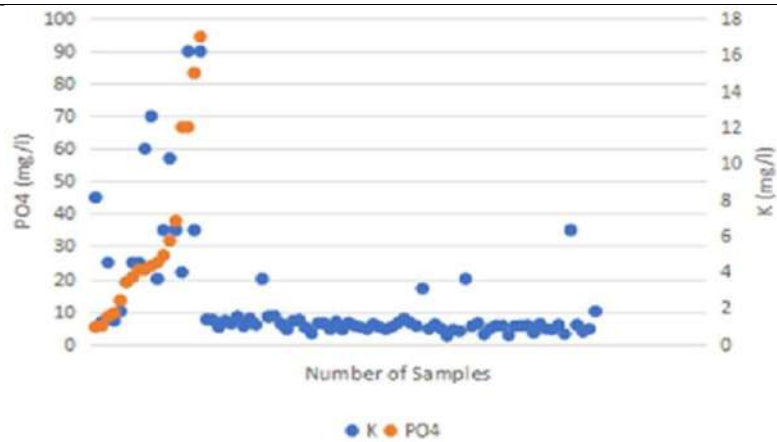
Fig. - 3.6 : Piper Trilinear Diagram for Assessing Chemical Characteristics of Water

In NAQUIM 2.0 area, the ground water samples of shallow as well as deeper aquifers as shown in piper diagram, follows the order of Mg-HCO3 type >> Mixed type >> Na-HCO_3 type of hydro-chemical characteristics. As per the results it is found that ground water is mostly of mixed type Ca-Mg-Cl-SO_4 & Ca-Na-HCO_3 both in preand post-monsoon time.

US Salinity of Water Samples

USSL Class	Pre-Monsoon Period	Post-Monsoon Period
C2S1	28.75%	25.55%
C3S1	48.75%	55.46%
C3S2	18.75%	18.74%
C3S3	-	0.15%
C4S2	1.25%	-
C4S3	1.25%	-
C4S4	1.25%	-

High Potassium (K) & Phosphate (Po_4) in Surface Water



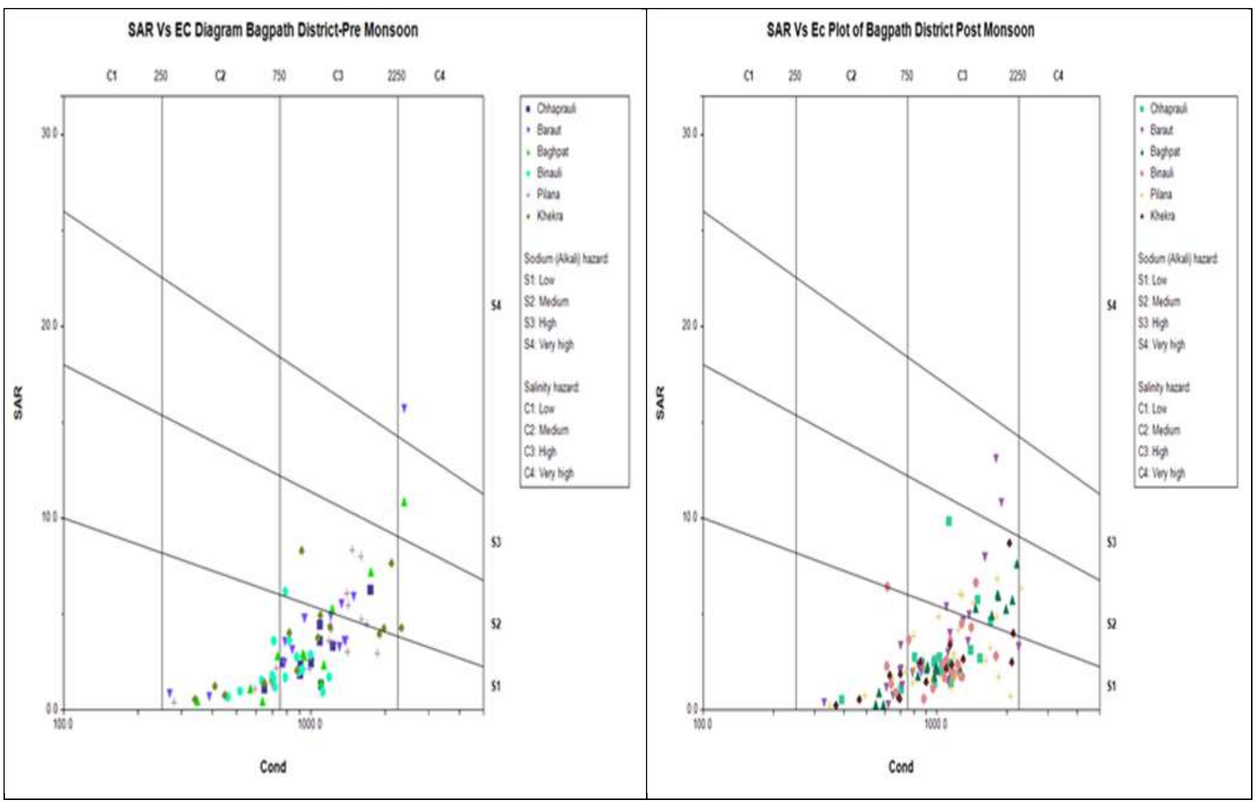


Fig. - 3.7 : SAR Vs EC Diagram for Ground Water Samples (Pre & Post Monsoon)

Table - 3.4 : Residual Sodium Carbonate (RSC) Ratio of Ground Water in NAQUIM 2.0 area

Residual Sodium Carbonate (RSC)	Water Type for irrigation	Pre-Monsoon		Post-Monsoon	
		No. of Samples	% Ratio	No. of Samples	% Ratio
> 2.50	Not suitable	33	40%	43	34%
1.25 - 2.50	Marginally suitable	21	26%	27	21%
<1.25	Good for irrigation	28	34%	58	45%

Table - 3.5 : Sodium Adsorption Ratio of Ground Water in NAQUIM 2.0 area

Sodium Adsorption Ratio (SAR)	WaterType for Irrigation	Pre-Monsoon		Post-Monsoon	
		Nos. of Samples	% Ratio	Nos. of Samples	% Ratio
>10	Not Suitable	1	1%	2	2%
<10	Suitable	81	99%	126	98%

3.2.2 Ground Water Quality Scenario

From chemical analysis results it has been observed that majority of water samples collected from Indian Mark–II drinking water hand pumped tube wells and shallow irrigation tube wells in the NAQUIM 2.0 area of Baghpat district constructed by tapping Aquifer Group-I(A) within 80 m depth are suitable for drinking purposes and crop irrigation purpose respectively, as all the chemical constituents in the ground water are generally found to be under desirable limit or well within the maximum permissible limit as per the respective standards. However, a few ground water samples collected from some isolated and randomly scattered places are found to have some elements like Fluoride, Iron and Uranium slightly beyond the maximum permissible limits as per BIS standards.

Sporadic Uranium (U) contamination (above max. permissible limit 0.03 mg/lt) has been noticed in ground water available from Indian Mark-II hand pumps (30 to 65 m depth).

Based on the chemical analysis results in respect of basic parameters, it is found that ground water is mostly of mixed type and Magnesium Bi-Carbonate (Mg-HCO_3) type and the water is slightly alkaline in nature as the pH of ground water of NAQUIM 2.0 area in Baghpat district ranges in between 6.95 to 8.27 in pre-monsoon and 6.75 to 8.25 in post-monsoon period with an average value of 7.83 and 7.80 for pre-monsoon and post-monsoon respectively. No significant seasonal (pre- to post-monsoon) variation in chemical quality of ground water has been noticed.

Table - 3.6 : Contaminating Chemical Elements in Water Samples (Pre-Monsoon : 2023)

Sl. No.	Block	Location Details	Latitude	Longitude	Source	F mg/l	NO_3 mg/l	Fe mg/l	Mn mg/l	Pb	U mg/l	Remarks
1.	Pilana	Dhaula	29. 956395	77.339374	HPTW (M-II)			2.135				NAQUIM 2.0 Premonsoon Study
2.	Pilana	Pura Mahadeb	28.998075	77.750272	HPTW (M-II)						0.050	
3.	Pilana	Pura Mahadeb	29.001042	77.460856	Hindon River				0.542			
4.	Pilana	Shobhapur	28.989942	77.363176	HPTW (M-II)				0.207		0.035	
5.	Pilana	Shobhapur	28.989942	77.363176	SW (Pond)	1.60						
6.	Pilana	Sughawali Ahir	28.957022	77.402726	HPTW (M-II)			2.080	0.104			
7.	Pilana	Baleni	28.958782	77.471114	Hindon River					0.032		
8.	Pilana	Baleni	28.958782	77.471114	HPTW (M-II)				0.470			
9.	Binauli	Tabelgarhi	29.196984	77.459370	HPTW (M-II)						0.044	
10.	Binauli	Tikri	29.229819	77.361980	HPTW (M-II)			3.242				
11.	Binauli	Barnawa Bridge	29.114344	77.439828	Hindon River				0.897			
12.	Binauli	Nirpura	29.232846	77.393232	SW(Pond)				0.085			
13.	Binauli	Khaprana	29.190616	77.470663	HPTW (M-II)			1.051				
14.	Binauli	Mangroli	29.190616	77.470663	HPTW (M-II)			7.857	0.062			
15.	Binauli	Edrishpur	29.172775	77.357218	HPTW (M-II)			5.519	0.105			
16.	Binauli	Bamnauli	29.145132	77.355066	Hindon River				0.110			
17.	Binauli	Barawad	29.068521	77.322560	HPTW (M-II)						0.052	
18.	Khekra	Lalyana	28.861182	77.409807	Hindon River				0.314			
19.	Khekra	Fakharpur	28.843364	77.297498	HPTW (M-II)			2.195				
20.	Khekra	Bhagout	28.805594	77.359877	TW				0.125			NAQUIM 2.0 Premonsoon Study
21.	Khekra	Bhagout	28.805523	77.360073	HPTW (M-II)				0.063			
22.	Khekra	Firojpur	28.840933	77.307320	SW(Pond)				0.137			
23.	Khekra	Badagaon	28.869482	77.321890	TW					0.011		
24.	Chhaprauli	Asara	29.24877	77.30312	HPTW (M-II)			5.753				
25.	Chhaprauli	Soop	29.20138	77.26443	HPTW (M-II)						0.052	
26.	Chhaprauli	Chhaprauli	29.206700	77.168520	SW(Pond)				0.060			
27.	Chhaprauli	Boddha	29.280058	77.164057	SW(Pond)				0.203			
28.	Baraut	Shadatpur Janmana	29.091470	77.217450	SW (Pond)						0.037	
29.	Baraut	Kotana	29.10270	77.16688	HPTW (M-II)				0.060		0.038	
30.	Baraut	Luhari	29.08064	77.19142	HPTW (M-II)			10.125				
31.	Baraut	Malakpur	29.105897	77.252327	HPTW (M-II)			3.369				
32.	Baraut	Luhari	29.08064	77.19142	TW				0.063			
33.	Baraut	Biharipur	29.037327	77.206627	HPTW (M-II)	1.8					0.043	
34.	Baghpat	Pawla Begmabad	28.93084	77.29461	HPTW (M-II)				0.065		0.041	
35.	Baghpat	Tatri	28.950169	77.266586	HPTW (M-II)			1.513				

Table - 3.7 : Contaminating Chemical Elements in Water Samples (Post-Monsoon : 2023)

Sl. No.	Block	Location Details	Latitude	Longitude	Source	Fe mg/l	As mg/l	U mg/l	Remarks
1	Chhaprauli	Asara	29.24877	77.30312	HP IM-II	6.803			NAQUIM 2.0 Post-monsoon Study
2	Chhaprauli	Soop	29.20138	77.26443	HP IM-II			0.046	
3	Chhaprauli	Soop	29.19456	77.26134	HP IM-II			0.031	
4	Baraut	Kotana	29.09374	77.15918	HP IM-II	4.434			
5	Baraut	Luhari	29.08064	77.19142	HP IM-II	4.211			
6	Baghpat	Pawla Begmabad	28.93084	77.29461	HP IM-II			0.030	
7	Baghpat	Pawla Begmabad	28.93824	77.28749	HP IM-II			0.036	
8	Baghpat	Kheriki	29.03881	77.23745	STW			0.037	
9	Binauli	Tikri	29.22982	77.36198	HP IM-II	1.763			
10	Binauli	Tabelgarhi	29.19698	77.45937	HP IM-II			0.036	
11	Pilana	Daula	28.95639	77.33937	HP IM-II	1.734			
12	Pilana	Doula	28.95242	77.33185	HP IM-II			0.033	
13	Pilana	Pura Mahadev	28.99220	77.45515	HP IM-II	2.743			
14	Pilana	Khindora	29.00596	77.36891	HP IM-II	3.843			
15	Khekra	Nagla Badi	28.82171	77.32272	TW/ BW	6.301			
16	Khekra	Firojpur	28.84093	77.30732	SW		0.021		
17	Pilana	Sidhauli	28.95702	77.40273	HP IM-II	1.725			
18	Pilana	Shobhapur	28.98966	77.36373	BW			0.037	
19	Pilana	Shobhapur	28.98966	77.36373	HP IM-II			0.034	
20	Pilana	Baleni	28.95878	77.47111	HP (Shallow)		0.032		

Sl. No.	Block	Location Details	Latitude	Longitude	Source	Fe mg/l	As mg/l	U mg/l	Remarks
21	Pilana	Gouspur	28.98008	77.34446	HP IM-II			0.031	NAQUIM 2.0 Post-monsoon Study
22	Chhaprauli	Chandan Hedi	29.16914	77.19548	HP IM-II			0.061	
23	Chhaprauli	Bachhor	29.16926	77.17793	HP IM-II			0.038	
24	Baraut	Baoli	29.14196	77.27001	HP IM-II	1.626			
25	Binauli	Mangroli	29.19062	77.47066	HP IM-II	3.972			
26	Binauli	Edrishpur School	29.17278	77.35722	HP IM-II	1.108			
27	Binauli	Barawad	29.07245	77.32426	SBTW			0.039	
28	Binauli	Barawad	29.06852	77.32256	HP IM-II			0.033	
29	Binauli	Nirpura	29.23330	77.39426	HP IM-II			0.041	
30	Binauli	Bari Nagla	29.06469	77.33110	HP IM-II			0.045	
31	Baraut	Biharipur	29.04406	77.20853	HP IM-II	1.914			
32	Baraut	Faizpur Ninana	29.02890	77.20442	HP IM-II			0.080	
33	Baraut	Barwala	29.15977	77.25249	HP IM-II			0.051	
34	Baraut	Shadatpur Jounmana	29.09147	77.21745	SW			0.045	

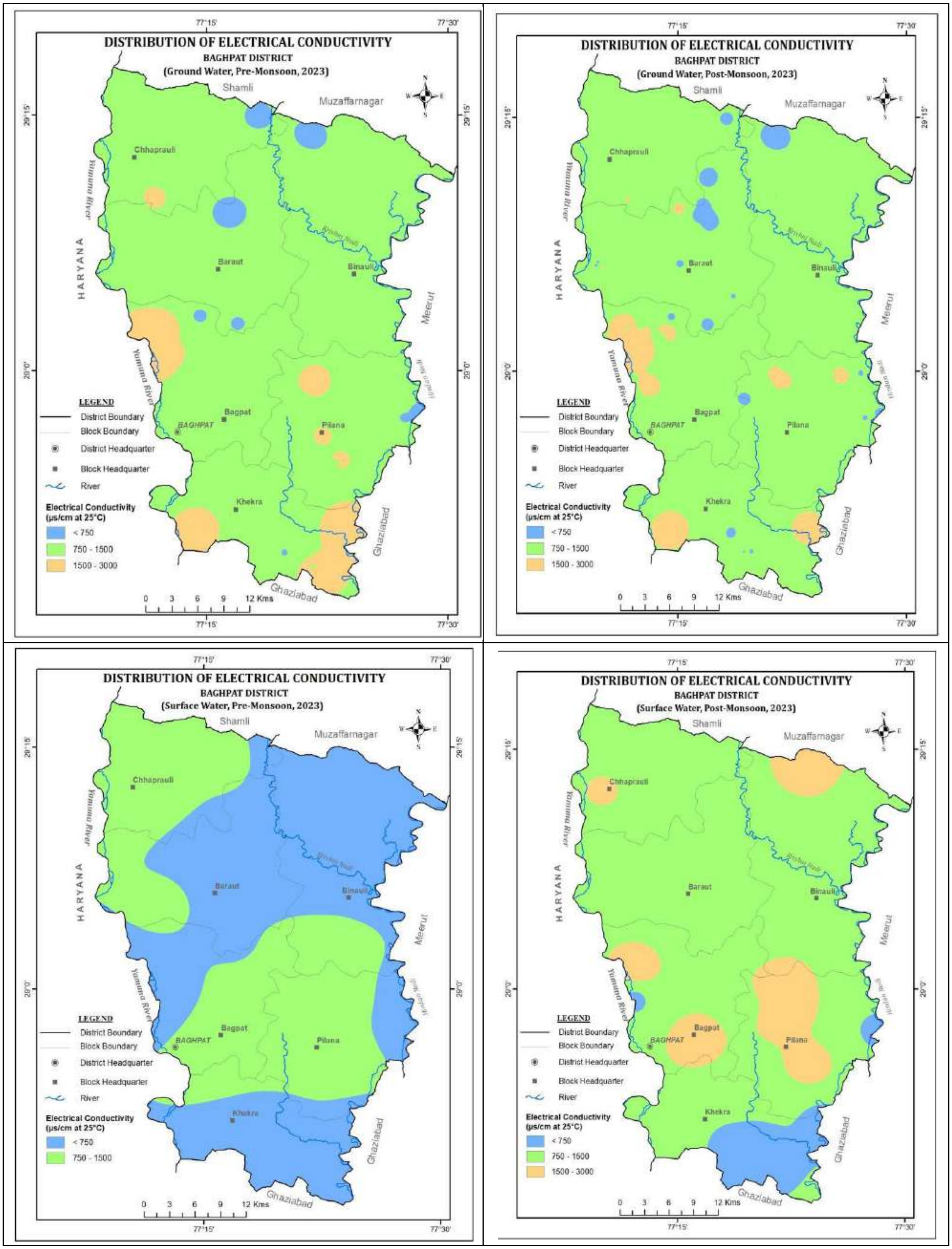


Fig. - 3.8 : Contour Map of EC in Ground Water and Surface Water (Pre & Post-Monsoon)

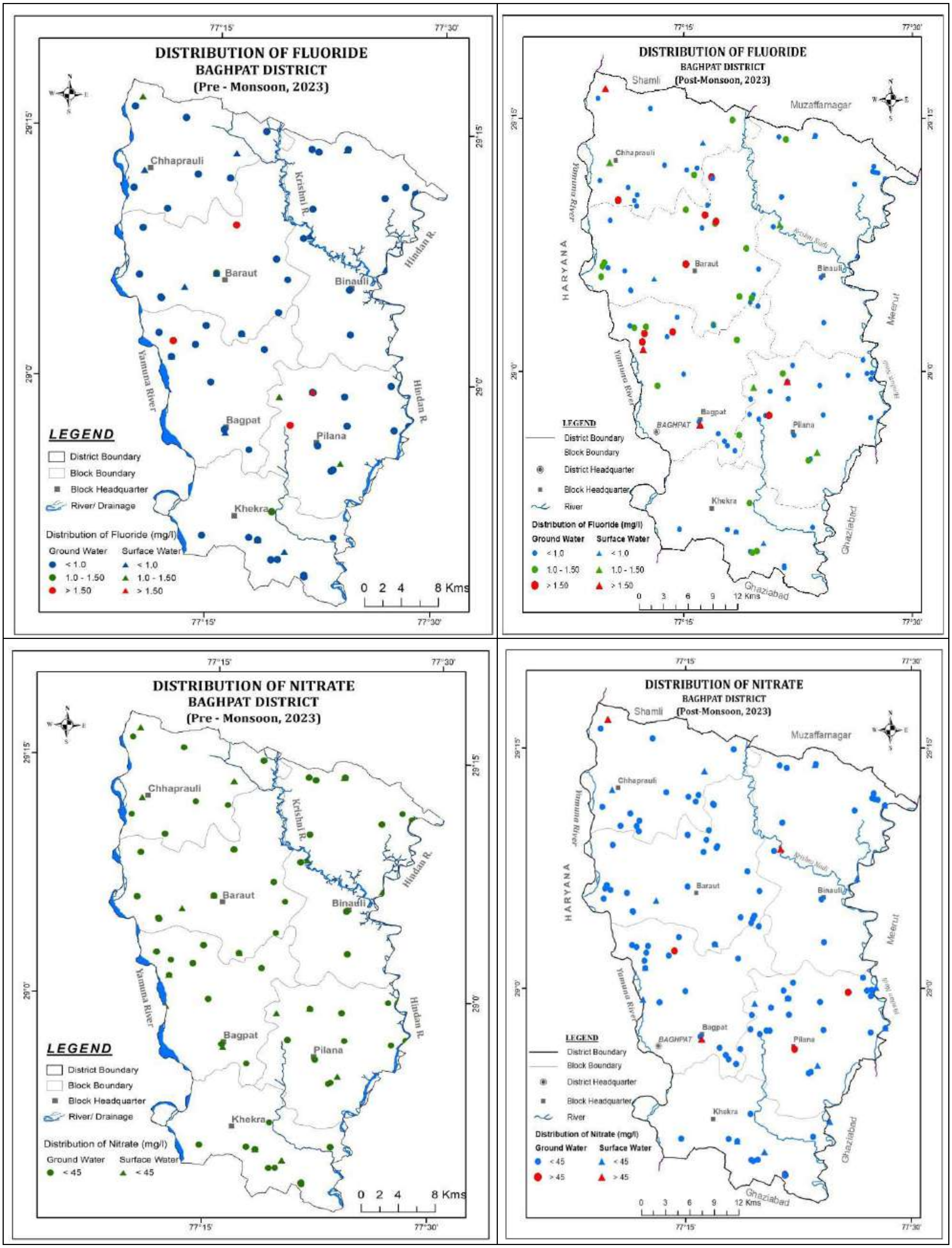


Fig. - 3.9 : Fluoride and Nitrate Content in Ground & Surface Water (Pre & Post-Monsoon)

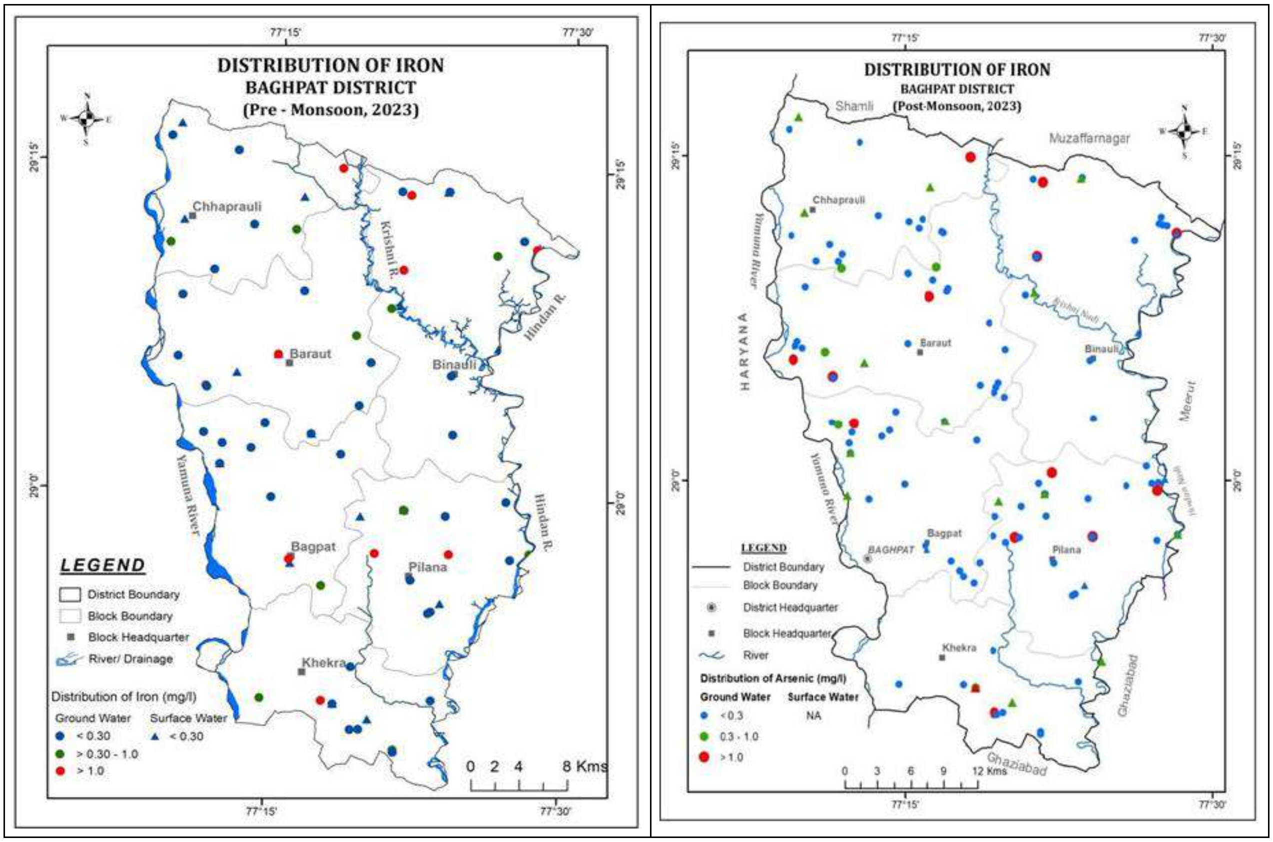


Fig. - 3.10 : Iron Content in Ground Water and Surface Water (Pre and Post-Monsoon)

3.2.3 Results of Chemical Analysis of Water Samples collected under NAQUIM 2.0

(i) Results of BASIC Parameter Analysis

Electrical Conductivity (EC in µS/cm):

EC ranges in between 269 to 2391 and 330 to 2300 µS/cm at 25°C for pre-monsoon and post-monsoon period respectively. 85% samples having EC values between 269 to 1500 uS/cm and 15% samples EC value falls between 1569 to 2391.

Carbonate and Bicarbonate (CO_3 and HCO_3):

Carbonate concentration has been observed to be nil in all samples and Bicarbonate concentration has been observed in the range of 110 to 1159 mg/lt and 146 to 1086 mg/lt during pre-monsoon and post-monsoon period respectively.

Chloride (Cl):

Chloride concentration varies from 7 to 425 mg/lt and 7 to 340 mg/lt during pre-monsoon and post- monsoon period respectively.

Nitrate (NO_3):

Nitrate concentration ranges from 0 to 36 mg/ltduring pre-monsoon period and from 0 to 140mg/lt during post-monsoon period. Out of 128 post-monsoon samples only in 6 nos. samples nitrate content was above maximum permissible limit (45 mg/lt).

Fluoride (F):

Most of the fluorides are sparingly soluble and are present in groundwater in small amounts. The type of rocks, climatic conditions, nature of hydro geological strata and time of contact between rock and the circulating groundwater affect the occurrence of fluoride in natural water. The presence of other ions particularly bicarbonate and calcium ions also affect the concentration of fluoride in groundwater. Out of total 82 samples collected during pre- monsoon, only in 4 samples fluoride content found to be more than maximum permissible limit and the concentration of fluoride varied from 0.11 to 3.5 mg/lt. Out of 128 samples collected during post-monsoon period 13 samples had fluoride concentration beyond the maximum permissible limit as per BIS 2012 standard and it ranged from 0.1 to 5.0 mg/lt and.

(ii) Results of Heavy Metals Analysis

Copper (Cu) :

As per BIS 10500:2012 drinking water standard, the acceptable (desirable) limit of copper concentrations in water is 0.05 mg/lt and the maximum permissible limit is 1.5 mg/lt in case of unavailability of alternative source. Copper concentration is well under acceptable limit in 100% samples from the NAQUIM 2.0 area.

Zinc (Zn) :

Zinc is essential and beneficial element in human metabolism. Acceptable and permissible limit for zinc is 5mg/lt and 15 mg/lt and it produces astringent taste to water, when concentration goes above 5mg/lt. The concentration of zinc in water of this NAQUIM 2.0 area ranges from 0.069 to 3.904 and 0 to 3.746 mg/ltduring pre and post monsoon respectively.

Iron (Fe):

The permissible limit of Iron in ground water is 0.3mg/lt as per the BIS Standard for drinking water. In the ground water sample collected from NAQUIM 2.0 area Iron concentration ranges from 0.013 to 10.125 in pre-monsoon and 0 to 6.803 mg/lt in post monsoon time. It is observed that after monsoon there happened a bit dilution in terms of Iron content.

Lead (Pb):

Lead concentration ranges from 0.001 to 0.32 mg/lt in pre-monsoon water samples and from 0.0 to 0.003 mg/lt in post-monsoon samples. Most of the samples collected during both the season show Lead content under the acceptable limit (0.01 mg/lt) except a very few ones.

Chromium (Cr):

Concentration of Chromium (Cr) ranges between 0.002 to 0.004 mg/lt and 0 to 0.003 mg/lt during pre-monsoon and post-monsoon respectively. In NAQUIM area 100% water samples have a chromium concentration within the acceptable (desirable) limit i.e. 0.05 mg/lt.

Arsenic (As):

Arsenic has been recognized as a toxic element and hazaradous for human health if water with concentration above permissible limit is consumed for a considerably long time. As per BIS 10500:2012 drinking water standard, desirable limit is 0.01 mg/lt and the maximum permissible limit is 0.05 mg/lt. Range of Arsenic concentration in pre-monsoon water samples is from 0.001 to 0.0108 mg/lt, whereas concentration in post-monsoon samples is 0.00 to 0.032 mg/lt. However, all the samples showed Arsenic highly with in desirable limit.

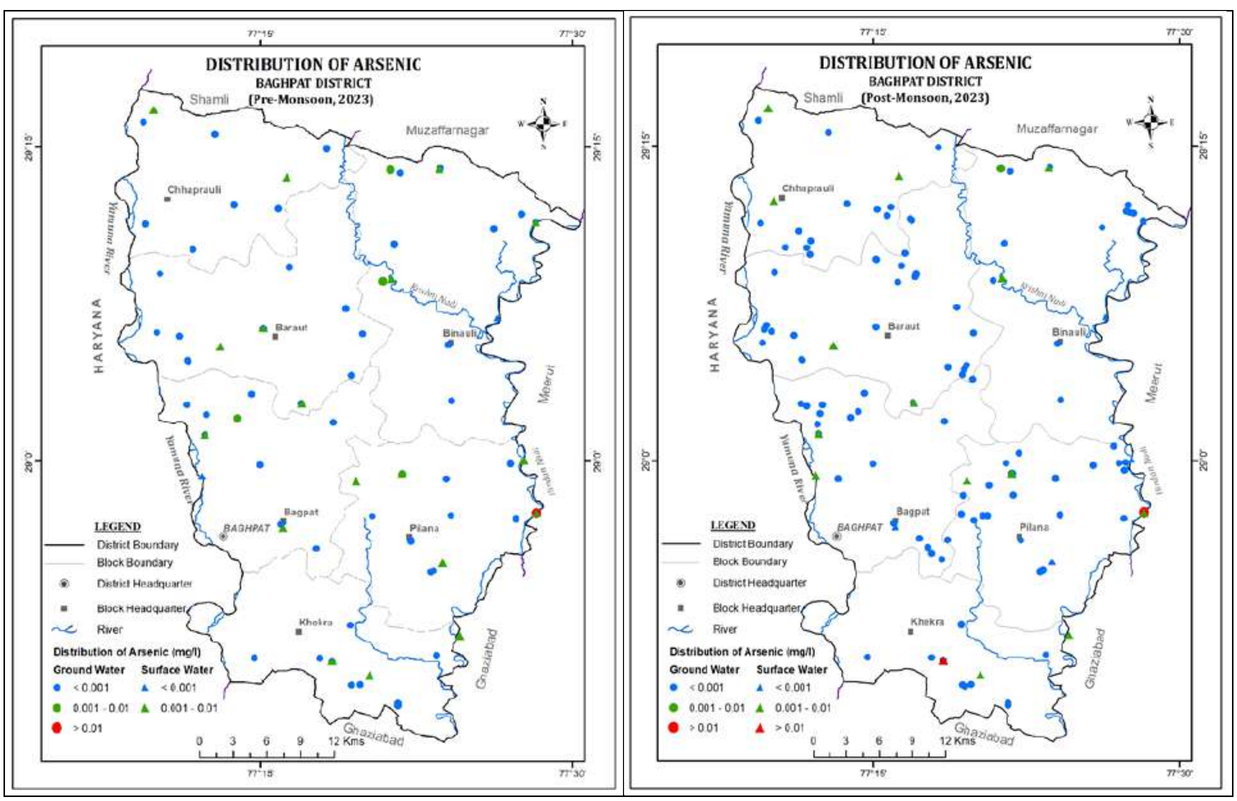


Fig. - 3.11 : Arsenic Content in Ground Water and Surface Water (Pre and Post-Monsoon)

Uranium (U):

Uranium (U) occurs naturally in ground water as well as surface water. Being a radioactive mineral, high uranium concentration can cause impact on water, soil and human health. It has both natural and anthropogenic sources, which includes leaching from natural sedimentary deposits, release in mill tailings and emissions from the nuclear industry, combustion of coal and other fuels and the excessive use of phosphate fertilizers. Uranium concentration in the shallow ground water varies primarily due to recharge and discharge procedure of ground water, which would have dissolved or leached the uranium element from the in situ weathered soil to the ground water zone. Studies have shown that phosphate fertilizer possesses uranium concentration ranging from 1 mg/kg to 68.5 mg/kg (Brindha K et al., 2011). Hence, the phosphate fertilizers manufactured from phosphate rocks may also contribute uranium to ground water in cultivated areas.

Water with uranium above the recommended maximum permissible concentration of 0.03 mg/lt i.e. 30 ppb (BIS 10500:2012) is not safe for drinking purpose as it can cause damage to internal organs by cancer of urinary tract and by toxicity in kidney on continuous intake for long. A recent study discovered a strong correlation between uranium concentration in drinking water and uranium presence in bones, suggesting that bones are good indicators of uranium exposure via ingestion of drinking water. In NAQUIM 2.0 area, uranium content ranges from 0.003 to 0.057 mg/lt and 0.00 to 0.08mg/lt in water samples collected during pre and post monsoon respectively.

Out of 82 pre-monsoon samples, in 4 samples at 4 different places, Fluoride content was above permissible limit with range from 0.11 to 3.5 mg/lt (avg. 0.64 mg/lt), whereas in 128 post-monsoon samples it ranged from 0.1 to 5.0 mg/lt (avg. 1.0 mg/lt). Nitrate (NO_3) was well within desirable limit as annual average concentration ranges from 7.33 to 14 mg/lt.

Out of 82 samples (GW-61, SW-21) collected for Trace Metal analysis during pre-monsoon, only 8 GW samples (13.11%) and 1 SW (pond) sample had Uranium, 11/13 GW samples (18.03%) had Iron and 2 samples (2.44%) had Arsenic contentabove permissible limit (BIS Standard:2012). Cu, Zn, Mn, Cr, and Pb were within the permissible limit.

Similarly, out of 128 samples (GW–108, SW–20) for TraceMetalanalysis during post-monsoon, 18GW samples (16.66%) and 1 SW (pond) sample had Uranium concentration, 13 GW samples (12.04%) had Iron content and 2 GW samples (1.85%) had Arsenic content more than permissible limit. Cu, Zn, Mn, Cr, and Pb were found within the permissible limit.

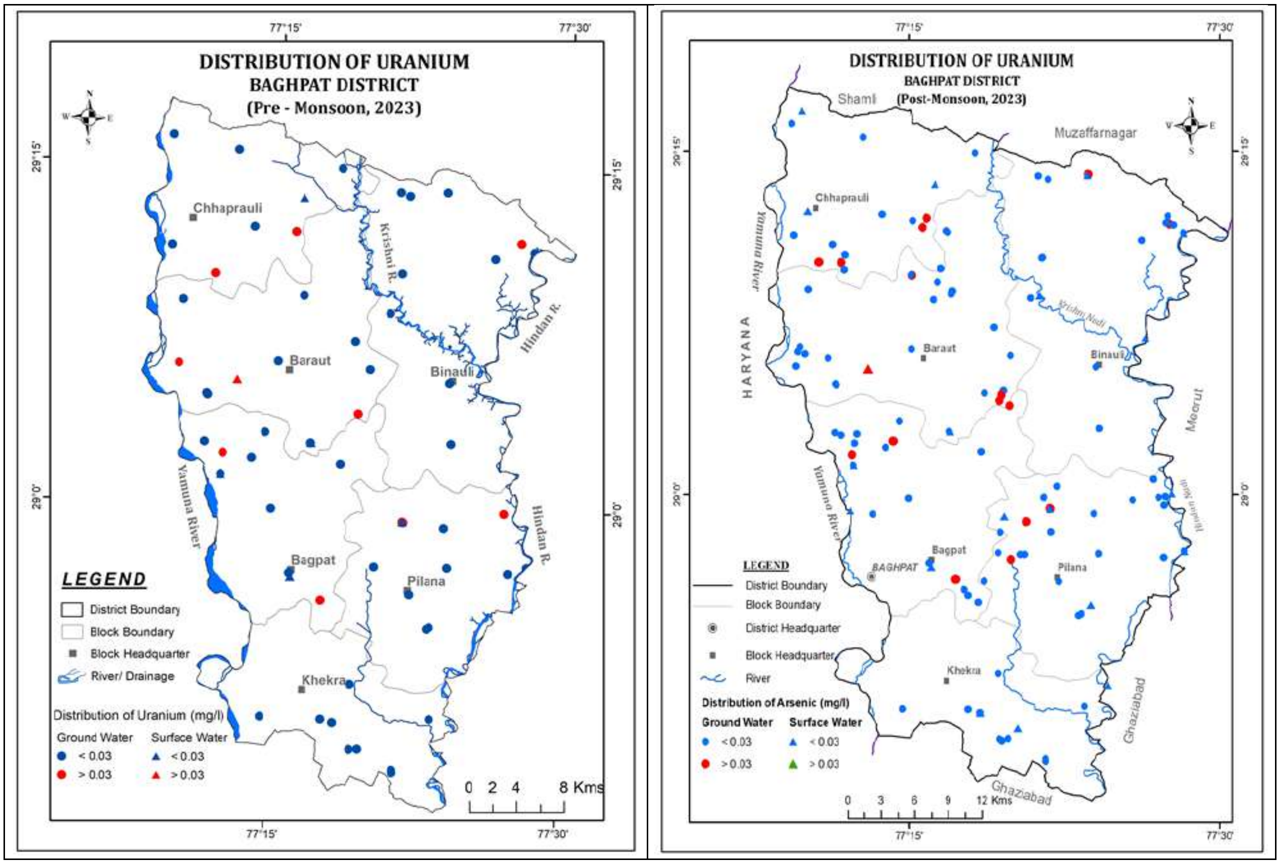


Fig. - 3.12 : Uranium Content in Ground Water and Surface Water (Pre and Post-Monsoon)

Higher concentration of Uranium in pre-monsoon sample was found to be 0.052 mg/lt in a hand pump fitted TW at Barawad in Binauli block and also in a Mark-II tube well at Soop in Chhaprauli block and the highest concentration of 0.057 mg/ltin a hand pump fitted TW at Chandan Heri, Chhaprauli block, whereas a Uranium content of 0.08 mg/lt was recorded in a post-monsoon sample from a hand pump fitted TW at Faizpur Ninana in Baraut block.

Table - 3.8 : Higher Concentration of Uranium in NAQUIM 2.0 area (Pre-Monsoon: 2023)

Sl. No.	Village	Block	Latitude	Longitude	Ground Water/ Surface Water	Concentration (ppm)
1.	**Soop**	Chhaprauli	29.20138	77.26443	Ground Water (M-II TW)	0.057
2.	**Kotana**	Baraut	29.10270	77.16688	Ground Water (M-II TW)	0.038
3.	**Biharipur**	Baraut	29.037327	77.206627	Ground Water (M-II TW)	0.043
4.	**ShadatpurJanmana**	Baraut	29.091470	77.217450	Surface Water (Pond)	0.037
5.	**Pawala Begmabad**	Baghpat	28.93084	77.29461	Ground Water (M-II TW)	0.041
6.	**Pura Mahadev**	Pilana	28.998075	77.750272	Ground Water (M-II TW)	0.050
7.	**Shobhapur**	Pilana	28.989942	77.363176	Ground Water (M-II TW)	0.035
8.	**Tabelagarhi**	Binauli	29.196984	77.459370	Ground Water (M-II TW)	0.044
9.	**Barawad**	Binauli	29.068521	77.322560	Ground Water (M-II TW)	0.052

Table - 3.9 : Higher Concentration of Uranium in NAQUIM 2.0 area (Post-Monsoon: 2023)

S. N.	Village	Block	Latitude	Longitude	Ground Water/Surface Water	Content (ppm)
1.	**Soop**	Chhaprauli	29.20138	77.26443	Ground Water (Mark - II TW)	0.046
2.	**Chandan Hedi**	Chhaprauli	29.16914	77.19548	Ground Water (Mark - II TW)	0.061
3.	**Bachhor**	Chhaprauli	29.16926	77.17793	Ground Water (Mark - II TW)	0.038
4.	**FaizpurNinana**	Baraut	29.02890	77.20442	Ground Water (Mark - II TW)	0.080
5.	**Barwala**	Baraut	29.15977	77.25249	Ground Water (Mark - II TW)	0.051
6.	**Shadatpur Jounmana**	Baraut	29.09147	77.21745	Surface Water (Pond)	0.045
7.	**PawalaBegmabad**	Baghpat	28.93824	77.28749	Ground Water (Mark - II TW)	0.036
8.	**Kheriki**	Baghpat	29.03881	77.23745	Shallow Tube Well (STW)	0.037
9.	**Shobhapur**	Pilana	28.98966	77.36373	Small Bore TW (Submersible)	0.037
10.	**Tabelagarhi**	Binauli	29.19698	77.45937	Ground Water (Mark - II TW)	0.036
11.	**Barawad**	Binauli	29.07245	77.32426	Small Bore TW (Submersible)	0.039
12.	**Nirpura**	Binauli	29.23330	77.39426	Ground Water (Mark - II TW)	0.041
13.	**Bari Nagla**	Binauli	29.06469	77.33110	Ground Water (Mark - II TW)	0.045

3.2.4 Conclusion on Chemical Analysis Results and Recommendation

Conclusion

There are two types of contamination sources: point and non-point sources. In this area, naturally occurring non-point sources of contamination including pollutants like Iron, Uranium and runoff from pesticides and fertilizers may infiltrate the soil and make their way into an aquifer.

By and large, ground water quality of NAQUIM 2.0 area is suitable for for drinking (BIS 10500:2012 Standard) as well as for irrigation purpose except a very sporadic occurrence of Fluoride, Iron and Uranium above maximum permissible limit in some parts.

Concentration of Uranium may increase due to heavy withdrawal of ground water for irrigation as it is more soluble in oxidizing condition being created in shallow topmost aquifer. Interaction of Uranium with Bi-Carbonate can further enhance its solubility in ground water.

Recommendations

In areas of high Iron is found in ground water, alternate sources of safe water should be identified and Iron removal plants should be installed for community supply of drinking water.

Landfills should be properly designed, maintained and operated. Dumping ground and waste (solid or liquid) disposal sites should be located far away from sensitive ground water areas and human habitats. Pipelines should be properly installed, regularly maintained against corrosion.

Ground water should be regularly tested, especially in urban areas where it is a major source. In addition to all regulations, common citizens should be aware of their actions/daily activities, which pollute ground water and should act accordingly to reduce all kinds of potential pollutions.

3.3 Geophysical Data Interpretation, Integration for Aquifer Mapping

3.3.1 Interpretation and Integration of VES Data

The VES data collected are mostly smooth except for a few and did not require much pre-interpretation processing. Primarily the VES curves are of 3-layer K-type and 4-layer KQ type, i.e., depth-wise curve segments indicate ‘low-high-low’ and ‘low-high-low-very low’ resistivity layers respectively. Out of these, the bottom-most low to very low resistivity layer - the substratum - is attributed to the relative predominance of clays at depths. Though all the VES curves show a thick low resistivity layer at depth, the order of resistivity varies. The layers overlying it are attributed to the sand-predominating formation with better granularity holding fresh ground water. Near-surface layers having a wide range of resistivity are indicative of varied lithology and water saturation.

Since the alluvial formation holds several layers of clays and sands of varied grain size and resistivity, the K and KQ type VES curves get modified at places, giving rise to a variety of 4- to 6-6-layer VES curves with the last segment invariably descending indicating the presence of less resistive layers at depths under investigated. Thus, the VES curves are of KQ ($\rho_1<\rho_2>\rho_3>\rho_4$), AKQ ($\rho_1<\rho_2<\rho_3>\rho_4>\rho_5$), KQQ ($\rho_1<\rho_2>\rho_3>\rho_4>\rho_5$), HKQ ($\rho_1>\rho_2<\rho_3>\rho_4>\rho_5$), HK ($\rho_1>\rho_2<\rho_3>\rho_4$), KHK ($\rho_1<\rho_2>\rho_3<\rho_4>\rho_5$), KQQQ ($\rho_1<\rho_2>\rho_3>\rho_4>\rho_5>\rho_6$) and AKQQ ($\rho_1<\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$) types where ρ_1, ρ_2, ρ_3...represent the first, second and third layer-resistivity respectively. VES field data and curves with interpreted layer parameters are given in Annexure-II.

Validation of VES with Borehole Logs

Validation process has been attempted for the boreholes at Koordi, Sherpur, and Tabelagarhi. The electrical logs of these boreholes and the field and synthetic VES curves are shown in Fig.-3.14**.**

Hydro-geological Explanation of VES Interpretation

With the help of geophysical logs and lithological logs of boreholes the layer parameters obtained from VES were standardized, and generalized resistivity ranges for different lithological predominance of the NAQUIM 2.0 area were obtained as shown in Fig.-3.14. There will likely be overlaps in the resistivity ranges due to the mixed nature of sediments as well as some deviations from these ranges at the local level. These ranges are to be considered as a guide and to be ascertained or modified for the local subsurface hydrogeological situations.

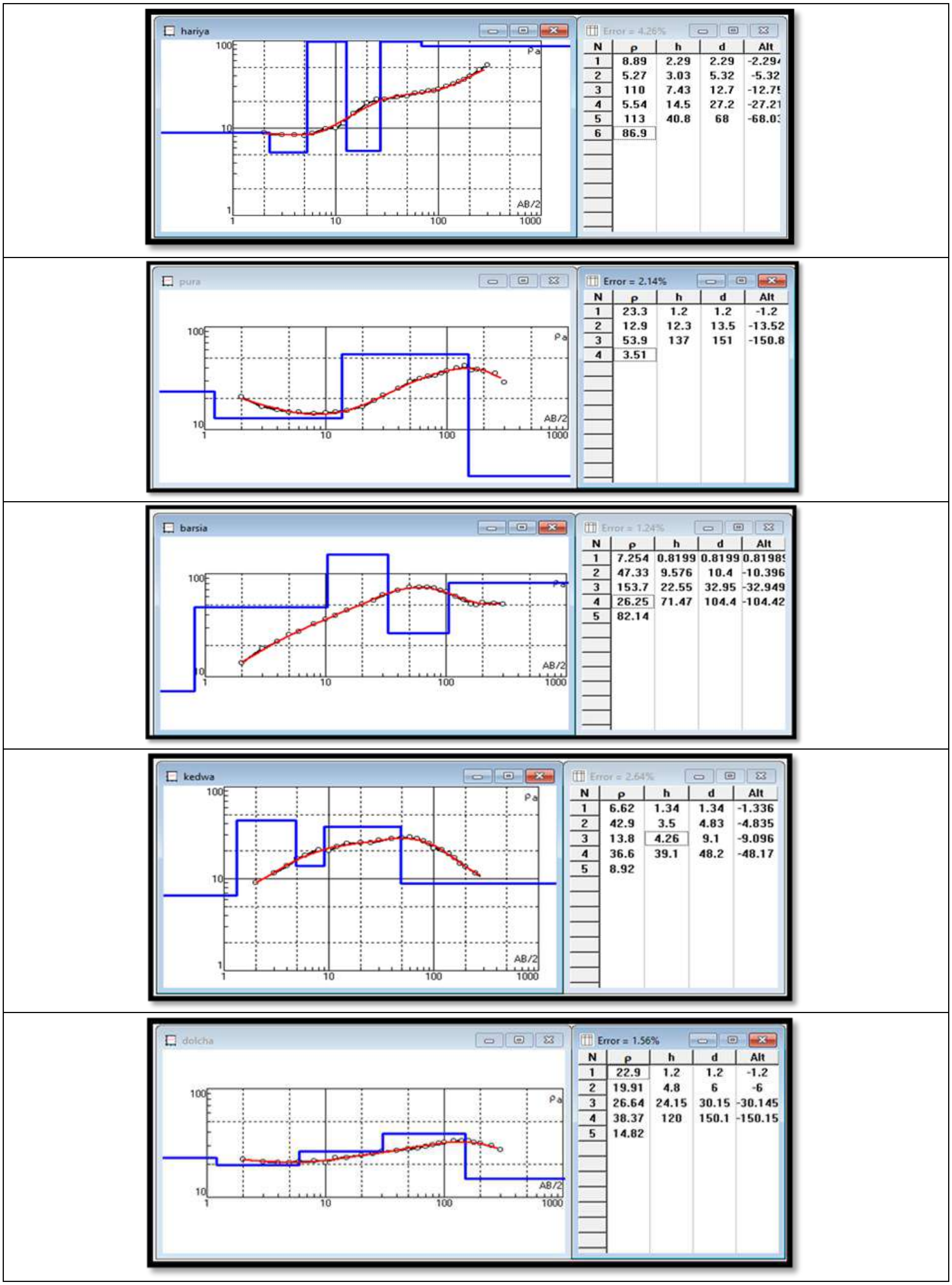
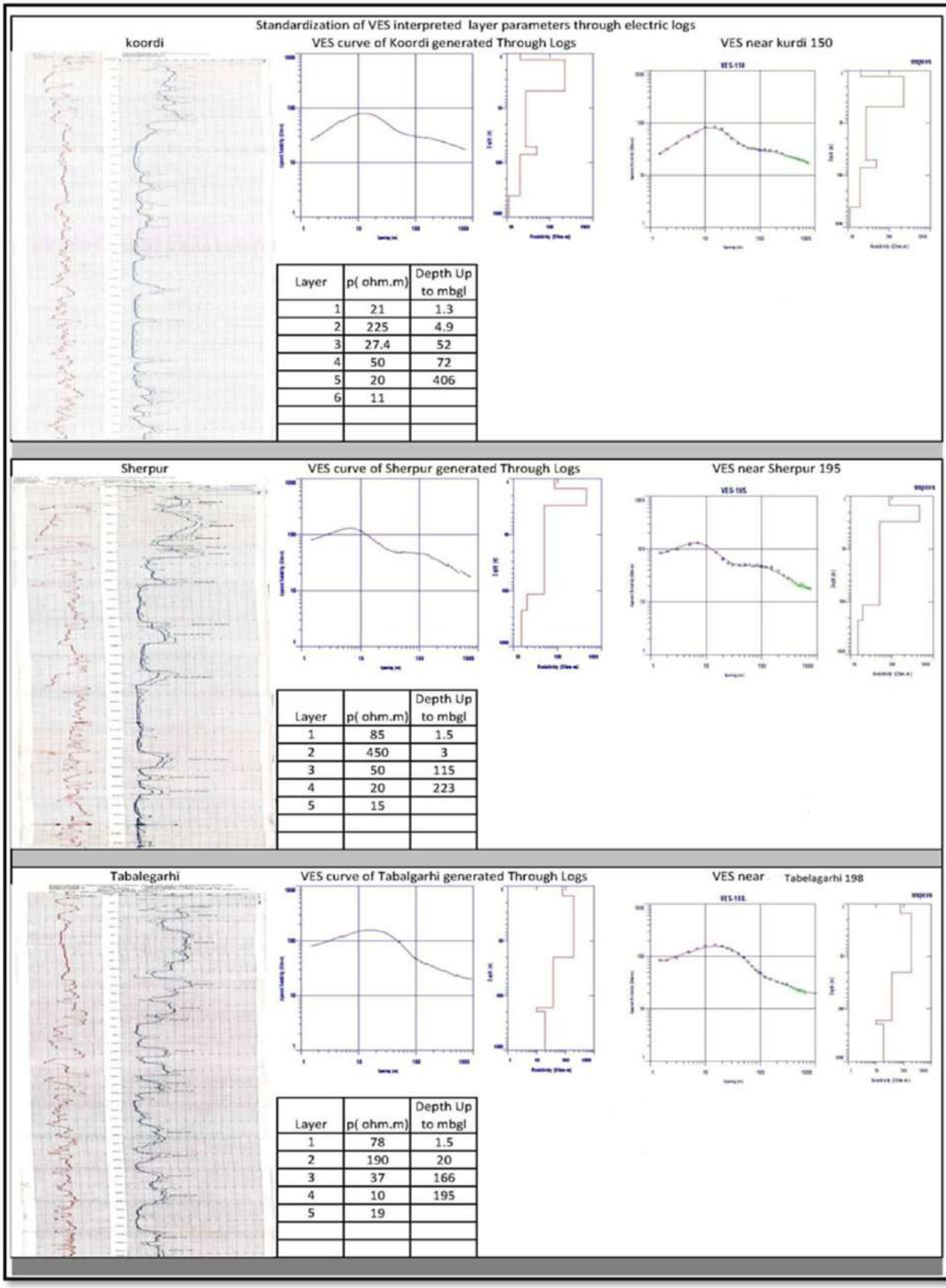


Fig. – 3.13 : VES Curves with the Resistivity Parameters of Sub-surface Layes



Layer	p(ohm.m)	Depth Up to mbgl
1	21	1.3
2	225	4.9
3	27.4	52
4	50	72
5	20	406
6	11	

Layer	p(ohm.m)	Depth Up to mbgl
1	85	1.5
2	450	3
3	50	115
4	20	223
5	15	

Layer	p(ohm.m)	Depth Up to mbgl
1	78	1.5
2	190	20
3	37	166
4	10	195
5	19	

Fig. - 3.14 : Synthetic VES Curves drawn from Resistivity Logs of some Exploratory Boreholes

3.3.2 Interpretation and Integration of TEM Data

93 nos. of TEMs were carried out at 18 locations with 5 soundings stacking at one location. Analysis of these TEM soundings in correlation with litholog unveil a layered subsurface structure with alternating sand & clay units i.e. a stratified sub-surface profile.

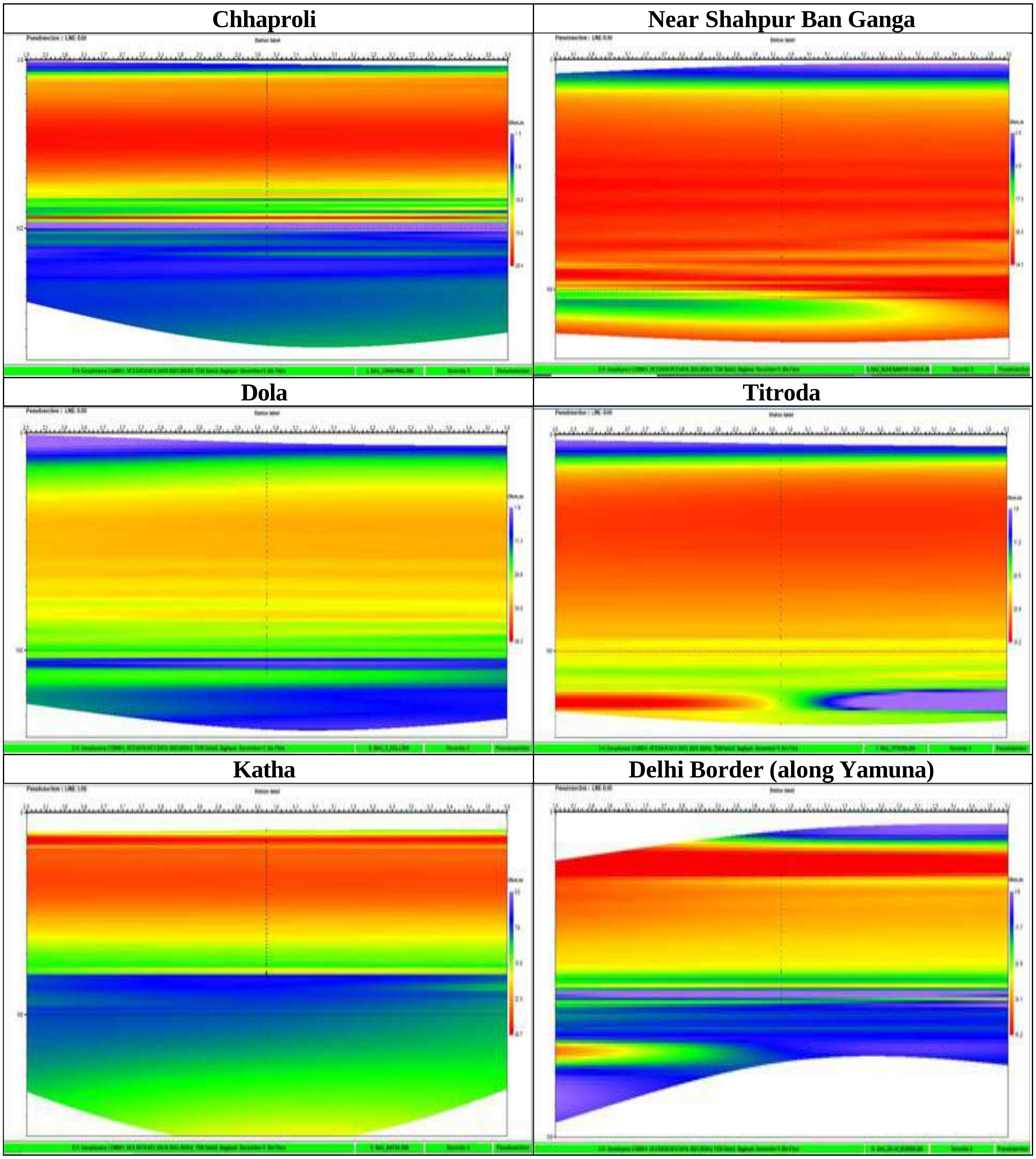


Fig. - 3.15 : TEM Profile Traverses in NAQUIM 2.0 area, Baghpat district

Resistivity values associated with each layer provide valuable insights into grain composition and moisture content of the aquifer materials by their electrical properties. This information is essential for some applications including ground water resource assessment and hydro-geological modeling. Further ground water exploration by exploratory drilling beyond the recorded depth is recommended to fully characterize the subsurface conditions and enhance the understanding of the geological and hydro-geological setting. Locations of TEM sites are given in Table–2.14.

The topsoil layer, characterized by a variable resistivity in order of 10 to 20 ohm- m, suggests a relatively low moisture content and the presence of typical surface materials. The clay layers exhibit lower resistivity values (11.3 to 20.0 ohm-m), indicating higher moisture content and potentially higher clay mineral concentrations. The sand (fine) layers, with resistivity values ranging from 30.5 to 80.0 ohm-m, suggest a water saturated fine to coarser sand composition. Significant variation in resistivity within the sand layers indicate changes in grain size or mineral composition.

3.3.3 Interpretation and Integration of ERT Data

Raw data was refined and processed to eliminate noise and unreliable data points. Res2DInv program v.3.59 was used to generate inverted 2-D images for data visuals. Gauss-Newton method was used to create 2-D model of dataset (Loke-1997). Forward modelling sub-routine computed resistivity values and smoothness-constrained least squares method was used to optimize the inversion routine (Sasaki 1992; de Grooth-Hedlin and Constable 1990; Loke and Barker 1996).

The software has two options to process inversion data, smoothness-constrained least- squares inversion and robust or blocky inversion technique (Loke et al. 2000; Loke 2001). Smoothness-constrained least-squares inversion technique was used as the sub-surface resistivity varied in a gradient manner, and this method is suitable over the other to produce tangible output. It produces a 2-D inversion model with a smooth variation of resistivity values by attempting to reduce the model's squares of roughness (spatial changes). The inversion algorithm divides the sub-surface into rectangular blocks and resistivity of the blocks is changed to minimize the difference between the computed and measured apparent resistivity values iteratively (Loke and Barker 1996; Sasaki 1992).

Four Electrical Resistivity Tomography were conducted along survey lines of ERT-1, ERT-2, ERT-3 and ERT-4 with a total distance of 2800 m. Final output (2-D inversion) from these surveys had an RMS error ranging from 4.3% to 8.99% after 4 to 6 iterations and provided insight into sub-surface disposition up to 150 m. Data density of ERT surveys is much higher than typical 1-D resistivity surveys, with 100 to 500 measurements obtained in a 400 to 800 m. stretch.

Humongous data from ERT surveys have contributed to a deeper understanding of the hydrogeology of different geological terrains (Kumar 2012). The profile lines were decided based on the availability of space, and two electrode configuration methods, namely Gradient and Wenner configurations, were used to demarcate fresh groundwater pockets within a saline aquifer. At the same time, Pole-Dipole was additionally employed at one location (ERT-1). The ERT results indicate the presence of two broad low-resistive zones, where the upper part of the inversion data shows fresh to moderate groundwater zones (15 to 50 Ωm), and the lower part indicates saline groundwater formations (<15 Ωm). Both methods yield near-similar results. Low resistivity pockets, with resistivity values ranging from 0 to 15 Ωm, indicated saline groundwater formations.

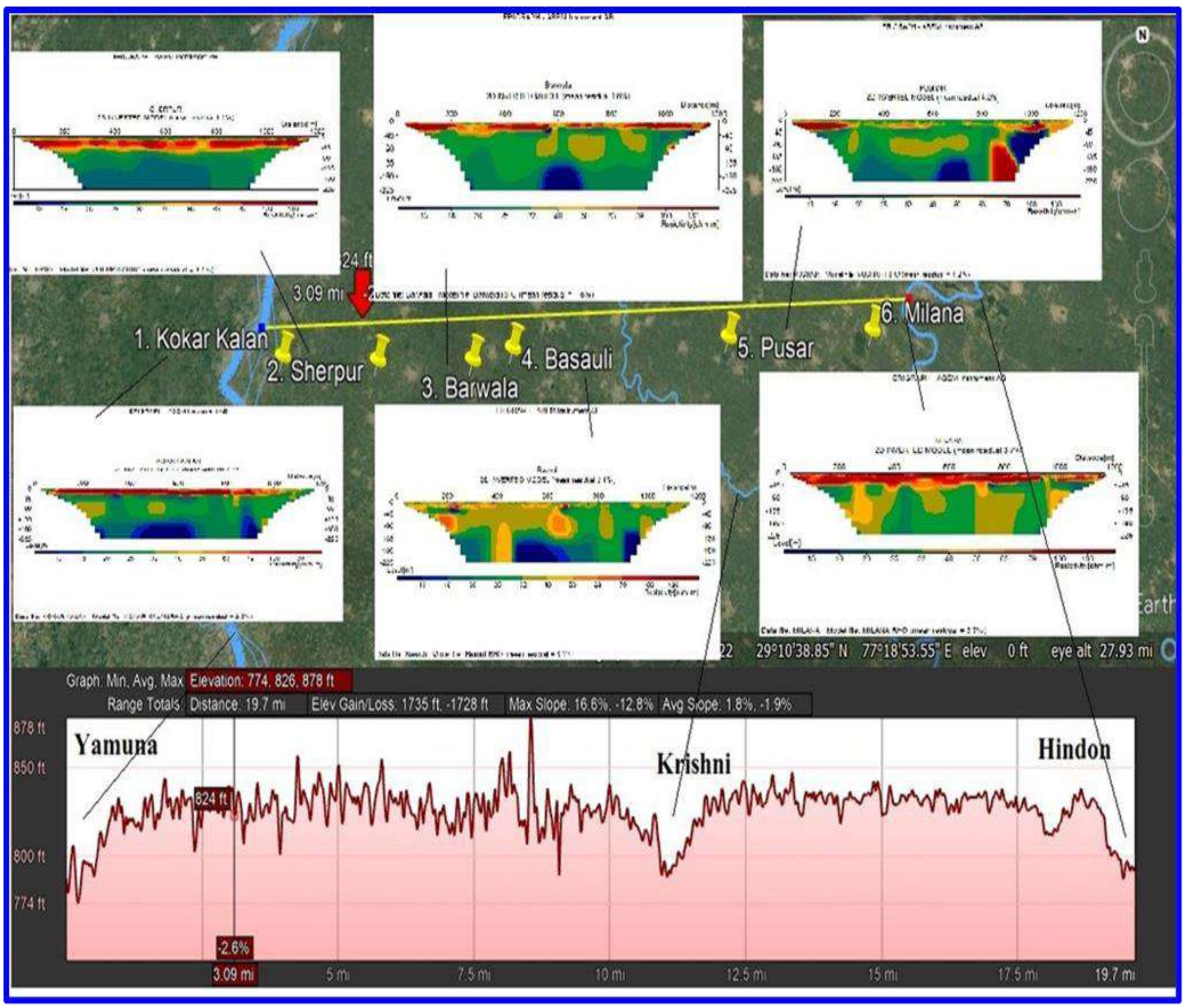


Fig. - 3.16 : Location of all Resistivity Sections across Yamuna and Hindon river (ERT Analysis in Doab area of Yamuna & Hindon)

Before inversion, the imaging data is processed and edited using computer software and the data quality is checked using the software ERIGRAPH. If required, topographic variations along the profile are incorporated. This method based on computer provides more flexibility to compare different scenarios. Imaging data inversion was done by 'Robust Inversion' of RES2DINV software.

Electrical resistivity imaging was conducted roughly along a 7.2 km long profile line passing through boreholes near SherpurandTabelagarhi, which were around 6 km apart.

The imaging was conducted using an ABEM LS Terrameter with 120 electrodes with inter-electrode distance as 10 m covering a surface stretch of 1200 m. Imaging was conducted using a multiple gradient array of electrodes. The maximum depth of information obtained was 240-250 m. Results of resistivity imaging in the form of coded color contours in the x-z section were standardized through resistivity logs of the boreholes and aquifers were characterized. However, it is to be noted that color contours are obtained through interpolation and extrapolation and need not be always associated with lithological interfaces. So, the images only reveal a generalized variation in resistivity and it is necessary to translate them into realistic hydro-geological attributes.

Overall, these images could reveal the subsurface variations up to about 200 m depth in general with a depth-wise decrease in resolution. However, from these images, the areas with deeper aquifers in depth range of 100 to 250 m can be ascertained and locations where a relatively higher probability of deeper aquifers exists can be identified. The near-surface occurrences of very high resistivity sediments reveal their suitability for artificial recharge.

As moved towards the east of river Yamuna, in the Yamuna-Hindon interfluve area of Baghpat district, the presence of layers with relatively higher resistivities and their thickening indicates a general improvement in granularity as well as the potentiality of aquifers. The first aquifer extends to depths beyond 150 m. The images at Barwala and Basauli reveal that the aquifers up to about 150 m depth are regionally extensive in the Barwala-Basauli area. A similar occurrence is noticed in the Kakor Kalan image also, but it is of limited lateral extent only. Further east up to river Hindon in images Pusar and Milana, though the aquifers are potential and extend to depths beyond 150 m they are not regionally extensive as in the Barwala-Basauli area. Significant is the conspicuous presence of thick very high resistivity near the surface layer in the images viz., Sherpur, Kokar Kalan, Barwala, and Milana, which can be compared with the high resistivity layers obtained in VES. The images have been quite useful in demarcating the localized boundaries of the aquifers.

These ERT images reveal the presence of a regionally extensive potential aquifer up to about 150 m depth. In ground water flow modeling one of the important inputs is aquifer boundary. This is revealed by the resistivity images mentioned above. One such important observation is the aquifer disposition across river Hindon where a clear demarcation of lateral discontinuity in the aquifer is observed. Other prominent aquifer boundaries observed are between Sherpur and Barwala.

The localized variations in granularity estimated by resistivity variations and the thicknesses as picked up from these images and their correlation with aquifer characteristics can help define the micro-level variations in ground water resources and so the village-wise resource can be estimated.

The granularity of near-surface material within 20 to 30 m depth is observed from these images in terms of resistivities. The regionally extensive near-surface resistive sediments occur near Sherpur. Similar occurrences are seen in other images also. The presence of such layers can be ascertained through resistivity imaging to identify the locations for artificial recharge structures. Time-lapsed resistivity imaging at artificial recharge structures can reveal the variations in near-surface layer resistivities and hence help monitor the movement of recharged water.

3.3.4 Interpretation and Integration of Borehole Logging Data

Exploratory drilling and geophysical well logging are the most practical solutions for executing ground water exploration programs. Geological formations with varying chemical quality of water present in their pore spaces offer distinguishable resistance to the flow of electric current through them. Thereby came up with the idea of in-situ measurements of electrical potential. The resistivity of the formation layers encountered under the ground is measured through logging by a sensor- bearing current pumped into the ground and the potential measuring points lowered in the un-cased mud/water-filled borehole. Electrical logging can be classified into two categories:

(i) Response of natural earth currents - **Self Potential (SP)**. The potential development in a borehole column is measured, which is the product of mud resistance and ionic current.

(ii) Response to external current input– **Resistance/Resistivity (N-16 & N-64)**

The logging sensor or probe imparts a preset constant current, while traversing in the borehole, given the present positions of potential and current measuring points, the developed potential is calibrated in terms of resistivity. Bore holes are logged to confirm and locate fresh water zones by Electrical Logs:SP Log(Red), Normal Resistivity N-16”(Green) and Normal Resistivity N-64”(Blue).

(A) SP Log

Upon being penetrated by a borehole containing drilling fluid and dissolved salts different from that in the formation water, the sub-surface gives rise to voltage development at the contacts between shale/clay and granular zones. Consequent to potential differences, natural current flow occurs through four different media: the borehole, the invaded zone, then the invaded part of the Permeable formation, and the surrounding shale, clays sandy clays. In each medium potential drops in proportion to the resistance, and the total potential drop along a line of current flow is named self or spontaneous potential (SP). The development of SP is mainly a function of chemical activities between the borehole fluid and water formation. Besides, the clay type and lithology also play a role in developing SP. The electromotive forces driving the natural Currents are of two types: **(a) Electrochemical and (b) Electro-kinetic.**

(B) Resistivity Log

The simultaneous recording is done of the two types (N-16” and N-64”) of resistivity measurements. For regular resistivity measurements, 3 openings or electrodes are provided in the probe. The bottom-most electrode is used for 16” potential measurements and is located 16” below the current pumping electrode. The other electrode is located near the top of the probe 64" above the current pumping electrode. Generally, for resistivity measurements, recorder channels 2 and 3 are used with different colours of pen inks. In the chart paper, the resistivity recording is conventionally done on the right track.

3.3.5. Findings of Geophysical Studies, Conclusions and Recommendations

(i) Aquifer Boundaries and Continuities

2D resistivity imaging helps to delineate the aquifers and demarcate their boundaries and lateral continuities between the boreholes drilled which will help locate well sites, groundwater flow modeling, resource estimation and identifying suitable areas for artificial recharge. The basic objective of the imaging was to delineate the deeper aquifers in alluvial formations efficiently where the resistivity contrast between various lithological units is low to moderate and to ascertain the continuity of the aquifers deciphered from the depth wise geophysical logs (VES and Bore Hole Logging). The biggest advantage is that while VES or borehole logging gives only depth-wise information at a point, resistivity imaging gives depth-wise as well as lateral information with a very high density of data. Given the large data density and 2-D view of the subsurface, the ERT imaging may be considered more economical as compared to VES when a large area is to be covered.

Resistivity imaging data was used to roughly along a 7.2 km long profile line. Imaging was conducted at the boreholes and in between the boreholes, wherever 1.2 km straight stretches of land almost collinear with the boreholes. The imaging was conducted using an ABEM LS Terrameter with 120 electrodes. The inter- electrode distance was kept at 10 m, thus covering a surface stretch of 1200 m. The imaging was conducted using a multiple gradient array of electrodes. The maximum depth of information obtained was about 240-250 m. The results of resistivity imaging in the form of coded color contours in the x-z section were standardized by resistivity logs of boreholes. However, color contours obtained through interpolation and extrapolation need not be always associated with lithological interfaces. Hence the images only reveal a generalized variation in resistivity and it is necessary to translate them into realistic hydro-geological attributes.

The 2D image sections reveal lateral inhomogeneity, local thinning, and thickening of aquifers and even their discontinuities within a distance of 100 to 200 m. There is a clear indication of changes in lithofacies and granularity within the aquifers. As moved towards east near river Yamuna the aquifers were associated with higher resistivity values compared to the extreme westernmost part indicating improvement in granularity toward the east. Also, the underlying clay predominating layers become deeper as move towards the east. Overall, these images could reveal the subsurface variations up to about 200 m depth with a depth-wise decrease in resolution. However, from these images, areas with deeper aquifers in depth range of 100 to 250 m can be ascertained and locations where a relatively higher probability of deeper aquifers exists can be identified. Near-surface occurrences of very high resistivity sediments reveal their suitability for artificial recharge.

The Yamuna-Hindon inter-fluve area of Baghpat district, the presence of layers with relatively higher resistivities and their thickening indicates a general improvement in granularity as well as the potentiality of aquifers. The first aquifer extends to depths beyond 150 m. The images at Barwala and Basauli reveal that the aquifers upto about 150 m depth are regionally extensive in the Barwala-Basauli area. A similar occurrence is noticed in the Kakorkalan image also, but it is of limited lateral extent only. Further east up to river Hindon in images Pusar and Milana, though the aquifers are potential and extend beyond 150 m they are not regionally extensive as in the Barwala-Basauli area. Conspicuous presence of very high resistivity near the surface layer in the images is significant at Sherpur, Kokarkalan, Barwala and Milana, which can be compared with high resistivity layers obtained in VES. Images are useful in demarcating localized boundaries of aquifers.

Granularity of near-surface material within 20 to 30 m is observed from these images in terms of resistivities. The regionally extensive near-surface resistive sediments occur near Sherpur. Similar occurrences are seen in other images also. Presence of such layers can be ascertained by resistivity imaging to identify the locations for artificial recharge structures. Time-lapsed resistivity imaging at artificial recharge structures can reveal the variations in near-surface layer resistivities and hence help to monitor the movement of recharged water.

(ii) Aquifer Disposition

To obtain a three-dimensional generalized view of the aquifer disposition, 3D multi-log and 3D model of aquifers been prepared based on lithologs of exploratory wellsand VES-interpreted layer parameters. The thickening of the first aquifer towards the north is evident. conspicuous presence of a highly resistive near surface layer forming the top portion of the first aquifer is significant, whose resistivity varies from 90 to 500 ohm.m. It is also quite thick in the southern part. Lithological logs and electrical logs of the old and newly constructed exploratory well in present NAQUIM 2.0 area are considered for interpreting aquifer disposition, grouping and 3D modelling.

Table - 3.10 : Details of Exploratory Wells analyzed for Aquifer Grouping and 3D Modelling

S. N.	Location	Latitude	Long-itude	Dep-th	Elev-ation	S. N.	Location	Lati-tude	Long-itude	Dep-th	Elev-ation
1.	Koordi	29.2475	77.15556	475	252	9.	Pilana	28.93278	77.37667	450	241
2.	Tabelagarhi	29.19556	77.46250	472	256	10.	Shahpur BanGanga	29.13825	77.44752	152	246
3.	SanjarpurKaidwa	29.02194	77.40583	456	242	11.	Titroda	29.04132	77.37551	300	247
4.	Firojpur	28.83361	77.31028	404	240	12.	Shobhapur	28.99035	77.36322	150	244
5.	Sherpur	29.16694	77.21750	462	256	13.	Barnawa	29.10833	77.41667	452	246
6.	Baraka	29.07861	77.27500	450	251	14.	Tikri	29.22500	77.36667	455	254
7.	Guripur	28.99111	77.22139	442	239	15.	Mitli	28.95972	77.30416	451	245
8.	Kakripur	29.25583	77.27667	442	257	16.	Chhaprauli	29.20505	77.16584	300	251

Depth of Bed Rock

In borehole at Firozpur, block– Khekra in southern part, bedrock was encountered at 399 m.

Occurrence of Brackish Water Aquifers

Resistivity below 10 ohm.m at specific depths indicate the presence of brackish ground water zones, the shallowest is observed at 140 m in Firozpur while the deepest at 260 m in Tabelagarhi. In the western region of the NAQUIM 2.0 area, encompassing Koori, Sherpur and Gauripur, the brackish water zone was inferred by bore hole electrical logs within the depth range of 140 to 210 meters. Conversely, the eastern region exhibits a distinct pattern with two to three relatively thinner brackish zones. These zones, surrounded and vertically sandwiched by fresh water layers, are having the thicknesses which diminishes towards the eastern and northeastern boundaries of the district.

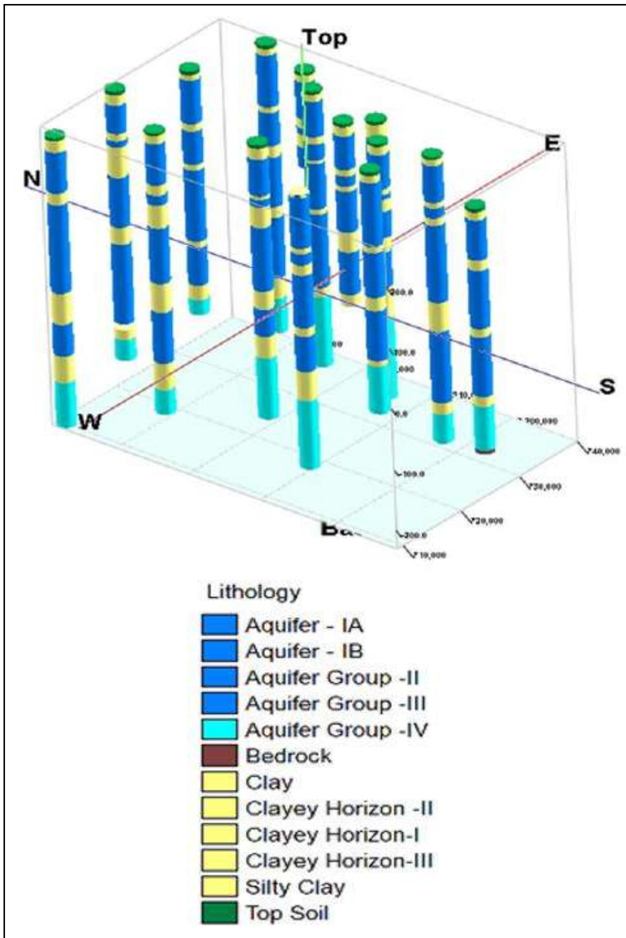


Fig. - 3.27 : 3D Multi-Log (Strip Log) of the Exploratory Wells in NAQUIM 2.0 Area

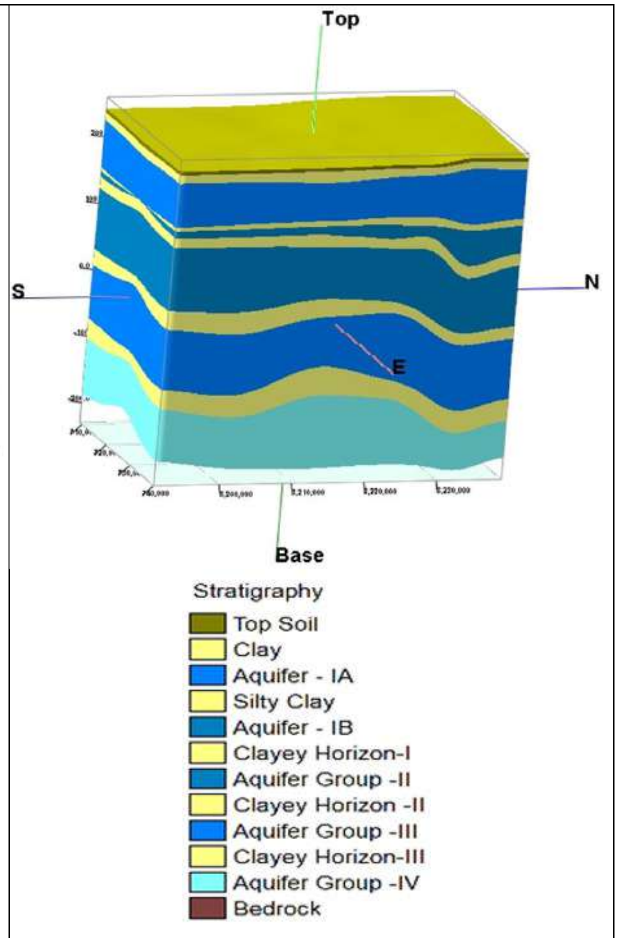


Fig.- 3.28: 3D Model of Aquifer Disposition in NAQUIM 2.0 Area

Areas for Artificial Recharge of Ground Water

Artificial recharge requires two basic conditions, viz., the presence of permeable near-surface material and the water level should be deeper than 5 m. The post-monsoon water level of top-most Aquifer Group–I(A) ranges from 5.87 to 34.25 m bgl and its block wise average ranges from 16.24 to 26.53 m bgl. The near-surface layer resistivity varies from 10 to 166 ohm.m and mostly above 30 ohm.m. Also, resistivity of the second layer occurring immediately below the topsoil varies from 16 to 500 ohm.m, mostly above 30 ohm.m and water level is also deeper. Therefore, the whole area is suitable for artificial recharge. However, for selecting suitable artificial recharge sites resistivity imaging is to be carried out for ascertaining disposition of aquifer layers.

Summary of Aquifer System identified by Geophysical Studies

Aquifer system is characterized by an unconsolidated stratigraphy, featuring multiple aquifers separated by intervening clay layers. Geophysical data from various locations reveals a consistent pattern of aquifer distribution and a system which includes 4 distinct aquifer groups - Aquifer-I (further bifurcated to I(A) & I(B)), Aquifer Group-II, Aquifer Group-III and Aquifer Group-IV.

Aquifer-IA extends from the surface to a depth around 91 m and is associated with a diverse lithologies including sand, silty clay and clayey silt, whereas the Aquifer-I(B) extends up to around 150 m bgl. A thick impermeable clay bed separates the Aquifer GroupI(A) and I(B).

The Aquifer Group-II, Aquifer Group-III, and Aquifer Group-IV are identified as major water-bearing units occurring at varying depths below the clay bed underlying the Aquifer-I(B).

At some places, like Firozpur, the aquifer system encounters bedrock at around 398 mbgl, suggesting potential constraints on ground water accessibility beyond that depth. However, in other areas unconsolidated alluvial formation continues up to explored depth of 473 m.

Conclusions

Group-I(A) is the most prominent and regionally extensive near-surface fresh water aquifer, which extends maximum up to 80 to 90 m. Group-I aquifer extends nearly down to 170-180 m in the extreme north-eastern part near the right bank of River Hindon, whereas it goes up to 70-80 m in the extreme south-western parts near Yamuna. Generally, thickness of Aquifer-I increases towards east. Prominent 'marker' clay beds, with a minimum thickness of 10-12 m, separate different aquifer groups. Towards extreme south, deeper aquifers are found to be brackish.

Lateral variations in resistivity of aquifer materials along east-west trend as interpreted from 2D ERT indicate granularity differences. Resistivity value declines with depth, ranging from approximately 40 ohm.m for Aquifer Group-I to 15 ohm.m for Group-IV, which indicates a decrease in granularity or an increase in fineness of aquifer material with depth.

Due to availability of sufficient borehole logs along with Vertical Electrical Sounding (VES) of the area, the layer parameters of Aquifer Group-I have been calculated more accurately. Resistivity of Aquifer Group-I varies from 25 to 50 ohm.m, with its thickness ranging from approximately 60 m in the south-western part to about 180 m in the north-eastern part. This aquifer characterizes the central interfluve part of Rivers Yamuna and Hindon, displaying higher resistivities indicative of better granularity. A layer with resistivity exceeding 100 ohm.m forms the top part of Aquifer Group-I, prominent in central and western parts. The thick layer beneath Aquifer Group-I having 15-20 ohm.m resistivity indicates mixing of sands with clays in varying proportions. The gradient of the descending last segment, between 0.2 and 0.5 ohms, and an apparent resistivity value exceeding 25 ohms.m at AB/2:100m qualitatively suggest the presence of deeper aquifers.

The 2-D image sections disclose lateral inhomogeneities, lithofacies variations and local thinning and thickening of aquifers at the micro-level in the order of tens of meters. Generally, the images indicate an improvement in aquifer granularity, both in resistivity and thickness, towards river Hindon, with a prevalence of clays towards south-west. Lower apparent registivity values near banks of Yamuna and Hindon indicate presence of potential granular zones, whereas areas away from rivers show higher resistivity, which denotes variation of geology and hydrogeology across the river courses in inter-fluvial (Doab) area. Local aquifer boundaries within 100 to 150 m range have been identified. Images provide data up to 240-250 m, though the resolution diminishes with depth.

Recommendations

(i) Utilizing the geophysical methods in larger scale for mapping of the subsurface strata vertically as well as laterally to verify continuity of aquifers beyond NAQUIM 2.0 area.

(ii) Studies to decipher hydrogeological connectivity between Yamuna and Hindon rivers and the potential ground water flow paths in the interfluvial area by distribution of apparent resistivity.

(iii) Development of a comprehensive hydrogeological model based on the results of geophysical studies to simulate and understand the ground water flow in localized and regional scale for developing a suitable and sustainable ground water management plan for NAQUIM 2.0 area.

4. GROUND WATER RESOURCES

From lithological disposition in NAQUIM 2.0 area it is understood that Group-I(A) aquifers are under unconfined to semi-confined and Group-I(B) aquifers are under confined condition.

4.1 Dynamic Ground Water Resources of Unconfined Aquifer Group-I(A)

The estimation of Dynamic Ground Water Resources as on 31st March 2023 of Aquifer Group-I(A) in NAQUIM 2.0 area covering the whole Baghpat district has been carried out by Ground Water Resource Estimation 2015 methodology taking the administrative blocks as assessment units. As per GWRE-2015 norms, assessment units i.e. blocks are categorized on the basis of Stage of Ground Water Extraction (SoGE). If, SoGE is <=70%, then the category is 'Safe'; if SoGE is >70% and <=90%, then the category is 'Semi-Critical'; if SoGE is >90% and <=100%, then the category is 'Critical'; if the SOGE is >100%, then the category is called 'Over-Exploited'.

Stage of Ground Water Extraction (SoGE) has been calculated as the percentage ratio between present Total Annual Ground Water Extraction for all uses and Total Annual Extractable Ground Water Resources available. As per estimation for year 2023, the maximum Stage of Ground Water Extraction is 130.59% in Pilana and the minimum is 74.41% in Chhaprauli block. Khekra, Pilana and Binauli blocks are 'Over-Exploited' and Chhaprauli, Baraut and Baghpat blocks are 'Semi-Critical'. Significant improvement in ground water scenario in terms of SoGE, has been noticed in Baghpat block, where the block category has been improved from 'Critical' in 2022 to 'Semi-Critical' in 2023.

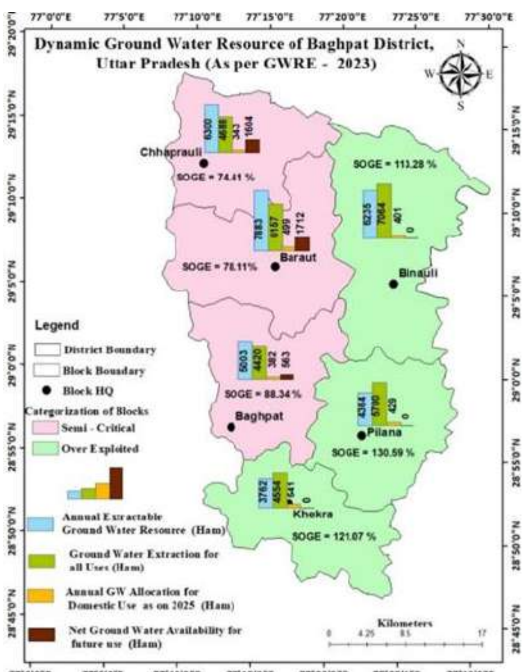


Fig. – 4.1 : Categorisation of Administrative Blocks in respect of Ground Water Extraction

Table – 4.1 : Block wise Dynamic Ground Water Resources as on 31.03.23 with Categorisation

Name of the Block (Assessment Unit)	Geographical Area (Ha)	Recharge Worthy Area (Ha)	Ground Water Recharge (Ham)				Total Annual Ground Water Recharge (Ham) (4) + (5) + (6) + (7)	Total Natural Discharge (Ham) {10 % of (8)}	Annual Extractable Ground Water Resource (Ham) (8)–(9)
			Monsoon Recharge		Non-monsoon Recharge				
			Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Chhaprauli	20532	20532	2294.73	1817.00	143.61	2745.51	7000.85	700.08	6300.77
Baraut	27686	27686	3094.27	2014.03	193.65	3457.04	8758.99	875.90	7883.09
Baghpat	21063	21063	2824.91	1038.27	147.33	1549.08	5559.59	555.96	5003.63
Khekra	16037	16037	2150.86	758.96	112.17	1158.34	4180.33	418.03	3762.30
Pilana	20714	20714	2778.06	757.94	144.89	1168.98	4849.87	484.99	4364.88
Binauli	29000	29000	3252.97	1434.79	203.58	2037.45	6928.79	692.88	6235.91
Total	**135032**	**135032**	**16395.8**	**7820.99**	**945.23**	**12116.4**	**37278.42**	**3727.84**	**33550.58**

Current Annual Ground Water Extraction (Ham)				Annual Ground Water Allocation for Domestic Use as on 2025 (Ham)	Net GW Availability for future use (Ham) (10) – (11) – (12) – (15)	Stage of GW Extraction (%) {(14/10) x 100)}	Categoriza- tion (OE/ Critical/ Semi-critical /Safe)
Irrigation Use	Industrial Use	Domestic Use	Total Extraction (11) + (12) + (13)				
(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
4350.45	1.638	336.3227	4688.41	343.72	1604.96	74.41	Semi-Critical
5670.8	0	486.537	6157.34	499.50	1712.79	78.11	Semi-Critical
4049.25	9.018686	361.8471	4420.10	382.29	563.09	88.34	Semi-Critical
3995.12	32.56843	527.1593	4554.84	541.09	0	121.07	Over-Exploited
5285.4	0	414.8035	5700.20	429.21	0	130.59	Over-Exploited
6673	0	391.3245	7064.32	401.36	0	113.28	Over-Exploited
30024.02	**43.22511**	**2517.994**	**32585.21**	**2597.17**	**3880.84**	**98.02**	

Name of the Block (Assessment Unit)	Total Recharge from Rainfall	Total Recharge from Other Sources					Pre-Monsoon Long-Term WL Trend	Post-Monsoon Long-Term WL Trend
		Canals	Surface Water Irrigation	Ground Water Irrigation	Tanks and Ponds	Conservation Structure		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Chhaprauli	2438.34	3633.27	53.82	849.46	25.38	0.576	Falling	Falling
Baraut	3287.92	3927.66	395.63	1113.18	32.26	2.34	Neither Rising, Nor Falling	Neither Rising, Nor Falling
Baghpat	2972.24	1698.66	43.7	801.84	36.74	6.402	Falling	Neither Rising, Nor Falling
Khekra	2263.03	1056.82	39.51	799.02	20.03	1.916	Falling	Rising
Pilana	2922.95	807.36	52.47	1038.69	25.15	3.251	Falling	Neither Rising, Nor Falling
Binauli	3456.55	1709.29	417.36	1307.39	36.42	1.783	Falling	Neither Rising, Nor Falling
Total	**17341.03**	**12833.06**	**1002.49**	**5909.58**	**175.98**	**16.268**		

Table – 4.2 : Block wise Dynamic Ground Water Resources of 2023, 2022 & 2017

Assessment Unit Name	Stage of Ground Water Extraction in 2017	Categorization in 2017	Stage of Ground Water Extraction in 2022	Categorization in 2022	Stage of Ground Water Extraction 2023	Categorization in 2023	Remark
Chhaprauli	71.17	Semi-Critical	79.1	Semi-Critical	74.41	Semi-Critical	No Change
Baraut	79.81	Semi-Critical	86.8	Semi-Critical	78.11	Semi-Critical	No Change
Baghpat	93.98	Critical	93.3	Critical	88.34	Semi-Critical	Improved
Khekra	104.46	Over Exploited	129.7	Over-Exploited	121.07	Over-Exploited	No Change
Pilana	107.66	Over Exploited	133.5	Over-Exploited	130.59	Over-Exploited	No Change
Binauli	111.55	Over Exploited	117.5	Over-Exploited	113.28	Over-Exploited	No Change

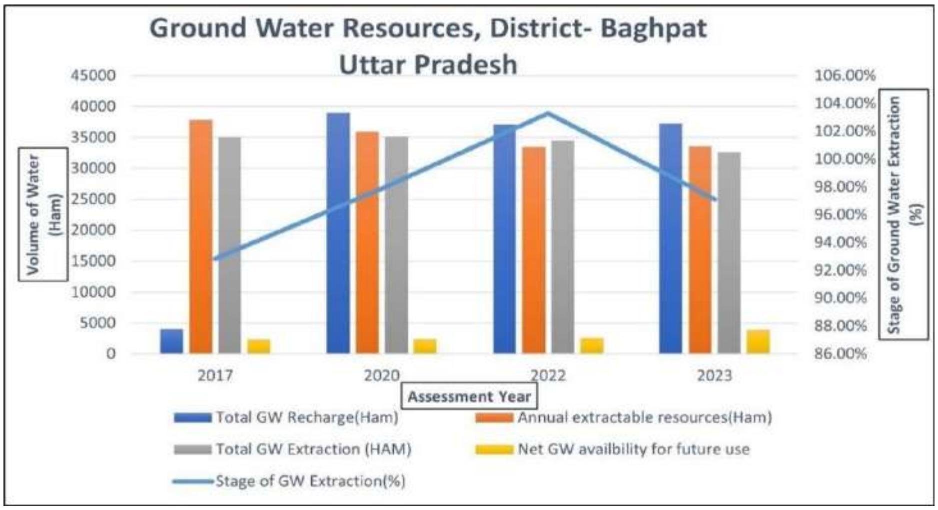


Fig. - 4.2 : Change of Ground Water Resources with Time (2017 to 2023)

4.2 Static/In-Storage Ground Water Resources of Unconfined Aquifer Group-I(A)

Block-wise average thickness of granular zone/aquifer below the Water Level Fluctuation zone or pre-monsoon water table i.e. the average thickness of the saturated unconfined aquifer below water table have been calculated from the water level monitoring data of the key wells established for NAQUIM 2.0 study. Other sub-units and assumptions recommended here are similar to the computation of dynamic resources. Equations for estimating Static Ground Water Resources for Unconfined Aquifer of Group-I(A): **Static/In-Storage Ground Water Resources** (Ham) = **Thickness of the unconfined Aquifer** (granular/productive zone) below the zone of water level fluctuation down to the bottom level of unconfined aquifer (m) x **Specific Yield** (%) x **Areal Extent** (Ha) i.e. **Q = SyAΔh = SyA(h0 – ht),** where **h0** isthe depth of the bottom of the unconfined aquifer; **ht** is the depth of the pre-monsoon water level/ water table at any given time 't'; **Sy** is the Specific Yield and **A** is the area of the block/assessment unit.

In this way the block wise total Static/In-Storage Ground Water Resource of the topmost unconfined aquifer has been calculated. The highest static resource (79.46 MCM) is available in Chhaprauli block and lowest (7.95 MCM) in Pilana block, whereas for the whole NAQUIM 2.0 area the available static resource is 294.13 MCM.

Table – 4.3 : Block wise Static Ground Water Resources in Unconfined Aquifer Gr–I(A)

Block	Area (Ha)	Avg. Post-Monsoon DTWL (m bgl)	Depth of the Bottom of Topmost Aquifer of Group–I(A)	Saturated Thicknessof Topmost Aquifer of Gr.–I(A) (m)	Average Specific Yield (Sy)	Static Resource of Topmost Aquifer of Gr.-I(A) (Ham) (2) x (5) x (6)	Static Resource of Topmost Aquifer of Group-I(A) (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	20532	16.55	23.00	6.45	0.06	7945.88	79.46
Baraut	27686	20.44	24.50	4.06	0.06	6744.31	67.44
Baghpat	21063	18.39	24.00	5.61	0.06	7089.81	70.90
Khekra	16037	22.07	24.80	2.73	0.06	2626.86	26.27
Pilana	20714	28.98	29.62	0.64	0.06	795.42	7.95
Binauli	29000	28.08	30.50	2.42	0.06	4210.80	42.11
Total	**135032**					**29413.08**	**294.13**

4.3 In-Storage Ground Water Resources of Confined Aquifers Group–I(B)

It has been attempted to assess the ground water resource in confined aquifers of Gr.–I(B)by storage concept method, where only the water held under confining pressure more than 1 atmospheric pressure is considered as the ground water resource potential.

Assessment of ground water resources of confined aquifers assumes crucial importance, since over-exploitation of these aquifers may lead to far more detrimental consequences than to those of shallower unconfined or semi-confined aquifers. If the piezometric surface of the confined aquifer is lowered below the upper confining layer so much that the desaturation of aquifer occurs and then the coefficient of storage is no longer remains related to the elasticity of the aquifer but to its specific yield. When a very small amount of water released from the storage of confined aquifers, large scale pumping from confined aquifers may cause decline in piezometric levels amounting to over a hundred metre and subsidence of land surface triggering serious geotechnical problems.

As per GWRE 2015, if any development activity is started in confined aquifer, then there is a need to assess the dynamic as well as in-storage resources of the confined aquifer(s). To assess ground water resources of confined aquifer, sufficient number of observation wells tapping exclusively that particular aquifer and proper monitoring of piezo-metric heads are needed.

As per the recommendation of GEC 2015, ground water storage approach is applied to assess the ground water resources of the confined aquifers. The co-efficient of storage or storativity of an aquifer is defined as the volume of water it releases or takes into storage per unit surface area of the aquifer per unit change in head (Δh). Hence the quantity of water added to or released from the aquifer (ΔV) can be calculated as follows: **ΔV=S Δh** if the areal extent of the confined aquifer is **A**, then the total quantity (**Q**) of water added to or released from the entire aquifer is **Q = A ΔV = SAΔh,** where **Q** = Quantity of water confined aquifer can release and Δ**h** = Change in Piezo-metric head

Therefore, for assessing in-storage ground water resource of confined Aquifer Group–1B, first the resources contained between the pre-monsoon piezometric head of this particular aquifer and the bottom of its overlyingandconfining layer are computed and then that thickness is multiplied with the Storage Co-efficient/Storativity of the aquifer material and with the arealextensionof the aquifer using the following formula: **QI = SAΔh = SA (hPRE–h0),** Where **QI**= In-storage Ground Water Resource of Confined Aquifer (m^3); **S**=Storativity; **A**=Areal extent of the confined aquifer (m^2); Δ**h**=Change in Piezometric head (m); **h0**=Bottom level of top confining layer (m amsl); **hPRE**=Piezometric head in pre-monsoon (m amsl)

Table – 4.4 : In-Storage GW Resource of Group–I(B) Confined Aquifers (Storage Concept)

Block	Area (sq. km.)	Average Storativity (S)		Pre-monsoon Piezometric Surface of Aquifer-I(B) (Average) (m bgl)	Depth of Bottom of Confining Layer above Lowermost Aquifer-I(B) (in m bgl)	Δh=Differ-ence between Piezometric Surface and Bottom of Confining Layer (5) – (4)	Available Storage /In-Storage GW Resources in Aquifer-I(B) (MCM) (2) x (3) x (6)
(1)	(2)	(3)		(4)	(5)	(6)	(7)
Chhaprauli	205.32	6.925×10^{-4}	0.0006925	21.12	104.83	83.71	11.902
Baraut	276.86	4.925×10^{-4}	0.0004925	20.00	109.00	89.00	12.135
Baghpat	210.63	4.480×10^{-4}	0.000448	23.00	99.00	76.00	7.172
Khekra	160.37	1.680×10^{-5}	0.00001680	22.40	97.00	74.60	0.201
Pilana	207.14	2.207×10^{-5}	0.00002207	24.51	115.12	90.61	0.414
Binauli	290.00	5.712×10^{-4}	0.000571	28.80	105.50	76.70	12.701
Total	**1350.32**	**1**		**08**			**44.525**

Total In-Storage Ground Water Resource in NAQUIM 2.0 area calculated by storage concept in unconfined aquifer-I(A) is 294.13MCM (Table–4.3) where as the total In-Storage Ground Water Resource in confined aquifer -I(B) is 44.525 MCM (Table–4.4).

The present ground water draft in the NAQUIM 2.0 area is made mainly for drinking and irrigation purposes. The community drinking water wells are mostly the deep tube wells constructed throughtapping aquifer–I(B) by Jal Nigam, Govt. of Uttar Pradesh under various water supply schemes such as 'Jal Jeevan Mission' in both rural and urban areas and there are also innumerable govt. and private hand pumped wells and Mark-II tube wells tapping mainly aquifer I(A) as spot sources of drinking water. Govt. irrigation tube wells are of intermediate depth mostly constructed by tapping Group–I(A) aquifers within the depth of 100 m and rarely up to the depth of 150 m by tapping aquifer–I(B) also. Shallowest tube wells for irrigation and drinking are all private wells, which invariably tap unconfined to semi-confined Gr.-I(A) aquifers as it is very costly affair for a common farmer to construct a deep tube well tapping Group–I(B) aquifers.

4.4 Seasonal Change of Storage in Aquifer Group–I(B)

Aquifers of Group-IB always occurs under confined condition. Seasonal change in in-storage resource has been calculated on the basis of fluctuation in piezometric surface between preand post-monsoon 2023. The change is insignificant and amounting only 0.588275 MCM, which indicates that this Aquifer Gr.-I(B) is not under stress. (Table–4.5).

Table – 4.5 : Seasonal change in In-Storage GW Resource of Aquifer Group–I(B)

. Block	Area in sq. km.	Seasonal Fluctuation of Piezometric Surface (Pre to Post) (m)	Average Storativity of Group–I(B) Confined Aquifer	Seasonal Change in Storage (MCM) (2 x 3 x4)
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Chhaprauli	205.32	0.92	0.0006925	0.130809
Baraut	276.86	0.83	0.0004925	0.113173
Baghpat	210.63	0.80	0.000448	0.07549
Khekra	160.37	1.40	0.00001680	0.003772
Pilana	207.14	1.83	0.00002207	0.008366
Binauli	290.00	1.55	0.000571	0.256665
Total	**1350.32**			**0.588275**

5. GROUND WATER RELATED PROBLEMS AND ISSUES

5.1 Disposition and Nature of Aquifers

(a) Aquifer-I(A) is used for drinking water through government/private hand pumps as spot source, while Group-I(B) aquifer is utilized through construction of heavy-duty deep tube wells for community water supply by the concerned State Govt. Agency. Occurrence of iron rich ground water at shallower depth especially in Aquifer Group-I(A), which occurs in alluvial sediments up to the depth of 70-90 m in almost all the blocks, often restricts economic withdrawal of ground water for drinking purpose from this aquifer as for construction of iron-free tube wells, it is necessary to tap the next deeper aquifer–I(B).

(b) In all the six blocks, the unconfined aquifer-I(A) is highly exploited, extremely stressed and its ground water resource is being constantly depleted due to heavy indiscriminate withdrawal of ground water by the farmers for irrigation of the crops specially sugarcane (occupying 80% of the cropped area in the district for the period of around 10 months in a year) and other high crop water requiring crops like paddy. At many places a single aquifer exists as aquifer group–I(A) and continues up to the depth of 90-100 m and thus sometimes, this aquifer-I(A) is persistently and irreversibly being dewatered, which may be aggravated in future if the cultivation of the high- water requiring crops like sugarcane is not monitored and reduced gradually by replacing with the low-water requiring crops.

(c) Water supply tube wells of UP Jal Nigam, Govt of Uttar Pradesh (including the tube wells under Jal Jeevan Mission) are mainly tapping the deeper confined Group-I(B) aquifers, depth of which varies from block to block depending on the depth, thickness, regional extension and nature of the aquifer materials of the individual aquifers i.e. on the presence of potential aquifer in terms of quantity and quality of ground water. Here in this NAQUIM 2.0 area of Baghpat district, the drinking water tube wells are usually needed to be constructed with a depth ranging from 100 to 150 m. In most of the areas, the construction cost of drinking water tube wells for obtaining good quality of water would be very high due to requirement of deeper drilling depth and more pipes and other related materials and thus would go beyond the economic capacity of the local common farmers or villagers.

5.2 Deeper and Constantly Declining Ground Water Level

Ground water level (WL) in respect of Aquifer Group–I(A) is very deep. During pre- monsoon period (2023) water level ranges from 8.75 to 42.51 m bgl (Avg.- 23.47 mbgl; WL < 20 m in 48%, 20 to 30 m in 24% and > 30 m in 28% Wells) whereas during post-monsoon period (2023) it ranges from 5.87 to 34.25 m bgl (Avg.- 20.47 mbgl; WL < 20 m in 43.44%, 20 to 30 m in 53.27% and > 30 m in 2.46% Wells). Long term (10 years – 2014 to 2023) trend of water level in respect of Group-I(A) aquifer shows a continuous decline in all 6 blocks at an alarming rate (at Khekra, Khekra block @ 0.75 m/year and at Pilana, Pilana block @ 0.80 m/year). The piezometer constructed at Titroda, block–Binauli (zones tapped 46-58 & 65-74 mbgl in Aquifer–IA) showed a static water level (SWL) as 6.56 mbgl (04.01.2024). Tube wells tapping the Aquifer Group–I(B) are limited and thus the water level data of aquifer-I(B) are scanty. The magnitude of decline in water level is comparatively less in these aquifers under confined condition, which indicates that the Group-I(B) aquifers are still not being developed up to the optimum scale.

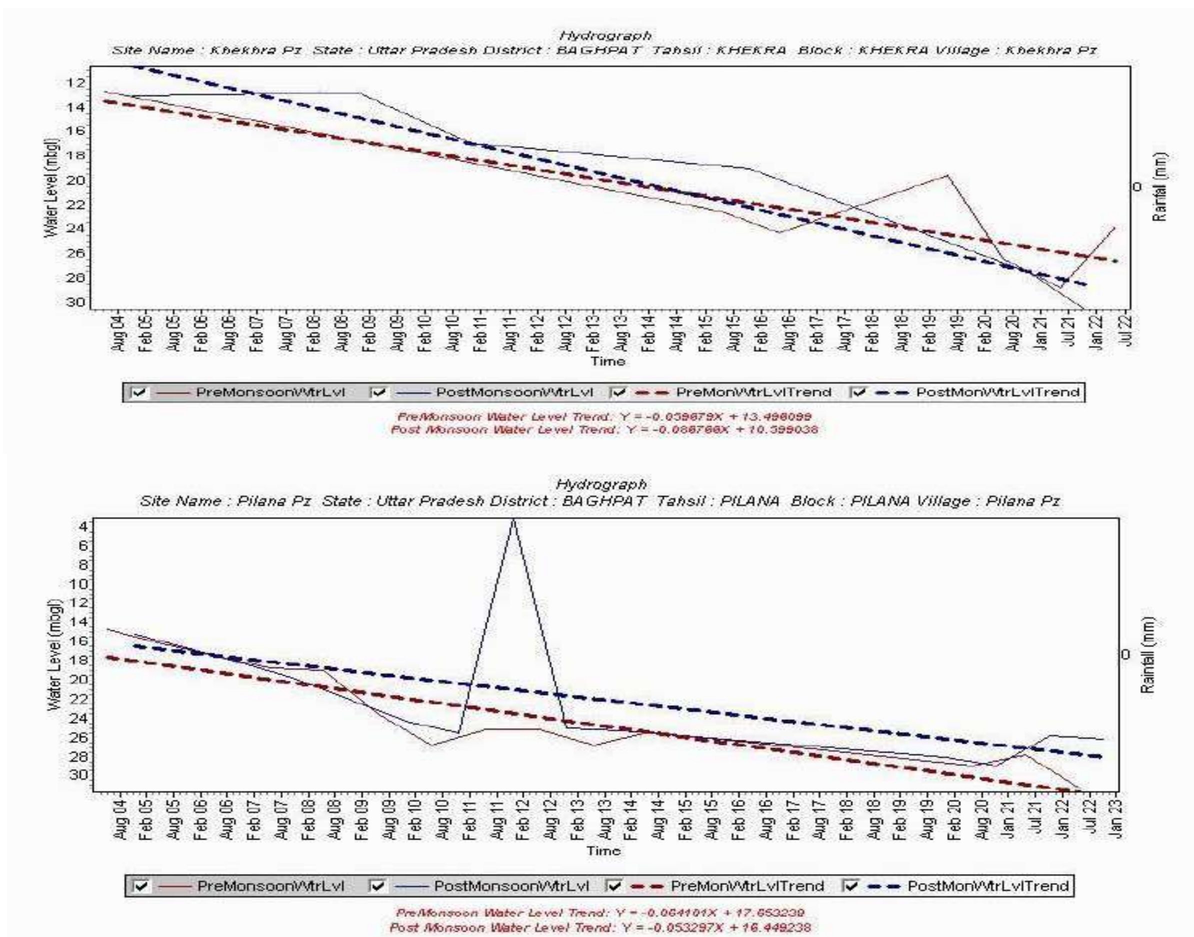


Fig. - 5.1 : Hydrographs of Pilana PZ and KhekraPz (NHNS) in NAQUIM 2.0 area

Only two tube wells were monitored at Pilana, block – Pilana (Pre-monsoon - 27.53 m bgl and post-monsoon – 28.42 m bgl) and Tikri, block – Chhaprauli (Pre-monsoon - 33.24 m bgl and post-monsoon – 32.15 m bgl) during pre-monsoon period. However, the water level data collected from the drinking water tube wells constructed under Jal Jeevan Mission (JJM) by tapping Aquifer–I(B) shows that the pre-monsoon water level ranges from 14.00 to 28.80 m bgl and the post-monsoon water level ranges from 20.20 to 27.25 m bgl. Moreover, under NAQUIM 2.0 project two exploratory wells (EW) were constructed at two sites namely Shobhapur, block – Pilana and Shahpur Banganga, block – Binauli by tapping Aquifer–I(B). The Static Water Level (SWL) in Shobhapur EW (zones tapped: 113-125, 132-138 & 147-150 mbgl) was 24.25 mbgl (05.10.2023) and that of Shahpur Banganga EW (zones tapped: 92-104 & 122-134 mbgl) was 11.28 mbgl (13.02.2024)

Ground Water Abstraction structures tapping the Aquifer Group–II are very rare. Under ground water exploration program pertaining to NAQUIM 2.0 project two exploratory tube wells were constructed at two sites namely Titroda, block–Binauli and Chhaprauli, block–Chhaprauli by tapping Aquifer–II. Static Water Level measured in Titroda EW (zones tapped: 213-216, 224-242 & 265-274 mbgl) was 22.08 mbgl (07.10.2023) and that of Chhaprauli EW (zones tapped: 163-169, 175-178, 184-190, 200-206 & 236-239 mbgl) was 21.16 mbgl (09.03.2024).

5.3 Semi-Critical to Over-Exploited status of all Administrative Blocks

The dynamic ground water resource has been calculated for all the 6 blocks of NAQUIM 2.0 area. As per the dynamic ground water resource estimation – 2017, the range of stage of ground water extraction was 71.17 % (Chhaprauli Block) to 111.55 % (Binauli Block), whereas in 2023 it is from 74.41% (Chhaprauli Block) to 130.59% (Pilana Block). This indicates a significant rise in ground water withdrawal from the shallow aquifer–1A within a very short period of 6 years, which is really alarming. In 2023, dynamic ground water resource status has shown that 3 blocks are under 'Semi-Critical' category and the other 3 blocks are under 'Over-Exploited' category. However, in last 1 year (2022 to 2023), only 1 block, namely Baghpat, has been improved from 'Critical' to 'Semi-Critical' as per the sole criteria for determining the category of the assessment units i.e. administrative blocks (GWRE-2015 Methodology). So, an unremitting depletion of dynamic ground water resources in shallow aquifers is occurring.

5.4 Ground Water Pollution

Generally, all chemical parameters in collected water samples show values within permissible limit. Both the shallow Group-I(A) aquifers and deeper Group-I(B) aquifers in the NAQUIM 2.0 area are generally having fresh potable water with EC values generally varies from 269 to 2391 (µs/ cm at 25 ^{0}C) in case of Group-I(A) aquifers and from 710 to 1597 (µs/cm at 25 ^{0}C) in case of Group-IB aquifers, which indicates that in some isolated and small pockets specially in Khekra and Pilana blocks adjacent to Ghaziabad district, sometimes the ground water from the hand pumped tube wells with depth range from 35 to 65 m tapping group–I(A) aquifers is brackish. Other parameters of routine analysis are also very much within permissible limits, excepting Iron (Fe), which shows a general concentration range from 0.01 to 1.0 mg/lt in Group–I(A) aquifers except at some scattered places like Asara (HP IM-II: 6.803 mg/lt), Kotana (HP IM-II: 4.434 mg/lt), Nagla Badi (STW: 6.301 mg/lt), and Khindora (HP IM -II: 3.84 mg/lt) whereas in Group-I(B) aquifers are free from any Iron contamination as the general range of Iron concentration is Nil to 1.0 mg/lt. Thus, in this NAQUIM 2.0 area the only chemical quality issue is sporadically high Iron in Group-I(A) aquifers. However, at some isolated locations spread in a sporadic manner, the occurrence of Nitrate (NO3) and other Heavy Metals like Manganese (Mn) and Uranium (U) above permissible limit have been noticed. In general, the chemical quality of ground water in aquifer–I(B) is comparatively better than that of aquifer–I(A).

6. MANAGEMENT STRATEGIES

To formulate a proper Aquifer Management Plan, it is required to understand the total available ground water resources, its quality and status of present development. On the basis of these studies, a sustainable effective management method may be prescribed.

6.1 Ground Water Management Plan for Drinking and Domestic Sector

In Uttar Pradesh, UP Jal Nigam is assigned with the job of drinking water supply in the NAQUIM 2.0 area (Baghpat district) to the rural as well as urban population. The community drinking water supply schemes are based on big diameter tube wells and this supply is given to a single village or to multiple villages. Besides the already commissioned ground water-based drinking water supply schemes, a substantial number of schemes (128 nos.) under Jal Jivan Mission (JJM) are also under the process of construction and installation, which will start functioning very soon and will expectedly be covering the whole population of the NAQUIM 2.0 area in Baghpat district. Block wise population, which are yet to be covered by piped water supply, have been identified. Population presently covered through the existing ground water- based schemes and the tentative block wise estimates of required drinking water for the uncoveredpopulation on the basis of projected population as in 2021 have been furnished in Table–6.1. In the NAQUIM 2.0 area, no surface water based drinking water supply schemes is available and thus it is necessary to check the feasibility of the installation of surface water treatment plants for community drinking water supply through utilisation of river water from the river Yamuna in order to lessen the dependency on the already imperilled and constantly decreasing ground water resources in Baghpat district.

6.1.1 Coverage under Piped Drinking Water Supply Schemes in NAQUIM 2.0 Area

It is assessed that about 36.36% i.e. 521157 people out of the total projected/ approximated (as in 2021) population **1433353** (as the Census 2021 statistics are not released yet) is under coverage of piped drinking water supply schemes and the rest population (912196) is still to be covered. In order to cover the remaining population in the NAQUIM 2.0 area an additional **13.318** MCM of water resource is required annually.

Table – 6.1 : Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam

Block	Total Popula-tion (Census: 2011)	Projected Population (2021) (Taking decadal growth as 10%)	Covered Popu-lation	Nos. of GPs	Nos. of GPs Covered	Population Yet to be Covered by Piped Water Supply Scheme (PWSS)	Annual water Resourcerequired to cater uncovered population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	172120	189332	80024	26	11	109308	1.5959
Baraut	279430	307373	124264	44	22	183109	2.6734

Block	Total Popula-tion (Census: 2011)	Projected Population (2021) (Taking decadal growth as 10%)	Covered Popu-lation	Nos. of GPs	Nos. of GPs Covered	Population Yet to be Covered by Piped Water Supply Scheme (PWSS)	Annual water Resourcerequired to cater uncovered population @ 40 lpcd (MCM)
Baghpat	228208	251028	30044	44	4	220984	3.2264
Khekra	223619	245980	24402	37	3	221578	3.2350
Pilana	167776	184554	102354	41	17	82200	1.2001
Binauli	231895	255086	160069	52	29	95017	1.3872
Total	**1303048**	**1433353**	**521157**	**244**	**86**	**912196**	**13.318**

6.1.2 Proposal for Development of Gr-I(A)& Gr-I(B) Aquifers by Drinking Water TWs

It is proposed that, the drinking water supply to the uncovered population may be carried out from ground water resources available in both the Group-I(A)& I(B) aquifers. However, the aquifers of Group-I(B) may be preferred for drinking water supply owing to have better quantity and quality of ground water and thus it has been proposed that 40% of total ground water resource (5.3272 MCM) required for catering uncovered population should be extracted from Gr.–I(A) and rest 60 % water (7.9907 MCM) from Gr.–I(B) aquifers. Here it is worth mentioning that the Group–I(A) aquifers are unconfined to semi-confined and the Group–I(B) aquifers are fully confined. Considering the average discharge of Group–I(A) and Group–I(B) aquifers in respective blocks and average 8 hours running per day, the annual unit draft of one such tube well has been assessed. Therefore, the total number of **41** tube wells is proposed in Gr.–I(A) aquifers and **49** tube wells in Gr.-I(B) aquifers to meet the drinking water demand of uncovered population from ground water resource in the NAQUIM 2.0 area (Table–6.2). The recommended number of tube wells will cater the remaining annual drinking water need of **13.318** MCM. The cumulative in- storage (static) resource in Aquifer Group–I(A) (294.13 MCM) and Aquifer Group–I(B) (44.525 MCM) for whole NAQUIM 2.0 area is **338.655**MCM and thus this resource can comfortably be utilised for supplying drinking water to the uncovered population as all the Gr.-I(A) as well as the Gr.-I(B) aquifers here contain fresh and potable ground water.

Table - 6.2 : **Proposed Planfor GW Draft from Aquifer Gr.–I(A)& Gr.-I(B) for Drinking Water**

Name of the block	Geog-raph-ical area (sq. km.)	Annual Resource required for un-covered popu-lation @40 lpcd (MCM)	Annual Resource proposed from I(A) Aquifer (40% of Requir-ment) (MCM)	Annual Resource proposed from I(B) Aquifer (60% of Requir-ment) (MCM)	Annual unit draft of one TW (taking avg. disch-arge of I(A) aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. disch-arge of I(B) aquifer and 8 hours/day running) (MCM)	Nos. of Tube Wells required in Group-I(A) aquifer(s) (4) / (6)	Nos. of Tube Wells required in Group-I(B) aquifer(s) (5) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Chhaprauli	205.32	1.5959	0.6384	0.9575	0.1314	0.1533	5	6
Baraut	276.86	2.6734	1.0694	1.6040	0.1314	0.1703	8	10

Name of the block	Geog-raph-ical area (sq. km.)	Annual Resource required for un-covered popu-lation @40 lpcd (MCM)	Annual Resource proposed from I(A) Aquifer (40% of Requir-ment) (MCM)	Annual Resource proposed from I(B) Aquifer (60% of Requir-ment) (MCM)	Annual unit draft of one TW (taking avg. disch-arge of I(A) aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. disch-arge of I(B) aquifer and 8 hours/day running) (MCM)	Nos. of Tube Wells required in Group-I(A) aquifer(s) (4) / (6)	Nos. of Tube Wells required in Group-I(B) aquifer(s) (5) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Baghpat	210.63	3.2264	1.2905	1.9358	0.1314	0.1583	10	12
Khekra	160.37	3.2350	1.2940	1.9410	0.1314	0.16352	10	12
Pilana	207.14	1.2001	0.4800	0.7201	0.1314	0.148	4	5
Binauli	290.00	1.3872	0.5549	0.8323	0.1314	0.1898	4	4
Total	**1350.32**	**13.318**	**5.3272**	**7.9907**	**0.1314**	**0.16387**	**41**	**49**

6.1.3 Effect of Development of Aquifers-I(A) & I(B) by Drinking Water Tube Wells

Further development of Group-I(A)&I(B) aquifers would definitely have an effect on the ground water regime. Block wise tentative decline of water level/piezometric surface for individual aquifer group has been assessed. It is observed that the probable decline of water level in Group-I(A) aquifers is from 0.032 to 0.135 m and that of piezometric surface in Group-I(B) aquifers is from 5.006 to 21.235 m (Table–6.3). As per National Water Policy, construction of tube wells for drinking water is foremost priority. However, keeping in view the further lowering of piezometric surface/water level the ground water extraction project involving tube well construction should always be implemented in phases with utmost precaution and must be compensated by construction of suitably designed artificial recharge structures for the respective aquifers.

Table - 6.3 : Probable Impact of GW Draft for Drinking Water on Ground Water Level

Name of the Block	Geogra-phical area (sq. km.)	Annual Water Resource proposed to be used from Group-I(A) Aquifers (MCM)	Annual Water Resource proposed to be used from Group-I(B) Aquifers (MCM)	Specific Yield (Sy) of Group-(A) Aquifers	Storativity (S) of Group-I(B) Aquifers	Decline of Water Level in Group-I(A) Aquifer (m)	Decline of piezometric surface inGroup-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	205.32	0.6384	0.9575	0.06	0.00057129	0.052	8.176
Baraut	276.86	1.0694	1.6040	0.06	0.00057129	0.064	10.136
Baghpat	210.63	1.2905	1.9358	0.06	0.00057129	0.102	16.136
Khekra	160.37	1.2940	1.9410	0.06	0.00057129	0.135	21.235
Pilana	207.14	0.4800	0.7201	0.06	0.00057129	0.039	6.089
Binauli	290.00	0.5549	0.8323	0.06	0.00057129	0.032	5.006
Total	**1350.32**	**5.3272**	**7.9907**				

Table–6.4: Cost Estimate of Tube Wells for Drinking &Domestic Water Supply to Projected Population (in 2031)

Block	Population in NAQUIM 2.0 area in 2011	Present Water Requirement for Human @70 lpcd (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate 10%)	Covered Human Population (2020-21)	Total Population to be covered in 2031 excepting already covered population (4) – (5)	Additional Water Requirement for Human @70 lpcd in 2031 (m^3/day)	Average Discharge of Group-I(B) Aquifers (m^3/hr)	Average Hours of Running of Tube Wells	Discharge of one TW (Unit Draft) in m3/day or 8 hours of pumping per day (8) x (9)	Nos. of Additional Tube Wells to be Constructed in I(B)Aquifer for catering Population in 2031 (7) / (10)	Cost of Tube Wells of 200 m depth in I(B)aquifer (approx.) 10"x6"dia@ Rs.10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Chhaprauli	172120	12048.40	208265	80024	128241	8976.884	52.50	8	420.00	21	210
Baraut	279430	19560.10	338110	124264	213846	14969.241	58.32	8	466.56	32	320
Baghpat	228208	15974.56	276132	30044	246088	17226.138	54.21	8	433.68	40	400
Khekra	223619	15653.33	270579	24402	246177	17232.389	56.00	8	448.00	39	390
Pilana	167776	11744.32	203009	102354	100655	7045.847	50.68	8	405.44	17	170
Binauli	231895	16232.65	280593	160069	120524	8436.677	65.00	8	520.00	16	160
Total	**1303048**	**91213.36**	**1576688**	**521157**	**1055531**	**73887.176**				**165**	**1650**

6.2 Ground Water Management Plan for Irrigation Sector

Agriculture is the principal source of livelihoods of the people in the NAQUIM 2.0 area of Bgahpat district. The major crops cultivated here areSugarcane, Wheat, Mustard, Rice and Vegetables. Sugarcane is grown substantially in this area, which is mostly dependent on ground water irrigation.

6.2.1 Ground Water Availability for Future Irrigation and Necessity of Planning

As per the technical data collected from various State Govt. agencies like Agriculture department and Minor Irrigation department and the Dynamic Ground Water Resources (2023) for Uttar Pradesh estimated by CGWB and Ground Water Department of Govt. of Uttar Pradesh on the basis of GEC 2015 methodology, the block-wise cultivable area, net cultivated area, net irrigated area, cultivale area to be brought under irrigation, water level and its long term trend, stage of ground water extraction and ground water availability for future irrigation etc. have been presented in Table – 6.5.

Out of cultivable area of **106690** Ha, net irrigated area is **102630** ha (96.19%) as per 5th Minor Irrigation Census data of Govt. of UP. Throughout the area, the major and prolific shallow aquifers show a significant falling trend in both pre-monsoon and post-monsoon water level. In almost all the blocks the decline in post-monsoon water level is reported invariably in Group- I(A) aquifers and sometimes also in Group–I(B) aquifers. However, Stage of Ground Water Extraction ranges between 74.41% (Chhaprauli) and 130.59% (Pilana). The high SOE and significant water level declining rate in post-monsoon compared to pre-monsoon may be due to massive ground water withdrawal for irrigation during post-monsoon and impact of pumping water level in one well affecting the others in the vicinity. As per Dynamic Ground Water Resource Estimation 2023, in respect of 3 nos. of semi-critical assessment blocks namely Chhaprauli, Baraut and Baghpat, total **3880.84** Ham ground water are available for future use (mainly for irrigation and industrial use) but it is suggested that this small amount of water should be kept in reserve as it is pertaining to Gr.-I(A) aquifers, where the water level is declining constantly. Thus, to be on a safer side, further irrigational use of ground water from the shallow Group-I(A) aquifers should be discouraged and in case of utter obligation, the irrigation water may be withdrawn mainly from the Group-I(B) aquifers. In irrigation water management plan, it is suggested to fulfil a considerable part of the future demand of irrigation water by harvesting and conservation of rainwater paired with adopting less water consuming micro- irrigation along with changing of cropping pattern through curtailment of high-water consuming sugarcane crop and resorting to the less water consuming crops like wheat, rice, vegetables and mustard. Moreover, a close and continuous monitoring of water level and quality for both the Aquifer Groups–I(A)&I(B) in pre-monsoon and post-monsoon period and the assessment of the ever-changing ground water development scenario are also essential. Accordingly, preparation of a fruitful and flexible ground water management plan on regular basisandexclusively for irrigation purposes in this NAQUIM 2.0 area of Baghpatdistrictis indispensable, which can be evidenced by the statistical figures of various parameters furnished in Table - 6.5.

Table – 6.5 :**Cultivable Area, Net Irrigated Area & Ground Water Availability (2023-24) and Scope & Necessity of Management Intervention**

Block	Geogra-phical Area (Ha)	Culti-vable Area (Ha)	Net cultiv-ated Area (Ha)	Cultu-rable Comm-and Area (CCA) i.e. Pre-sentlyIrr iga-ted Area as per MI-5 Census (Ha)	Remain-ing Cul-tivable Area to bring under Irriga-tion (Ha) (3) - (5)	Net Irrigated Comm-and Area by Ground Water as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Area by Surface Water as per MI Census-5 in 2020 - 21) (Ha)	Net Irrigated area by Ground Water and SurfcaeWa ter (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extrac-tion (%)	Net Ground Water Avail-ability for futureIrri ga-tion and Indus-trial Use (Ham)	Pre-Mon-soon Water Level Trend 2010 - 2021: Falling Trend (m/year)	Post-Mon-soon Water Level Trend 2010-21: Falling Trend (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (m bgl) (2023)	Average Post-Monsoon Water Level (Aquifer wise (m bgl) (2023)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Chhaprauli	20532	17380	16662	16626	754	16390	236	16626	74.41	1604.96			16.55 (IA) 21.12 (IB)	16.24 (IA) 20.20 (IB)
Baraut	27686	20664	20122	20098	566	19868	230	20098	78.11	1712.79			20.44 (IA) 21.33 (IB)	19.95 (IA) 20.50 (IB)
Baghpat	21063	17002	16448	16215	787	15977	238	16215	88.34	563.09			18.39 (IA) 24.80 (IB)	17.20 (IA) 24.00 (IB)
Khekra	16037	17274	16765	16753	521	16524	229	16753	121.07	0	0.75		22.07 (IA) 23.40 (IB)	20.83 (IA) 22.00 (IB)
Pilana	20714	13876	13245	13214	662	13025	189	13214	130.59	0	0.80		28.98 (IA) 24.51 (IB)	22.97 (IA) 22.68 (IB)
Binauli	29000	20494	19792	19724	770	19459	265	19724	113.28	0			28.08 (IA) 28.80 (IB)	26.53 (IA) 27.25 (IB)
Total	**135032**	**106690**	**103034**	**102630**	**4060**	**101243**	**1387**	**102630**		**3880.84**				

6.2.2 Demand side Interventions in Cropping Pattern and Irrigation Practices

1. Change in cropping pattern is the need of hour in this water stressed NAQUIM 2.0 area.
2. Enhancement in cultivation of low water requiring crops and a small modification of the prevailing cropping pattern is recommendable as per its suitability for the area.
3. Sugarcane crop ideally needs around 2.4 m of water column for irrigation for its whole life cycle, which is grown throughout the summer, monsoon and winter seasons by occupying the agricultural land for almost 10 to 12 months and thus heavily depends on ground water as the average annual rainfall in this NAQUIM 2.0 area is merely around 650 mm. So, a phase-wise lessening of sugarcane cultivation area is strongly suggested as on experimental basis and it is being initially proposed to be reduced by 10%. The total annual loss of income from sugarcane production could be compensated by the income expected from the additional production of crops like rice, wheat, vegetables and mustard, which would be irrigated by the amount of ground water saved through 10% lessening of sugarcane cultivation. In an alternative way, the whole released area of sugarcane may be utilised for growing Rice in Kharif and also three common low CWR crops wheat, vegetables and mustard in Rabi season by distributing the land equally.
4. For encouragement of cultivation of other crops instead of sugarcane, incentives may also be provided by the government to the farmers, who are interested for this change.
5. Sincere efforts should be made so that at least some small sugarcane areas can be irrigated by surface water, specially in monsoon and post-monsoon period, from the rivers, ponds, tanks existing nearby and other new surface water conservation structures being constructed under various govt. schemes for storing the harvested rain water.
6. Overall increase in cultivation area of mustard, vegetables and wheat may be recommended as analternative option as these crops are suitable for the local climate and soil type and need a lesser irrigation water column in the range of 0.40 to 0.45 m.
7. Rain water harvesting and artificial recharge techniques may be introduced at a larger scale to minimise the problem of declining water level and depletion of GW resource.
8. To improve the ground water scenario in shallow aquifers, modern irrigation systems like drip water irrigation and sprinklers irrigation should be adopted through which a considerable amount of ground water may be saved (20% to 50% depending on crop type) as the irrigation in the NAQUIM 2.0 area is mainly dependent upon ground water.

Benefits from Implementation of above-mentioned Management Strategy

1. By decreasing area of sugarcane cultivation and implementing micro-irrigation techniques, the ongoing massive draft of ground water round the year can be reduced.

2. Enhancement in irrigation coverage and cropping intensity, cultivation of multiple crops
3. Increase in revenue of the farmers and an overall economic development of the society.

The ground water level in unconfined to semi confined Group-I(A) aquifers suffers heavy decline wherever utilized for irrigation in this NAQUIM 2.0 area. Therefore, further large-scale installation of ground water structures for irrigation specially in shallow Group-I(A) aquifers should not be encouraged. To alleviate the situation, crop diversification and modification of cropping pattern by reducing 10% of sugarcane cultivation area may increase the cropping intensity, irrigation coverage and a notable gain in agricultural revenue.On the other hand,itmay effectively decrease the withdrawal of ground water for irrigation. The estimated irrigation water columns required for different major crops usually grown in this NAQUIM 2.0 area are given in Table–6.6 (A) & (B).

Table – 6.6 (A) : **Water Requirements for Irrigation of various major Crops**

Major Crops currently being grown in NAQUIM 2.0 area	**Requisite Water Colum for Irrigation (m)**	**Crops suggested for saving Ground Water(as perGW quality & quantity)**	**Water Column (m) recommended for less water requiring crops**	**Remarks/ Irrigation Techniques**
Sugarcane, Wheat Rice, Mustard, Potato, Arahar, Urd, Moong, Masoor, Bajra, Onion, Jowar, Vegetables etc.	**Sugarcane**: (2.0 – 2.4) **Rice**: (1.2-1.4) **Wheat**: (0.35 -0.45) **Pulse**: (0.1-0.12) **Oil Seed**: (0.2– 0.25) **Vegetable**: (0.15 - 0.4) **Potato**: (0.45 – 0.70)	Wheat, Mustard, Pulses, Vegetables	**Mustard**:(0.20–0.45) **Pulse**: (0.08 - 0.12) **Vegetable**: (0.2–0.4)	Drip Irrigation for sugarcane and vegetables. Sprinkler Irriga-tion for wheat, rice & mustard

Table – 6.6 (B) : **Water RequirementsforIrrigationof some lesser cultivated Crops**

Name of the Crop	**Water Require -ment (m)**	**Name of the Crop**	**Water Requirement (m)**	**Name of the Crop**	**Water Require -ment (m)**	**Name of the Crop**	**Water Require -ment (m)**
Maize	0.45 –0.65	**Onion**	0.35 –0.55	**Summer Veg.**	0.30 –0.40	**Cabbage**	0.38 –0.50
Green Gram	0.30 –0.35	**Tomato**	0.60 –0.80	**Rabi Veg.**	0.20 –0.35	**Pea**	0.35 –0.50
Black Gram	0.35 –0.40	**Cotton**	0.65 –0.90	**Chilies**	0.50	**Bean**	0.30 –0.50

The soil in NAQUIM 2.0 area is mainly composed of sandy loam, minor loam and sand and it is moderate to well drained. So, less water consuming crops should be grown particularly in non-monsoon period. As per soil type, irrigation facility available and cost factor of growing, some of these crops in a proportionate way may be cultivated in future as replacements of sugarcane for saving ground water presently being used for irrigation.

Total area of cultivation of sugarcane is **74091** Ha. If 10% (**7409.10** Ha) of sugarcane cultivation area is reduced then**17781.84** Ham water could be saved. This saved water may then be utilized proportionately for providing irrigation to lesser water requiring crops like wheat, rice, vegetables and mustard. The selection of these crops to which the saved water would be alloted is done on the basis of prevailing cultivation practices, irrigation patterns, crop water requirments and also the present sown area of those crops in the NAQUIM 2.0 area. This saved water can be utilized to create an alternative irrigation area (CCA) amounting **35749.76** Ha in lieu of 10% of sugarcane irrigation area and the effective increase in irrigation area could be **28340.66** Ha {Table–6.7 (A)}. Under this proposed scheme, from the four crops grown underalternativeirrigation area there may be an effective increase of agricultural income amounting 580.3849 crores. {Table–6.7 (B)}.

As an alternative way of **'demand side intervention'**, if the land released as a result of 10% reduction of all year-round sugarcane cultivation is allotted for growing rice in Kharif season and then in subsequent Rabi season, if it is allotted in equal proportion to three most viable low water requiring crops like mustard, wheat and vegetables then an effective gain/profit of **Rs.48.9608 Crore** can be attained and as an added benefit an effective saving of ground water would be **101.2577 MCM**which may in turn help in lowering the average Stage of GW Extraction (SOE) of the district from **97.12 %** (2023) to **74.61%** and an average rise of water level around **1.25 m** may also be noticed in respect of Aquifer-I(A) in the NAQUIM 2.0 area of Baghpat district {Table– 6.7(C)}.

Table - 6.7 (A): Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present GW Draft

Additional area brought under coverage of other crops with the saved water from 10% reduction of Sugarcane Cultivation						Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10% Sugarcane Cultivation												Increase in area under Irrigation by reducing 10% of Sugarcane Cultivation	
Block	Present area under Sugar-cane (Ha)	10% of Sugar-cane Area (Ha)	Area under Sugar-cane after 10% reduc-tion (Ha)	Water Col-umn for Sugar cane Irriga-tion (m)	Volume of Irriga-tion water saved (Ham)	Wheat (Rabi Season) (Maximum Delta factor : 45 cm)			'Boro' Rice (January – April) (MaximumDelta factor :140 cm)			Vegetables (Rabi and Summer) (MaximumDeltafactor : 40 cm)			Mustard (Rabi Season) (MaximumDelta factor : 45 cm)			Total Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)	Effective Increase in Area of Irrigation i.e. CCA (Ha) (19) – (3)
						Water Ham (%)		Area (Ha)	Water Ham (%)		Area (Ha)	Water Ham (%)		Area (Ha)	Water Ham (%)		Area (Ha)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Chhaprauli	12416	1241.60	11174.4	2.4	2979.84	1340.93	45%	2979.84	595.97	20%	425.69	595.97	20%	1489.92	446.976	15%	993.28	5888.73	4647.13
Baraut	15492	1549.20	13942.8	2.4	3718.08	1673.14	45%	3718.08	557.71	15%	398.37	743.62	20%	1859.04	743.616	20%	1652.48	7627.97	6078.77
Baghpat	10958	1095.80	9862.20	2.4	2629.92	1314.96	50%	2922.13	525.98	20%	375.70	394.49	15%	986.22	394.488	15%	876.64	5160.70	4064.90
Khekra	7834	783.40	7050.60	2.4	1880.16	1034.09	55%	2297.97	282.02	15%	201.45	282.02	15%	705.06	282.024	15%	626.72	3831.20	3047.80
Pilana	11463	1146.30	10316.7	2.4	2751.12	1375.56	50%	3056.80	550.22	20%	393.02	412.67	15%	1031.67	412.668	15%	917.04	5398.53	4252.23
Binauli	15928	1592.80	14335.2	2.4	3822.72	1911.36	50%	4247.47	573.41	15%	409.58	764.54	20%	1911.36	573.408	15%	1274.24	7842.64	6249.84
Total	**74091**	**7409.10**	**66681.9**	**2.4**	**17781.84**	**8650.03**		**19222.3**	**3085.32**		**2203.81**	**3193.31**		**7983.27**	**2853.18**		**6340.40**	**35749.76**	**28340.66**

Table - 6.7(B) : **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Proposed reduction of Sugarcane Cultivation Area (Ha)	Loss in Production of Sugarcane as per Avg. Yield Rate 80 MT /Ha in 2023 -24 (MT)	Monetary Loss (in Crore) due to 10 % Reduction of Sugarcane Cultivation Area as per MSP 2023-24 of Sugarcane @ Rs. 3700 per MT	Wheat (Rabi Season)			'Boro' Rice (January-April)			Vegetables (Rabi and Summer)			Mustard (Rabi Season)			Additional Income from growing alternative crops with the ground water earlier being used by 10% Sugarcane cropping (Rs. in Crore) (7) +(10) + (13) +(16)	Total Effective Increase in Income from Proposed Intervention through change in Cropping Pattern (Rs. in Crore) (17) – (4)
				Additional Area to be Cultivated& Irrigated from Table-6.7 (A) (Ha)	AdditionalProduc-tion expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price Rs. 21250 per MT (2023-24) (Rs. in Crore)	AdditionalArea to be Cultivated& Irrigated from Table-6.7(A) (Ha)	AdditionalProduction expected as per Avg. Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price Rs.21830 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated& Irrigated for Vegetable from Table-6.7(A) (Ha)	AdditionalProduction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Additional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. in Crore)	AdditionalArea to be Cultivated& Irrigated From Table-6.7(A) (Ha)	AdditionalProduction expected as per Avg. Yield Rate 1.980 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in Crore)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Chhaprauli	1241.60	99328	36.7514	2979.84	10429.44	22.1626	425.69	1195.77	2.6104	1489.92	35758.08	107.2742	993.28	1966.69	10.7185	142.7657	106.0143
Baraut	1549.20	123936	45.8563	3718.08	13013.28	27.6532	398.37	1119.01	2.4428	1859.04	44616.96	133.8509	1652.48	3271.91	17.8319	181.7788	135.9225
Baghpat	1095.80	87664	32.4357	2922.13	10227.47	21.7334	375.70	1055.35	2.3038	986.22	23669.28	71.0078	876.64	1735.75	9.4598	104.5048	72.0691
Khekra	783.40	62672	23.1886	2297.97	8042.91	17.0912	201.45	565.86	1.2353	705.06	16921.44	50.7643	626.72	1240.91	6.7629	75.8537	52.6651
Pilana	1146.30	91704	33.9305	3056.80	10698.80	22.7350	393.02	1103.99	2.4100	1031.67	24760.08	74.2802	917.04	1815.74	9.8958	109.321	75.3905
Binauli	1592.80	127424	47.1469	4247.47	14866.13	31.5905	409.58	1150.50	2.5115	1911.36	45872.64	137.6179	1274.24	2523.00	13.7503	185.4702	138.3233
Total	**7409.10**	**592728**	**219.3094**	**19222.29**	**67278.03**	**142.9658**	**2203.80**	**6190.47**	**13.5138**	**7983.27**	**191598.48**	**574.7954**	**6340.40**	**12553.99**	**68.4193**	**799.6943**	**580.3849**

Minimum Support Price: Source–Directorate of Economics and Statistics, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare

Table-6.7(C): **Impact of Reducing Sugarcane area and allotting that to Rice in Kharif and equally distributing to 3 low CWR crops in Rabi on Income & Ground Water**

Block	Present Area of Sugarcane cultivation (Ha)	Present GW Draft for Sugarcane Cultivation (CWR = 2.4 m) (MCM)	Proposed 10% Reduction of Sugarcane cultivation Area (Ha)	Amount of Ground Water Saved by reducing 10% of Sugar cane Cultivation Area (MCM)	Yield Rate of Sugarcane MT/Ha	Loss in Production of Sugarcane due to reduction of cultivation area (MetricTon : MT)	Loss in Income from Sugarcane @ Rs. 3700 per MT (as per MSP of 2023-24) (Rs. in Cr.)	Gain in Production of Kharif Rice @ existing Avg. Yield 2.809 MT/Ha grown in freed 10% sugarcane area due to Alternate cropping pattern (MT)	Gain in Income from Kharif Rice @Rs. 21830 per M. Ton (as per MSP of 2023-24) (Rs. in Cr)	Proposed Cropping of Mustard, Wheat and Vegetable in Rabi Season (low CWR &normally practiced crops) in 1:1:1 Ratio in 10% Lost Sugar cane Area (Ha)	Gain in Production of Mustard @ existing Average Yield Rate 1.980 MT/Ha in NAQ-UIM Area due to Alternate cropping pattern (MT)	Gain in Income from Mustard @ Rs. 54500 per M. Ton (as per MSP of 2023-24) (Rs. in Cr	Gain in Production of Wheat @ existing Average Yield Rate 3.5 MT/Ha in NAQ-UIM Area due to Alternate Cropping Pattern (MT)	Gain in Income from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore Rs.)	Gain in Production of Vegetables @ Existing Average Yield Rate 24 MT/Ha in NAQ-UIM Area due to alternate cropping pattern (M. Ton)	Gain in Income from Vegetables @ Rs. 30000 per M. Ton (as per Farm Gate Price : 2023-24) (Crore Rs.)	Individual Ground WaterDraft for Additional CultivationofRice during Kharif period on thewhole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10% sugarcane area as per Crop Water Requirement 0.60 m, 0.45 m, 0.45 m and 0.40 m respectively for Kharif Paddy, Mustard, Wheat and Vegetables (MCM)				Total Ground Water Draft for Additional Cultivation of Kharif Rice and Mustard, Wheat & Vegetables in Rabi season (MCM)	Effective Saving of Ground Water by Cropping Pattern Change (MCM) {(5) - (19)}	Effective Gain inIncome for growing Kharif Rice and Rabi Mustard, Wheat & Vegetables n released area by 10% Sugarcane {(10) + (13) + (15) + (17)} – (8) (Rs. inCr)	Exis Ting Stage of Dynamic GW Extraction as per Ground Water Resource Estimation by GEC 2015 Method as on March 2023	Annual Extractable GW Resource as per Dynamic Ground WaterResource Calculated for 2023 (MCM)	Total Annual Ground Water Extraction for all purposes in respect of Dy. GW resource calculation 2023 (MCM)	Improved Stage of GW Extraction by Saving of Dynamic GW Resource (%) Considering that Irrigationwater for Sugarcane is drawn from Gr-IAAqu-ifer	Expected Rise in Pre-monsoon Water Level (m) of Unconfined to Semi-Confined Aqui- fer calculated taking Avg Sp. Yield
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must.	Wheat	Veg.								
Chhaprauli	12416	297.984	1241.6	29.7984	80	99328	36.7514	3487.6	7.6135	413.87	819.46	4.4660	1448.53	3.0781	9932.9	29.7986	7.4496	1.8624	1.8624	1.65547	12.8299	16.9685	8.2048	74.41	63.0077	46.8841	58.62	1.38
Baraut	15492	371.808	1549.2	37.1808	80	123936	45.8563	4351.7	9.4998	516.40	1022.47	5.5725	1807.40	3.8407	12393.6	37.1808	9.2952	2.3238	2.3238	2.0656	16.0084	21.1724	10.2375	78.11	78.8309	61.5734	61.57	1.27
Baghpat	10958	262.992	1095.8	26.2992	80	87664	32.4357	3078.1	6.7195	365.27	723.23	3.9416	1278.43	2.7167	8766.5	26.2994	6.5748	1.6437	1.6437	1.46107	11.3233	14.9759	7.2415	88.34	50.0363	44.2010	67.99	1.19
Khekra	7834	188.016	783.40	18.8016	80	62672	23.1886	2200.6	4.8038	261.13	517.04	2.8179	913.97	1.9422	6267.1	18.8014	4.7004	1.1751	1.1751	1.04453	8.0951	10.7065	5.1767	121.07	37.6230	45.5484	94.25	1.11
Pilana	11463	275.112	1146.3	27.5112	80	91704	33.9305	3219.9	7.0292	382.10	756.56	4.1232	1337.35	2.8419	9170.4	27.5112	6.8778	1.7195	1.7194	1.5284	11.8451	15.6661	7.5750	130.59	43.6488	57.0020	96.10	1.26
Binauli	15928	382.272	1592.8	38.2272	80	127424	47.1469	4474.2	9.7671	530.93	1051.25	5.7293	1858.27	3.9488	12742.3	38.2270	9.5568	2.3892	2.3892	2.12373	16.4589	21.7683	10.5253	113.28	62.3591	70.6432	83.97	1.25
Total	**74091**	**1778.18**	**7409.1**	**177.8184**	**80**	**592728**	**219.3094**	**20812.16**	**45.4329**		**4890.01**	**26.6505**	**8643.95**	**18.3684**	**59272.8**	**177.8184**	**44.4546**	**11.1137**	**11.1136**	**9.8788**	**76.5607**	**101.2577**	**48.9608**	**97.12**	**335.5058**	**325.852**	**74.61**	**1.25**

6.2.3 Supply Side Interventions through Artificial Recharge and Surface Storage

Water is to be collected from Roof Top Rain Water Harvesting and Non-Committed Surface Run-off for Augmentation of Ground Water Resources and through Storage in Conservation cum Irrigation Pond for Incresing Surface Water Resource

The area receives a moderate rainfall,however, a substantial amount of this rainfall is wasted as surface run-off which is usually drained out of the watershed/basin to the rivers. Non-committed surface runoff, generated by rainfall may be collected for conservation and artificial recharge to depleting shallow aquifers in NAQUIM 2.0 area.

Using Dhruvanarayan'1993 method a detailed water budgeting for individual blocks has been made on thebasis of normal rainfalldata, soil type and land slope etc. Applyingthismethod, the run-off components for conservation and recharge have been determined, followed by proposal of various types of artificial recharge structures and conservation structures in different blocks and then the total construction cost estimate for each block has been assessed to plan for the development of water resources as a whole. As a result of implementation of this plan, the economy of the area is expected to be improved. Steps for estimation of run-off, calculation of nos. of structures, cost estimation etc. are given below:

1. Determination of Total Volume of Surface Runoff (Ham) available Annually 'V_t'=(R_nxAxC)
2. Determination of 75% of 'V_t' = V
3. Determination of 50% of 'V' (Non-Committed) =V_{nc}
4. Considering 60% of 'V_{nc}' to be harvested = V_f
5. Source water allocation for artificial recharge structures like Re-excavated Existing Tank (REET) with Recharge Shaft, Injection Well and conservation structures like Farm Pond.
6. Finally, nos. of various feasible structures in different blocks based on soil characteristics and other aspects, along with their size specifications and cost estimates have been made.

The volume of monsoon runoff can be harnessed without creating any adversity to the environment is estimated by applying Druvanarayana'1993. Thus, after deducting the flow component, the non-committed surface run-off for whole NAQUIM 2.0 area has been calculated as **102.53993 MCM**(Table–6.8)**.** This volume of water may be utilized for artificial recharge through injection wells and for storing in surface conservation structures.

6.2.3.1 Rain Water Harvesting for Artificial Recharge

Both the aquifer systems viz Aquifer Group-I(A) and Aquifer Group-I(B) show deeper water levels. In the year 2023, the average pre-monsoon depth to water level ranges from 16.55 m to 28.98 m bgl for Aquifer Group–I(A) and from 21.12 m to 28.80 m bgl in case of Aquifer–I(B) whereas the average post-monsoon depth to water level ranges from 16.24 m to 26.53 m bgl for Aquifer Group–I(A) and from 20.20 m to 27.25 m bgl in case of Aquifer–I(B). The water level throughout the year in all over the NAQUIM 2.0 area is deeper. Group–I(A) aquifer experiences a significant long-term falling trend (0.75 m/yr to 0.80 m/yr) for the pre-monsoon period(Table-6.5). Both the Gr.-I(A) and I(B) aquifers in entire NAQUIM 2.0 area are suitable for artificial recharge. The available storage space (post-monsoon) for aquifer group-I(B) has been calculated for respective blocks by multiplying volume of the formation with its Storativity (Storage Co- efficient) value.

For artificial recharge through injection well we can assume that 100% of the NAQUIM 2.0 area is suitable for effective ground water recharge. However, it has to be taken into consideration that only 75% of source water applied for artificial recharge by injection method would be actually stored or recharged under the ground through occupying the vacant space available in the Aquifer Groups-I(A)&I(B).

The anticipated volume of source water to be generated from moderate annual rainfall in the NAQUIM area is very meagre in comparison to the total vacant spaces existing in Group-I(A) & I(B) aquifers, which are quite voluminous. Threfore, only small volumes of vacant and refillable spacesi.e. minor parts of the aquifers occurring in between 15 m bgl and their respective post- monsoon water level have been calculated block wise taking the specific yield as 0.06 in case of unconfined Group-I(A) aquifer in Older Alluvium and taking an average value of storativity as
5.71×10^{-4} (0.000571) for the confined Group-I(B) aquifer and have been proposed for filling up through artificial recharge by injection wells. For Group-I(A) aquifer an attempt may be made to fill up the proposed**481.0802**MCMstorage space and in order to recharge this **481.0802**MCMwaterinto this aquifer,a total amount of **641.4402** MCM source water is required, whereas for filling up **6.1394** MCM space in Group-I(B) aquifer,that is, for recharging this amount of water in this aquifer an amount of **8.1858 MCM** source water isrequired (Table- 6.9).

Suitable numbers of injection wellsareto be constructedalongwiththe roof top rain water harvesting units to inject the collected rain water to the aquifers. Considering a unit roof area as 100 sq. mt., total normal annual rainfall as **0.67476** m and runoff coefficient as 0.80, the unit capacity of one roof top structures is **0.000054** MCM. Therefore, to inject **481.0802** MCM of water into the Gr.-I(A)aquifer, **11882748** nos. of Roof Top (each of 100 sq. mt. size) Rain Water Harvesting (RTRWH) system each fitted with sufficient numbers of injection wells may be required. Similarly, to recharge**6.1394** MCM of water in to the Gr.-1B aquifer, **151644** Roof Top (each of 100 sq. mt. size) Rain Water Harvesting system fitted with required numbers of injection wells are recommended. Block wise number of roof top rain water harvesting cum injection recharge structures for partial filling/ recharging of the feasible space aviable in individual aquifersare estimated (Table–6.9).

Necessity may be judged for implementation of artificial recharge projects in the NAQUIM 2.0 area on the basis of higher ground water development, depth to ground water level, categorization of the blocks as per the Ground Water Resource Assessment as on March 2023 by GWRE 2015 methodology, source water locally available and availability of suitable lands/locations for setting up recharge schemes in the blocks. As per the local feasibility study,Re- excavation of Existing Tanks with Recharge Shafts and Injection Wells may be constructed as suitable recharge structures.Perolation tank type of recharge structures, usually recommended in alluvial terrain, are not viable in this area due to its unfavourablegeomorphologicalcharacterics, insufficiency of source water and absence of suitable large uncultivable/uninhabitable lands necessary for this type of structure.

The impact assessments of artificial recharge of water collected from Roof Top Rain Water Harvesting and Non-Committed Surface Run-off through injection well in respect of Group-I(A) unconfined aquifers have been presented in Table-6.10 and 6.13 in terms of rise in water level, saving of ground water and improvement of its dynamic resource.

For Alluvial area the flowing kinds of Harvesting and Recharge structures are feasible:

- **'REET'** – Re-Excavation of Existing Tanks, size 100m x 100m x 5m, Filling -2 times, **Storage Capacity – 10 Ham**, for Recharge and Irrigation
- **Irrigation cum Recharge Tank (Percolation Tank)** – size 100m x 100m x 5m, Filling -10 times, Storage **Capacity – 50 Ham**; for Recharge and Irrigation
- **Farm Pond or Conservation/Storage cum Irrigation Tank/Pond** - size 100m x 100m x 5m, Filling -2 times, **Capacity–10 Ham**; for Fishing cum Irrigation
- **Injection Wells** - dia. -10" x 6"; Depth - 300 m/200m/100m, **Capacity - 30 Ham**, for recharge in to deeper zones as well as for pumping

In general, the allocation of source water is done in the following manner: **35 % water to 'REET' and 30 % water to Injection Well, 35 % water to** Farm Pond**.** Average cost of construction: REET – **8 Lakh,** Injection Well (100 m) **– 5 Lakh,** Farm Pond – **8 Lakh**

Table – 6.8 :**Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Estimation of Non-Committed Run-off from rain fall and water Available for Harvesting in order to Recharge/Conserve

Block	Geogra-phical Area (Ha)	Normal Mon-soon Rainfall (m)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvana-rayana'1993 (Land slop, type of land and soil type) (Land slope 0 - 5%)	Major type of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt' = (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-commi-tted) = Vnc (Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt' = (Rn x A x C)	'V'	'Vnc'	'Vf'
Chhaprauli	20532	0.675	13859.10	0.5	Sandy loam & minor loam, Sand	Moderate to Well Drained	6929.55	5197.163	2598.581	1559.149
Baraut	27686	0.675	18688.05	0.5	Sandy loam & minor loam, Sand	Moderate to Well Drained	9344.03	7008.019	3504.009	2102.406
Baghpat	21063	0.675	14217.53	0.5	Sandy loam & minor loam, Sand	Moderate to Well Drained	7108.76	5331.572	2665.786	1599.472
Khekra	16037	0.675	10824.98	0.5	Sandy loam & minor loam, Sand	Moderate to Well Drained	5412.49	4059.366	2029.683	1217.810
Pilana	20714	0.675	13981.95	0.5	Sandy loam & minor loam, Sand	Moderate to Well Drained	6990.98	5243.231	2621.616	1572.969
Binauli	29000	0.675	19575.00	0.5	Sandy loam & minor loam, Sand	Moderate to Well Drained	9787.50	7340.625	3670.313	2202.188
Total	**135032**	**0.675**	**91146.6**	**0.5**			**45573.30**	**34179.975**	**17089.988**	**10253.993**

Table – 6.9 :**Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geographical Area (Sq. Km.)	Non-Committed Surface Runoff available for whole NAQUIM 2.0 Area (MCM)	Total surface runoff/harvested rain water required to fill a part of storage space in Gr-I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water required to fill a part of storage space in Gr-I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A)& Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7) + (12) (MCM)	Total harvested Rain water/ surface run-off water actually needed for injection to Gr.-I(A)& Gr.-I(B) Aquifer (14) x (100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure each of 100 sq. mt. roof size (area x total avg. annual rainfallx0.8) (MCM)	Nos. of RTRWH schemes (100 sq. mt. roof area) attached with Injection Wells required for recharging Gr.-I(A) Aquifers (8)/(16)	Nos. of RTRWH schemes (100 sq. mt. roof area) attached with Injection Wells required for rechargingGr.-I(B) Aquifers (13)/(16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(Normal Annual Rainfall– 0.67476 m)			Average post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 m bglandPost - mon-soon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2) x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7) x (100/75)	Avg. Post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 m bgl andPost-monsoon water level (m)	Stora-tivity (S)	Storage Space for Recharge /Volume of Water to be stored (2)x(10)x(11)	Rain water to be harv-ested for Gr.I(B) Aquifer (12) * (100/75)					
hhaprauli	205.32	15.59149	16.24	1.24	0.06	15.2758	20.3677	20.20	5.20	0.000571	0.6096	0.8128	15.8854	21.1806	0.000054	377315	15058
Baraut	276.86	21.02406	19.95	4.95	0.06	82.2274	109.6366	20.50	5.50	0.000571	0.8695	1.1593	83.0969	110.7959	0.000054	2031029	21476
Baghpat	210.63	15.99472	17.20	2.20	0.06	27.8032	37.0709	24.00	9.00	0.000571	1.0824	1.4432	28.8856	38.5141	0.000054	686742	26736
Khekra	160.37	12.17810	20.83	5.83	0.06	56.0974	74.7966	22.00	7.00	0.000571	0.6410	0.8547	56.7384	75.6512	0.000054	1385614	15833
Pilana	207.14	15.72969	22.97	7.97	0.06	99.0543	132.0725	22.68	7.68	0.000571	0.9084	1.2112	99.9627	133.2836	0.000054	2446656	22437
Binauli	290.00	22.02188	26.53	11.53	0.06	200.6220	267.4960	27.25	12.25	0.000571	2.0285	2.7046	202.6505	270.2006	0.000054	4955392	50104
Total	**1350.32**	**102.53993**				**481.0802**	**641.4402**				**6.1394**	**8.1858**	**487.2195**	**649.6261**		**11882748**	**151644**

6.2.3.2 Probable Impact of Proposed Artificial Recharge Structures (Injection Well)

For implementation of rainwater harvesting schemes for artificial recharge to ground water the probable impact on the ground water regime of respective group of aquifers has also been assessed. It is expected that if the prescribed roof top rain water harvesting cum injection well recharge projects are implemented properly then for Gr- I(A) aquifer water level in shallow tube wells may rise by 1.24 to 11.53 m, whereas in tube wellstappingGr-I(B) aquifer, rise in piezometric surface may range from 5.20 to 12.25 m (Table-6.10).

Table – 6.10 : Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime

Name of the Block	Geographical Area (sq. km.)	No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined Aquifers (Table - 6.9: 17)	Amount of water to be recharged in Aquifer Gr.-I(A) (Table-6.9: 7)	Impact on Water Level of Aquifer Gr.–I(A) (rise in m)	No. of RTRWH with Injection Well designed for Gr.-I(B) Confined Aquifers (Table- 6.9: 18)	Amount of water to be recharged in Aq. Gr.-I(B) (Table - 6.9: 12)	Impact on Piezometric Surface of Aquifer Gr.–I(B) (rise in m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	205.32	377315	15.2758	1.24	15058	0.6096	5.20
Baraut	276.86	2031029	82.2274	4.95	21476	0.8695	5.50
Baghpat	210.63	686742	27.8032	2.20	26736	1.0824	9.00
Khekra	160.37	1385614	56.0974	5.83	15833	0.6410	7.00
Pilana	207.14	2446656	99.0543	7.97	22437	0.9084	7.68
Binauli	290.00	4955392	200.6220	11.53	50104	2.0285	12.25
Total	**1350.32**	**11882748**	**481.0802**		**151644**	**6.1394**	

6.2.3.3 Use of Non-committed Surface Run-Off for Injection Recharge & Surface Conservation

Very limited amount of rainfall generated non-committed surface runoff is available, which is insufficient for fully saturating the dewatered part of the Group-I(A) aquifer and to substantially recharge the Gr.-I(B) aquifer as well. However, major part of the non-committed surface runoff may be injected for recharging Group-I(A) aquifer and a smaller amount of it may be allocated for recharging Group-I(B) aquifer and the remaining amount for surface storage/conservation cum irrigation tanks. If unit capacity of one tank is taken as 0.1 MCM (Size-100m x 100m x 5m, Filling-2 times, Capacity–0.1 MCM), the non-committed runoff, remained after using in injection recharge projects, may be storedin 184 tanks to be constructed at suitable locations in the NAQUIM 2.0 area (Table–6.11).

Table – 6.11 :Conservation of Surplus Non-Committed Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds after Artificial Recharge by Injection Wells

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Comm-itted Surface Run-off (by Dhruv-anarayan'93) (MCM)	Surface runoff/ water to be usedfor partly filling storage space Aquifer-I(A) by Injection Well(75% efficiency) (MCM)	Surface runoff/ water to be utilised for partly filling storage space in Aquifer – I(B) by Injection Well (75% efficiency) (MCM)	Volume of WaterLeft for Conservation /Storagecum Irrigation Tanks (MCM)	Capacity of single Conser-vation/ Irrigation Tanks (MCM)	Feasible Num-bers of Conser-vation/ Irrigation Tanks (6) / (7)
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Chhaprauli	205.32	15.59149	11.250	1.734	2.60749	0.1	26
Baraut	276.86	21.02406	15.400	2.103	3.52106	0.1	36
Baghpat	210.63	15.99472	10.750	2.079	3.16572	0.1	32
Khekra	160.37	12.17810	8.250	1.510	2.4181	0.1	25
Pilana	207.14	15.72969	10.250	2.283	3.19669	0.1	32
Binauli	290.00	22.02188	15.000	3.799	3.22288	0.1	33
Total	**1350.32**	**102.53993**	**70.900**	**13.508**	**18.13193**		**184**

6.2.3.4 Utilization of Conserved Water and Creation of Additional Irrigation Potential

A considerable volume (assumed as 25%) of the water stored in surface conservation structure is lost through evaporation. Due to presence of surface clay at the bottom of the conservation structures i.e. ponds and tanks the percolation loses of water would be negligible. If the remaining water is utilized for direct irrigation for Rabi crops like Mustard, Wheat, Vegetables etc. and average required delta factor is considered as 30 cm, then **4532.986Ha** additional irrigation potential can be created (Table-6.12).

Table – 6.12: **Additional Irrigation Potential to be Created from Storage cum Irrigation Tank**

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Comm-itted Surface Runoff Available (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)	Evapo-ration loss (25% of storage) (MCM)	Remaining Water can be utilized for Irrigation (MCM)	Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank taking average CWR as 30 cm for Rabi crops: Wheat, Mustad, Vegetables etc.	
						Sq. Km.	Ha
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	205.32	15.59149	2.60749	0.651873	1.955618	6.51873	651.873
Baraut	276.86	21.02406	3.52106	0.880265	2.640795	8.80265	880.265
Baghpat	210.63	15.99472	3.16572	0.79143	2.37429	7.9143	791.43
Khekra	160.37	12.17810	2.4181	0.604525	1.813575	6.04525	604.525
Pilana	207.14	15.72969	3.19669	0.799173	2.397518	7.99173	799.173
Binauli	290.00	22.02188	3.22288	0.80572	2.41716	8.0572	805.72
Total	**1350.32**	**102.53993**	**18.13193**	**4.532986**	**13.59895**	**45.32986**	**4532.986**

6.2.4 Final Implications of Management Interventions (Demand & Supply) in Irrigation Sector

By demand side management intervention in cropping pattern through reduction of 10% sugarcane area (Table-6.7A: Col.-20) **28340.66** Ha agricultuaral land can be additionally irrigated and by supply side management intervention through collecting a part of non-committed surface run-off in storage tanks/ponds**4532.986 Ha**extra irrigation area may be created (Table–6.12: Col.- 8). It is observed that 100% of the remaining cultivable landunderNAQUIM 2.0 area would easily be brought under assured irrigation only bythewater collected from rainwater harvesting as non- committed surface run-off and then stored in surface conservation structure such as irrigation tanks/farm ponds.

Considering 100% of NAQUIM 2.0 area as recharge-worthy, artificial recharge through injection of**70.90 MCM** 'non-committed surface run-off' as source water into the shallow Group-I(A) aquifer can increase the dynamic ground water resource by **53.1750 MCM** and lower the Stage of Ground WaterExtruction(SoE) in NAQUIM 2.0 area from existing **97.12%** (2023) to **83.84%**. On the other hand, from changing in cropping pattern through releasing 10% sugarcane area and allotting that area fully to Rice in Kharif season and then in Rabi season to wheat, mustard and vegetables in equal proportion, **101.2527 MCM** ground water may be saved and consequently may lower the stage of extraction (SoE) from existing **97.12%** (2023) to **74.61%** due to increase in annual extractable ground water resource. So, collectively by the 'supply side intervention' through artificial recharge with injection wells and 'demand side intervention' through changing the cropping pattern, the total effective increase in dynamic ground water reserve in shallow unconfined Group–I(A) aquifers may be **154.4327 MCM,** which can eventually lower the Stage of Ground Water Extraction from **97.12%** (2023) to **66.51%** (Table-6.13).

As per the 5th Minor Irrigation Census 2020-21 data in respect of NAQUIM 2.0 area, the cumulative cultivable area is **106690Ha** out of which **102630** Ha is the total Culturable Command Area (CCA), where the irrigation facility has already been generated by all the existing ground water and surface waterbased irrigation structures. The remaining **4060 Ha**of Cultivable Area is yet to be brought under Culturable Command Area through obtainingthe assured irrigation facility.

As a collective outcome of both the supply side intervention through irrigation from conservation cum irrigation tanks/ponds (**4532.986 Ha**) and demand side intervention through allocation of ground water saved by 10% curtailment of sugarcane for irrigation (**28340.66 Ha**) of other low CWR crops a cumulative **32873.6457** Ha agricultural land can be irrigated additionally.Therefore, by these two types of management interventions, **100%** of remaining unirrigated cultivable area can be brought under Cultural Command Area (CCA) i.e. under assured irrigation and additional**30.80%** of total presentcultivable area can be irrigated with an increase of **32.02%** in present CCA. In respect of total NAQUIM 2.0 area, enentheextra irrigation potential amounting **4532.986 Ha** generated by supply side intervention can singly and absolutely cover the whole remaining unirrigated area of **4060 Ha**withassured irrigation by the water to be stored in the surface conservation tanks/ponds from a part of non-committed surface run- off(Table–6.14).

Table–6.13:**Expected Improvement of GW scenario due to Artificial Recharge of Unconfined Aquifers Gr.–I(A) over the whole NAQUIM 2.0 area with part of Non-committed Surface Run-off (Supply Side Intervention) and Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extract-able Ground Water Resource (Ham) {Table - 6.7(C)}	Total Current Annual Ground Water Extra-ction (SoE) (Ham) {Table - 6.7(C)}	Existing Stage of Dynamic GW Extrac-tion as per GW Resource Estima-tion (GEC'15) as on March 2023 (%) {(3) / (2)} x 100	Part Storage Space for Recharge/ Volume of Water to be stored in to Aquifer I(A) throughout 100% of NAQUIM 2.0 area to Enhance Dynamic GW Resource (Ham) from Table-6.9(7)	Allocated Source Water from Non-Commi-tted Surface Runoff for Rechar-ging Aquifer - I(A) (Ham) {Table-6.11: (4)}	Actual amount of water to be rechar-ged in Aquifer Gr-I(A) (Ham) (75% of Source Water) (6) x 0.75	Impro-ved Stage of Ground Water Extrac-tion (%) singly by Artifi-cial Rech-argefrom non-comm-itted surface run-off through Injec-tion Well [(3)/ {(7) +(2)}] x 100	Effective Saving of Ground Water by Cropping PatternChange byGrowing Kharif Rice on the whole land area freed by 10% reduction of sugarcane and also through distribution of 10% Sugar-cane area to mustard, wheat and vegetables in 1:1:1ratioin Rabi Season {Table-6.7(C): col.-20} (Ham)	Impro-ved SoE singly by Saving of Dynamic GW Resource by Cropp-ing Pattern Change assuming that Shallow Aquifer I(A) being used for Sugar-cane [(3) / {(9) + (2)}] x 100 (%)	Total Effective Increase in Ground Water Reserve due to Artificial Recharge and Change in Cropping Pattern (Ham) {(7) +(9)}	Cumu-lative Improve-ment in SoE due to both Artificial Recharge and Saving through Change of Cropping Pattern (%) [(3) / {(2) + (11)}] x 100
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Chhaprauli	6300.77	4688.41	74.41	1527.58	1125.00	843.75	65.62	1696.85	58.62	2540.60	53.03
Baraut	7883.09	6157.34	78.11	8222.74	1540.00	1155.00	68.13	2117.24	61.57	3272.24	55.20
Baghpat	5003.63	4420.10	88.34	2780.32	1075.00	806.25	76.08	1497.59	67.99	2303.84	60.49
Khekra	3762.30	4554.84	121.07	5609.74	825.00	618.75	103.97	1070.65	94.25	1689.40	83.55
Pilana	4364.88	5700.20	130.59	9905.43	1025.00	768.75	111.04	1566.61	96.10	2335.36	85.07
Binauli	6235.91	7064.32	113.28	20062.20	1500.00	1125.00	95.97	2176.83	83.97	3301.83	74.07
Total	**33550.58**	**32585.2**	**97.12**	**48108.02**	**7090.00**	**5317.5**	**83.84**	**10125.77**	**74.61**	**15443.27**	**66.51**

Table - 6.14 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geogra-phical Area (Ha)	Total Cultivable Area (Ha)	Total CCA (As per MI Census-5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation Facility (Ha) (3) – (4)	Additional Irrigation Potential Created by Harvesting Surface Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A)& Group-I(B) aquifers considering its feasibility in 100% area) and by Changing Cropping Pattern (Ha) {data from Table – 6.7 (A) & 12}			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Intervention {(8/5) * 100}	Percent (%) of Total Cultivable Land where Irrigation Potential can be Created additionally by Management Intervention {(8/3) * 100}	Percent (%) of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Manage-ment Inter-vention {(8/4) * 100}
					Increase in Irrigation Area using Harvested Run-off Water Stored in conservation cum Irrigation Tanks (Ha) {Table-6.12:(8)}	Increase in Irrigation Area by Water Saved through Change in Cropping Pattern (Ha) {Table - 6.7(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Chhaprauli	20532	17380	16626	754	651.8730	4647.1314	5299.0044	> 100	30.49	31.87
Baraut	27686	20664	20098	566	880.2650	6078.7657	6959.0307	> 100	33.68	34.63
Baghpat	21063	17002	16215	787	791.4300	4064.8962	4856.3262	> 100	28.56	29.95
Khekra	16037	17274	16753	521	604.5250	3047.7990	3652.3240	> 100	21.14	21.80
Pilana	20714	13876	13214	662	799.1730	4252.2271	5051.4001	> 100	36.40	38.23
Binauli	29000	20494	19724	770	805.7200	6249.8438	7055.5638	> 100	34.43	35.77
Total	**135032**	**106690**	**102630**	**4060**	**4532.9860**	**28340.6632**	**32873.6492**	**> 100**	**30.81**	**32.03**

6.2.5 Feasibility and Construction Cost of Artificial Recharge & Conservation Structures

Post-monsoon water level, long term trend of water level, stage of ground water extraction and categorization of assessment units (administrative blocks) are given due importance in identifying the area feasible for artificial recharge. For formulating the artificial recharge proposal, the post-monsoon average depth to water level maps and long-term trend in water level map has been superimposed over administrative block boundaries to identify the most feasible area for recharge. The entire NAQUIM 2.0 area of Baghpat district shows post-monsoon water levels more than 5 m bgl with the long-term falling trend more than 20 cm/year and all the blocks are of OCS category, which fulfills the standard criteria for suitability of artificial recharge in thisOlderAlluviumPlains.

As the unconfined to semi-confined Aquifer Gr.-I(A) is very thick and in most of the areas almost30 to 40% of its thickness on top remains unsaturated throughout the year along with the post monsoon water level generally around 20 m bgl, it is practically not possible to refill/recharge the full unsaturated portion of the aquifer in between 5 m bglandpost-monsoon water level due to unavailability of sufficient amount of source waterfrom non-committed surface run-off. So,it has been recommended to make an attempt for filling a small part of the unsaturated thickness at the bottom. On the other hand, as the Aquifer Gr.-I(B) is purely confined,althoughthe depth of post- monsoon water level i.e. piezometric surface throughout the year remains more than 20 m bgl, a large-scale recharge of ground water through injection wells is not that much feasible. Thickness of Aquifer-I(A) to be saturated by recharge is calculated by dividing quantity of water with area and specific yield. In recharge of Aquifer-I(B), rise in piezometric surface is calculated by dividing quantity of water with the area and storativity of this confined aquifer. Volume of source water applied for recharge should be more than the actuallyrecharged and stored water in the specific volume of aquifer as the efficiency of recharge structures is usually taken as 75%, which means 75% of injected source water would be stored and retained in the aquifer.Themeagerness of source water owing to inadequate rainfall leads to a significant challenge informulating a sustainable and efficacious management plan.

The cumulative volume of small parts of the storage spacesavailable in the Group–I(A) and Group–I(B) aquifers amounts to be **487.2195 MCM,** which isproposed to be filled (Table–6.9). Considering the whole NAQUIM 2.0 area as suitable for artificial recharge and the efficiency of recharge structure as 75%,an amount of**649.6261 MCM**source water would be required (Table– 6.9). However, the non-committed surface run-off calculated by Dhrubanarayan'93 method and available as the source water for recharge and conservation activities is **102.53993MCM**, which is only 15% of the total source water requirement for the proposed partial filling of the Group-I(A) & I(B)Aquifers.

According to the geomorphology of the area and due to lack of suitable big sized unused land and limited source water/surface run-off, the percolation tank may not be feasible in this area. So, the REET with RS and surface conservation ponds have been suggested here. Average unit cost of construction of the structures are: REET with Recharge Shaft–**8 Lakh**, Farm Pond–**8 Lakh** and Injection Well– ranging from **5 to 25 Lakhs** depending upon the depth of drilling and the nature of formation (cost is estimated as: for **300 m** depth**- 15 Lakhs, 200 m** depth**- 10 Lakh** and for **100 m** depth**– 5 Lakh)** (Table– 6.15).

In **Model-I**of the '**Supply Side Intervention'** suggested for usingthe source water containing totalamount of non-committed surface run-off (**102.53993 MCM)** has been allocated tothree most feasible artificial recharge structures inastandard way: **35%** to **'REET'** (Re- Excavation of Existing Tanks with Recharge Shaft), **30%** to **Injection Wells**and**35% water** to small **Farm Ponds**or **Conservation Tanks.**For utilizing theseallocated amounts of water **271 nos. Re-excavation** of **Existing Tanks**, **79 nos. Injection Wells**for Aquifer Gr-I(A) and **360 nos. Farm Ponds**have to be constructed as per the availability of suitable sites evenly spread all over the NAQUIM 2.0 area, which mayincur an expenditure of **Rs. 54.43 Crore**at the rate of Rs. **5.31** per**CuM**water i.e. an expenditure of Rs. 5.31 for recharging one cubic meter volume of source water(Table–6.15).

In **Model-II** of the **'Supply Side Intervention'**suggestedforutilization oftheavailablenon-committed surface run-off (**102.53993 MCM)**,it has been recommended that the major part of thissource water may be devided into two parts: **70.90 MCM** for the shallowinjection wells and **13.508 MCM** for the intermediate depth injection wells in order to partially recharge the Group- I(A) and Group-I(B)Aquifers respectively.After accomplishing the feasible artificial recharge to both the Group-I(A) and Group-I(B) aquifers, in order to accommodate the remaining**18.13193 MCM**of water, construction of a sufficient number of the surface storage/conservation tanks/farm ponds has been recommended. Water stored in tanks/ponds can later be utilised for irrigation of the Rabi/Summer crops like wheat, mustard, vegetables as and when requiredduring lean period.

So, as per**Model–II** of **'Supply Side Intervention'**, out of **102.53993 MCM** of total 'non-committed surface run-off' **70.900 MCM** water is suggested to be used for filling up a very small part of unsaturatedvacant space in Aquifer Group-I(A) and **13.508 MCM** of water may be allocated for partly recharging the Aquifer Group-I(B). In order to accomplish this artificial recharge work, **239 nos. Injection Wells** for Group-I(A) aquifers and **46 nos. Injection Wells** have to be constructed for Group-I(B) aquifers. After injecting a total **84.408 MCM**waterforrecharging the aquifers**,** the remaining **18.13193 MCM** water may be stored in **184 nos.**

Farm Ponds or **storage cum irrigation tanks**. For construction of these recharge and conservation structures (injection wells and farm ponds), the total expenditure would be **Rs. 31.27 Crore** andthe rate of expenditure would be **Rs. 3.05** per**CuM**of water**,** which means an amount of Rs. 3.05 has to be spent for utilising one cubic meter source water in the projects of articicial recharge and conservation (Table–6.16).

Keeping in view the geomorphological and hydrogeological set-up, land use and land cover, aquifer geometry and characteristics, availability of source water, ease of construction of various structures suggested and overall efficacy and longevity of the structures in the NAQUIM 2.0 area of Baghpat district, the Model-I of the 'Supply Side Intervention' through artificial recharge and conservation of water is more viable than Model-II, although the expenditure rate for enhancing the water resoureces as a whole under the Model-I is higher than that estimated under Model-II.In Model-I focus has been given absolutely on the most endangered Aquifer–I(A) for recharging it as well as saving it from being futher depleted. Moreover, in case of Model-I, scope of storing water on the surface both by re-excavation of existing tanks/ponds and construction of new ponds would be more for easily irrigating more cultivated area in comparison to Model-II.

Table- 6.15: **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Committed Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model–I)**

Block	Geographical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge and Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate of ructures			Total Cost Estimate for construction of artificial recharge and conservation structures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expenditure for Recharging and Conserving 1 CuM(m^3) harvested Source Water) (in Rs.) (14) x 10^5/ (4) x 10^6
				Allocation of 35 % of Source Water forRe-excavation of Existing Tanks with RechargeShaft (REET) to store water on surface and recharge Group-I(A) aquifer (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) for recharging Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Efficiency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% efficiency of Recharging (6) x 0.75/ 0.30	Nos. of Farm Ponds (7)/0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakhper unit (Rs. in Lakh) (8) x 8	Cost of Construction of Injection Well Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh) (9) x 5	Cost of Construction of Farm Ponds @ Rs. 8 Lakhper unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Chhaprauli	205.32	Sandy loam & minor loam, Sand	15.59149	5.457022	4.677447	5.457022	41	12	55	328	60	440	828	5.31
Baraut	276.86	Sandy loam & minor loam, Sand	21.02406	7.358421	6.307218	7.358421	56	16	74	448	80	592	1120	5.33
Baghpat	210.63	Sandy loam & minor loam, Sand	15.99472	5.598152	4.798416	5.598152	42	12	56	336	60	448	844	5.28
Khekra	160.37	Sandy loam & minor loam, Sand	12.17810	4.262335	3.65343	4.262335	32	10	43	256	50	344	650	5.34
Pilana	207.14	Sandy loam & minor loam, Sand	15.72969	5.505392	4.718907	5.505392	42	12	55	336	60	440	836	5.31
Binauli	290.00	Sandy loam & minor loam, Sand	22.02188	7.707658	6.606564	7.707658	58	17	77	464	85	616	1165	5.29
Total	1350.32		102.53993	35.88898	30.76198	35.88898	271	79	360	2168	395	2880	5443	5.31

Table- 6.16: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in this NAQUIM 2.0 area - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geogr-aphical Area (sq.km.)	Non-Com -mitted Surface Run-off available (Calcu-lated by Dhruvan-arayan'93 Method) (MCM)	Total surface runoff/source water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% of NAQUIM 2.0 area by Injection Wells (IW) (with 75% efficiency) (MCM)	Total surface runoff/ source water to be utilized for partly filling the storage space in Aquifer–I(B) over 100% of NAQUIM 2.0 area by Injection Wells (IW) (with 75% efficiency) (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks/Farm Pond (MCM)	Numbers of Injection Wells to be constructed in Aquifer-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer-I(B) (5) / 0.3	Nos. of Conser-vation/ Storage/ cum Irrigation Tanks/Farm Pond suggested @ 10 Ham Storage Capacity per unit (6) / 0.1	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh per unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-I(B) @Rs.10 lakhs per unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conser-vation/ Storagecum Irrigation Tanks/ Farm Pond @Rs. 8 lakhs per unit (Rs. in Lakh) (9) x 8	Total Cost of all Artificial Recharge and Conser-vation Structures (Rs. in Lakh) (10) + (11) +12	Cost-Benefit Ratio: (Expenditure of Recharging /Conserving 1 CuM (m^3) harvested Source Water) (in Rs.) (13) x 10^5/ (3) x 10^6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Chhaprauli	205.32	15.59149	11.250	1.734	2.60749	38	6	26	190	60	208	458	2.94
Baraut	276.86	21.02406	15.400	2.103	3.52106	52	7	36	260	70	288	618	2.94
Baghpat	210.63	15.99472	10.750	2.079	3.16572	36	7	32	180	70	256	506	3.16
Khekra	160.37	12.17810	8.250	1.510	2.4181	28	5	25	140	50	200	390	3.20
Pilana	207.14	15.72969	10.250	2.283	3.19669	35	8	32	175	80	256	511	3.25
Binauli	290.00	22.02188	15.000	3.799	3.22288	50	13	33	250	130	264	644	2.92
Total	**1350.32**	**102.53993**	**70.900**	**13.508**	**18.13193**	**239**	**46**	**184**	**1195**	**460**	**1472**	**3127**	**3.05**

SUMMARY AND FINDINGS

1. The NAQUIM 2.0 area comes under the alluvial plains in north-western part of Uttar Pradesh and comprises all the 6 blocks of Baghpat district, which area water stressed and belong to OCS category. The area has a uniform topography and lithology and homogeneous soil.

2. The whole NAQUIM 2.0 area is covered by Quaternary sediments comprising mainly Older Alluvium in major part and also Younger Alluvium in small near the rivers.

3. Ground water in entire NAQUIM 2.0 area occurs in the aquifers under unconfined, semi confined and confined condition and separated by some thick persistent clay layers.

4. In general, the thickness of Quaternary sediment increases from North-West and West to South-East and East direction in NAUIM 2.0 area. There is a huge vertical and lateral variation in grain size of the formation materials across the area. Besides, aquifer percentage (thickness) within the individual aquifer groups also varies considerably. The correlation of stratigraphic units reveals an undulating depositional surface.

5. The NAQUIM 2.0 area is covered by a very fertile soil and thus quite rich in agriculture specially in sugarcane cultivation, which occupies morethan 70% of cultivable land.

6. At present agriculture accounts for 70 to 80% of the total water requirement and only 20 to 30% goes for the domestic, livestock and industrial uses. In coming years, the domestic needs may go up to be 40% of the total water requirement of the district.

7. The first confined aquifer is generally encountered between 90 and 110 m and the water table in upper unconfined aquifer usually remains less than 35 m bgl throughout the year with wide spatial and seasonal variation. In riverine ‘Khaddar’ tract the water table happens to be shallow due to seepage activity whereas the heavy clay beds of ‘Bhangar’ have deeper water table.

   During pre-monsoon 2023, depth to water level in key wells tapping shallow Aquifer Group-I(A) ranges from 8.75 to 42.51 m bgl (Average: 23.47 mbgl), whereas the block wise average water level varies from 16.55 to 28.98 m bgl. During pre-monsoon, in 48% wells water level was less than 20 mbgl, in 24% wells 20 to 30 mbgl and in 28% wells more than 30 mbgl. Water level during post-monsoon 2023 varies from 5.87 to 34.25 mbgl and the block wise average varies from 16.24 to 26.53 m bgl. Seasonal fluctuation of water level was ranging from (-3.40) to (+15.54 m) and for major parts of NAQUIM 2.0 area except Pilana block, it is 0 to (+)2 m.

Old ground water abstraction structures tapping the Aquifer Group–II are very rare in NAQUIM 2.0 area of Baghpat district. Only two tube wells tapping this aquifer were found during pre-monsoon field work and monitored at Pilana, block–Pilana (27.53 m bgl) and Tikri, block – Chhaprauli (33.24 m bgl).

However, some drinking water tube wells newly constructed in Aquifer-I(B) under Jal Jeevan Mission (JJM) could be monitored.The block wise average depth to water level (Piezometric Surface) in these wells (JJM) ranges from 21.12 to 28.80 mbgl during pre-monsoon and from 20.20 to 27.25 mbgl during post-monsoon.Block wise average seasonal fluctuation of piezometric surface in Aquifer–I(B)ranges from 0.80 to 1.83 m, which indicates that the Aquifer-I(B) is still not being developed up to the optimum scale and thus it is not at all stressed in terms of ground water extraction.

8. Long term water level data related to aquifers of both Group-I(A)&I(B) are not sufficiently available due to absence of any persistent ground water monitoring well. Only 2 nos. of wells (National Hydrograph Network Stations) namely Khekra (Khekra block) and Pilana (Pilana block) and tapping Aquifer Group–I(A)were available in the recent past for long term water level monitoring, which show a long-term (2014 to 2023) continuous declining trend of water level in the tune of 0.75 m/year and 0.80 m/year respectively.The shallow Aquifer Group-I(A) is experiencing a steady long-term decline of water level/water table over the years and thus being permanently being de-watered/de-saturated. However, no suitable ground water structures tapping Group-II, III or IV was available before for long term monitoring.

9. The general and regional ground water flow is from NW to SE and W-NW to E-SE. However, due to variation of development magnitude in a local scale, the localised flow direction has been modified by the formation of some ground water troughs.

The shallow aquifers adjacent to the river Yamuna and Hindon are very thick and prolific due to existence of course granular materials. The northern, north-western and western fringe areas of Baghpat district may be considered as natural recharge area and especially the area all along river Yamuna i.e. along western boundary is locally a very good recharge zone where water table in Group–I(A) aquifer ranges from 12 to 15 m bgl, whereas the rest part of the district may be treated as natural discharge area.

Yamuna River, flowing along the western boundary of NAQUIM 2.0 area, shows its influent nature in the south for the major portion of its length. Therefore, it is feasible to construct a series of shallow tube wells on the left bank of Yamuna along its course in order to facilitate the induced recharge and for balancing of ground water storage with the extraction from the shallowest unconfined Group- I(A) aquifer.

Hindon, a highly polluted river due to discharge of huge industrial wastes, is flowing along the eastern boundary of the NAQUIM 2.0 area and showing its effluent nature for major portion of its length in the north. A large ground water trough area covering major parts of Pilana and Khekra blocks and southern part of Binauli block has been created due to excessive withdrawal of ground water locally for irrigation, due to which the adjacent portion of Hindon River course situated in the south section of eastern boundary of NAQUIM area has become influent. Consequently, this elongated stretch has become vulnerable in terms of pollution of ground water in shallow aquifers as the river may contribute contaminated water to the neighboring shallowest aquifers, which are sometimes extending even up to the ground surface. So, construction of any kind of tube well for induced recharge or further construction of shallow irrigation tube wells in huge numbers on the right bank of Hindon, especially in the southern section, should be prohibited as the induced recharge due to these proposed tube wells may pollute the ground water presently available through existing drinking water tube wells and other shallow tube wells, which is occasionally being reported by the villagers.

The whole NAQUIM 2.0 area especially along a large expanse trending NNE to SSW falling in Binauli, Pilana and Khekra blocks is highly feasible for artificial recharge in Aquifer-I(A) as the respective ground water level in this locality invariably remains above 20 m bgl throughout the year and there is long-term water level decline from 0.75 to 0.80 m/year.

10. From the geophysical study including Vertical Electrical Sounding (VES), Bore Hole Electrical Logging (SP, Long Normal, Short Normal & Gamma Log), TEM and 2D Electrical Resistivity Tomography (ERT), it has been interpreted that a very prominent and regionally extensive near-surface freshwater aquifer (Aquifer Group-I(A)) is present throughout the NAQUIM 2.0 area. It extends normally up to 166 m in the extreme eastern and north-eastern parts adjacent to the right bank flood plain of River Hindon, which ranges from 70 to 114 m in the western and south-western parts adjacent to the left bank flood plain of River Yamuna.

Resistivity values of Aquifer Group-I materials vary between 25 and 50 ohm.m with thickness ranging from roughly 60 m in south-western part to about 180 m in north-eastern part. Lateral variations in resistivity of aquifer materials along east-west trend as interpreted from data of 2D resistivity imaging through Electrical Resistivity Tomography (ERT) indicates granularity differences, inhomogeneity in lithofacis and localized thinning and thickening of aquifers in the order of tens of meters. The vertically measured resistivity values of aquifer materials/granular zonesdecline with depth, ranging from approximately 40 ohm.m for Aquifer Group-1 to 15 ohm.m for Aquifer Group-IV, which indicates a distinctive decrease of grain size with depth.

11. Broadly four (4) groups of aquifers are identified and classified on the basis of hydrogeological, geophysical and chemical characteristics of aquifer materials and ground water and the depositional environment as well within the maximum explored depth of 473 m. Aquifer Group-I : from 0.0 down to 59 m (min.) and to 166 m bgl (max.); Aquifer Group–II : starts from 84 m (min.), extends up to 301 m bgl (max.); Aquifer Group–III : starts from 215 m (min.), extends up to 404 m bgl (max.) and Aquifer Group –IV : starts from 316 m (min), extends up to 473 m bgl (maximum explored depth). Aquifer Group-I is again divided into two parts-I(A) (unconfined to semi-confined; occur from 0.00 to 80 m bgl max.) and I(B) (confined; occur from 55 m bgl min. to 166 m max.). Aquifers are separated by prominent and regionally extensive thick claybeds (> 10 m).

12. The Group-I aquifers exist within a depth span of 0.00 to 166 mbgl over the whole NAQUIM 2.0 area on the top with an average yield potential generally ranging from 1557 to 3458 lpm with the average drawdown ranging from 4.53 to 7.15 m. Hydraulic Conductivity (K) in Aquifer Group-I(A) measured at a location is 49 m/day, whereas in Aquifer Group-I(B) at another site it is 19.5 m/day. Transmissivity (T) of Group-I(A) aquifer varies from 1712 to 2458 m^2/day and that of Group-I(B) ranges from 474 to 1500 m^2/day. The storativity (S) of Aquifer–I(B) ranges from $2.438x10^{-5}$ to $2.5x10^{-3}$, which indicates that Group-I(B) aquifers is confined in nature. Both the Aquifer Group-I(A) and I(B) are extensive and potential in terms of ground water yield. Tube wells constructed by tapping Group-II aquifers, occurring from 84 m and continues up to 301 mbgl, have yield ranging from 1987 to 2300 lpm with drawdown widely varying from 6.30 to 14.44 m. Transmissivity range is 270 to 837 m^2/day with hydraulic conductivity ranging from 4.38 to 12.50 m/day and Storativity from $7.75x10^{-4}$ to$1.26x10^{-3}$.A very less numbers of tube wells have been constructed in NAQUIM 2.0 area through tapping the Group-III aquifers due to its high expenditure as it occurs in the depth span 215 to 404 m and availability of sufficient water in the overlying shallower aquifers of Group I(B) and Group-II.

Thus, from a meagre available data it is noticed that yield of the tube wells tapping Group-III aquifers having a yield range 1360 to 2200 lpm with a varied range of drawdown from 25.55 to 9.22. Transmissivity varies widely from 345 to 2285 m^2/day with a hydraulic conductivity varied largely from 3.5 to 23 m/day, whereas Storativity spans from $7.70x10^{-4}$ to $5.63x 10^{-3}$.

Further lesser numbers of tube wells are available in NAQUIM 2.0 area of Baghpat district which are constructed by tapping deepest Aquifer Group-IV occurring from 316 m to 473 m and beynd, the maximum explored depth although it is considerably potential in terms of yield, which varies from 2100 to 2200 lpm with an associated drawdown ranging from 12.52 to 22.62 m. This Group of aquifers has a comparatively lower Transmissivity value extending from only 301 to 763 m^2/day with Hydraulic Conductivity from 3.0 to 7.60 m/day and the Storativity value ranging $2.1x10^{-4}$ from $5.1x10^{-4}$.

13. As perthe Dynamic Ground Water Resources for the whole NAQUIM 2.0 area as on March 2023 estimated through GWRE 2015 methodology, the Annual Extractable Ground Water Resource is **33550.58** Ham (335.5058 MCM), Current Total Annual Ground Water Extraction for all purposes is **32585.21** ham (325.8521 MCM) and the overall Stage of Ground Water Extraction is **98.02%.** After allocating **2597.17 Ham** water resources for domestic use as on 2025, the Net Annual Ground Water Availability in the NAQUIM 2.0 area of Baghpat district for future use like Irrigation and Industrial Use is calculated to be **3880.84 Ham**. As per the block wise Stage of Ground Water Extraction ranging from **74.41%**(Chhaprauli) to **130.59%** (Pilana), the administrative blocks are categorized as follows –Khekra, Pilana and Binauli blocks are coming under **'Over-exploited'** category and Chhaprauli, Baraut and Baghpat blocks are **'Semi-Critical'**. In comparison with the GWRE 2017 and 2022, the GWRE 2023 showed a bit improvement as the category of Baghpat block has been changed from Critical to Semi-Critical. However, all the 6 blocks are remaining in OCS category since 2017. Available in-storage resource in Aquifer Group-I(A) and Aquifer Group-I(B) are **294.13 MCM** and **44.525 MCM** respectively. The seasonal change (pre-monsoon to post-monsoon) in in-storage resource of Aquifer-I(B) is 0.588275 MCM, which is very insignificant.

14. Ground water is of mixed type and mostly of Magnesium Bi-Carbonate type ($Mg – HCO_3$) and slightly alkaline in nature with average pH value 7.83. The ground water in Aquifers of Group-I(A) and I(B)in the NAQUIM 2.0 area is generally freshand potable as all the chemical constituents in the ground water are generally found to be well within maximum permissible limit except a very sporadic occurrence of Fluoride, Iron and Uranium above maximum permissible limit and thus mostly suitable for drinking as per BIS 10500:2012 Standard.The ground water is also highly suitable for irrigation purpose. No significant seasonal (pre-monsoon to post-monsoon period) variation in chemical quality of ground water has been noticed except the dilution of some elements.

Colossal and indiscriminate withdrawal of ground water from shallow unconfined aquifers for crop irrigation and continuous declining of water level along with permanent de-watering of this aquifer may have triggered the release of uranium by enhancement of its solubility and enrichment in the ground water at shallow depths under the induced oxidizing condition occurring within the alluvium formation. Presence of bicarbonates chemicals in higher concentration further enhance the solubility and enrichment of uranium in ground water. Uranium (U) contamination (above the maximum permissible limit of 0.03 mg/lt) has been noticed in ground water available through Indian Mark-II hand pumps (30 to 65 m depth) at many places across different blocks.

15. For drinking water Aquifer-I(A) is used through government/private hand pumps, while Group-1B aquifer is used through construction of heavy-duty deep tube wells for community water supply by UP Jal Nigam, the concerned State Govt. Agency. The Group-I(A) aquifer is extremely stressed and being constantly depleted due to heavy indiscriminate use for cultivation of sugarcane (occupying 80% of the cropped area in the district) and sometimes other high crop water requiring crops like paddy.

16. For aquifer wise management of ground water in NAQUIM 2.0 area of Baghpat district the following plan may be implemented in the irrigation sector, which recommends that the total requirement of irrigation water should not be fulfilled solely from Aquifer Gr-I(A) as being done currently, only 60% of irrigation water demand should be fulfilled from Group–I(A) and the rest 40% from Group–I(B) aquifers. All the large diameter and heavy-duty govt. deep tube wells for irrigation should be constructed preferably by tapping the Aquifer Group–I(B)only and if funds allow, then by tapping Group–II aquifers also. Ground water withdrawal from highly stressed Group-I(A) aquifers should also be lessened by 'demand side interventions', such as (i) changing of cropping pattern by reducing the cultivation of sugarcane and growing low CWR crops like Wheat, Mustard, Vegetables, Pulses etc. on the agricultural lands released through curtailing sugarcane farming and (ii) practicing micro-irrigation methods like sprinkler and drip irrigation in large scale and also by 'supply side interventions' for enhancement of water storage above the ground surface through conservation structures and below the ground surface through artificial recharge structures or through storage cum recharge structures like (i) construction of farm ponds in large numbers with recharge shaft wherever feasible, (ii) deepening and enlargement through desilting/re-excavationand protection of existing ponds, (iii) construction of new Check Dam, 'Nala Bund', 'Merh Bundi' etc., (iv) construction of soak pit/recharge shaft/injection tube wells or tube wells for induced recharge, (v) recharge shaft/tube wells attached with Roof Top Rain Water Harvesting (RTRWH) structures on all large government/private buildings or houses with a roof area more than 100 m^2.

17. Drinking water supply so far is being done with ground water withdrawn both from Aquifer Group–I(A) and I(B). A population of **521157** is so far covered **o**ut of total Population of

1433353(Projected Human population 2021, average decadal growth rate of the area 10%)**.** So, to meet the further drinking water demand (**13.318 MCM**) of uncovered population (**912196**) by ground water, as far as practicableit is recommended to prefer the Group–I(B) aquifers over Group-I(A) aquifers. As per the stipulation of drinking water policy for sustainable community supply of good quality drinking water from ground water sources, only 40% of drinking water requirement should be fulfilled from shallow Group-I(A) aquifers and the rest 60% demand should be fulfilled by deeper Group-I(B) aquifers. Therefore, it is proposed that 41 tube wells may be constructed by tapping Aquifer Group-I(A) and 49 tube wells are recommended to construct tapping Aquifer Group-I(B). For this proposed withdrawal of ground water for drinking purpose a decline may occur in various administrative blocks ranging from 0.032 to 0.135 m in Group-I(A) and from 5.006 to 21.235 m in case of Group-I(B) aquifers.

In another way, the future demand of the projected human population of 1576688 in 2031 taking a further enhanced rate of 70 LPD/head, 165 nos. of deep tube wells have to be constructed, which may incur an expenditure of Rs. 16.50 Crore. (Table–6.4)

18. Under**'Demand Side Intervention'**, if the highest irrigation water requiring current sugarcane area (**74091 Ha)** is reduced by 10% and consequently ground water saved thereby (**17781.84 Ham)** is distributed proportionately (as per present extent of cultivation) to low water requiring crops such as wheat, 'boro' rice, vegetables and mustard then a total alternative irrigation area **35749.76 Ha** would be generated in lieu of **10% Sugarcane area** andthe effective increase of irrigation area (CCA) could be **28340.66 ha.** By this intervention on water demand by utilising same amount of ground water for low CWR crops, which was earlier being utilized by sugarcane, a total agricultural income of **Rs. 799.6943Cr.** can be generated through cropping pattern change and an effective increase in income i.e. profit of **580.3849 Cr.** may be achieved after compensating the loss due to reduction of 10% sugarcane {Table–6.7(A), 6.7(B)}.

As an alternative way of **'demand side intervention'**, if the land released as a result of 10% reduction of all year-round sugarcane cultivation is allotted for growing rice in Kharif season and then in subsequent Rabi season, if it is allotted in equal proportion to three most viable low water requiring crops like mustard, wheat and vegetables then an effective gain/profit of **Rs.48.9608 Crore** can be attained and as an added benefit an effective saving of ground water would be **101.2577 MCM** which may in turn help in lowering the average Stage of GW Extraction (SOE) of the district from **97.12 %** (2023) to **74.61%** and an average rise of water level around **1.25 m** may also be noticed in Aquifer-I(A) of NAQUIM 2.0 area{Table–6.7(C)}.

19. The total Non-committed Surface Run-Off of the whole NAQUIM 2.0 area in Baghpat district amounting **102.53993 MCM** is considerably low**,** which may fill up only the small parts of the vacant spaces **481.0802** MCM and **6.1394** MCM existing respectively in Group-I(A) and I(B) aquifers because total filling of these spaces actually needs **641.4402 MCM** and **8.1858 MCM** source water respectively. For filling of these specified vacant spaces of the Group-I(A) and Group-I(B) aquifers all over the whole NAQUIM 2.0 area, construction of **11882748** nos. Roof Top Rain Water Harvesting (RTRWH) structures associated with necessary nos. of injection wells for Group– I(A) and **151644** RTRWH structures with necessary nos. of injection wells for Group–I(B) aquifers would be required. If these artificial recharge schemes with RTRWH and injection wells is implemented, then block wise rise of water level/piezometric surface may range from 1.24 to 11.53 m and 5.20 to 12.25 m for Gr.–I(A) & I(B) aquifers respectively. (Table–6.8, 6.9 & 6.10)

20. Out of total Non-committed Surface Run-off amounting **102.53993 MCM**, according to the recharge feasibility, vacanct space and aquifer type, **70.900 MCM** source water may be allotted for injection well recharge into Group-I(A) aquifers and **13.508 MCM** for injection well recharge into Group-I(B) aquifers. For holding remaining source water amounting **18.13193 MCM,** 184 nos. of conservation cum irrigation ponds/tanks should be constrcted specially in rural sector of the NAQUIM area. After 25% evaporation loss, the residual **13.59895 MCM** water may be utilized for bringing an additional **4532.986 Ha** cultivable land under assured irrigation facility in future. (Table– 6.11 & 6.12).

21. Considering 100% area as recharge-worthy, injecting 70.90 MCM 'non-committed surface run-off' (source water) into shallow Group- I(A) aquifer would increase of resource by **53.1750 MCM** and lowering Stage of GW Extruction in NAQUIM 2.0 area from existing **97.12%** (2023) to **83.84%**. Alternatively, from changing cropping pattern through releasing10% sugarcane area and allotting that area fully to Rice in Kharif season and then in Rabi season to wheat, mustard and vegetables in equal proportion, **101.2527 MCM** ground water may be saved and consequently may lowerthe stage of extraction (SoGE) from existing **97.12%** (2023) to **74.61%** due to increase in annual extractable resource. So, collectively by the 'supply side intervention' through artificial recharge with injection wells and 'demand side intervention' through changing cropping pattern, the total effective increase in dynamic ground water reserve in Group– I(A) aquifers may be **154.4327 MCM,** which can eventually lower the Stage of Ground Water Extraction from **97.12 %** (2023) to **66.51%.** (Table-6.13)

22. Out of total Cultivable Area of **106690 Ha**, **4060Ha** land is yet to be brought under Culturable Command Area (CCA) of irrigation. A cumulative **32873.6457** Ha CCA can further be generated in NAQUIM 2.0 area by management intervention through changing cropping pattern by 10% reduction of sugarcane (**28340.66 Ha**) (Table-6.7A) and harvesting non-committed surface runoff through storage tanks (**4532.986 Ha**) (Table-12). Thus, as a collective effect/impact of both the 'supply side intervention' and 'demand side intervention', after bringing 100% of the remaining cultivable land under culturable command area, a huge amount of water may still remain as surplus. By implementing the above-mentioned management intervention procedures, additionally **30.81%** of cultivable area can be brought under assured irrigation, where as a **32.03%** increase in present CCA may be achieved. (Table–6.14)

23. As per the **Model–I** of 'supply side intervention' the 'non-committed surface run-off' amounting **102.53993 MCM** may also be fully distributed in a ratio, generally suitable and prescribed for alluvial terrain, among the artificial recharge structures like Re-excavation of Existing Tank (REET-**35%**) along with Recharge Shaft (RS), Injection Well (IW-**30%**) and conservation structures like Farm Pond (FP-**35%**) and accordingly **271 nos.** Re-excavation of Existing Tanks, **79 nos.** Injection Wells and **360 nos.** Farm Ponds may be constructed, which would incur an expenditure of **Rs. 54.43 Crore** and the rate of expenditure for utilizing 'non-committed surface run- off' for enhancing water resource by 'supply side intervention' would be **Rs. 5.31 per CuM** of water (Table–6.15).

As the **Model–II** of the proposed tool for'supply side intervention', out of the insufficient **102.53993 MCM** of total 'non-committed surface run-off' **70.900 MCM** water may be used for filling up a very small part of vacant storage space in Aquifer Group-I(A) and **13.508 MCM** of water may be allocated to partly recharge the Aquifer Group-I(B), for which **239 nos. Injection Wells** have to be constructed for recharging Group-I(A) aquifers and **46 nos. Injection Wells** have to be constructed for Group-I(B) aquifers. After injecting the major amount of run-off water (**84.408 MCM**), the remaining **18.13193 MCM** water may be stored in **184 nos. Farm Ponds** or **storage cum irrigation tanks**. For construction of all these feasible and recommended structures (i.e. injection wells and farm ponds), the cost would be **Rs. 31.27 Crore** and the rate of expenditure for utilizing 'non-committed surface run-off' for enhancing water resource through 'supply side intervention' would be **Rs. 3.05 per CuM** (Table–6.16).

24. Periodic monitoring of the ground water level and quality in this NAQUIM 2.0 area of Baghpat district is highly recommended in order to detect the adverse effects/changes in the ground water regime in terms of its resource and pollution due to natural and ubiquitous dynamic activities and anthropogenic activities related to ever-increasing ground water draft for fulfilling the huge demand of irrigation water and also for supplying fresh drinking and domestic water to the fast-growing population of the district.

PART – II

(i) Aquifer Mapping and Management Plan of Chhaprauli block, Baghpat district

1. General Information of Chhaprauli block

District	Baghpat				
Block	**Chhaprauli**				
Geographical Area (km^2)	205.32				
Population& its Density	172120; 839 persons/sq. km.				
Principal Aquifer System	Quaternary Alluvium				
Major Aquifer System	Older Alluvial (80%), Younger Alluvium				
Normal Annual Rainfall	674.76 mm				
Forest Area (Ha)	132	**Rural Area under Non-Agricultural Use (Ha)**			2143
Cultivable Area (Ha)	17380	**Culturable Waste Land (Ha)**			556
Net Sown Area (Ha)	16662	**Gross Sown Area (Ha)**			27425
Net Irrigated Area (Ha)	16626	**Gross Irrigated Area (Ha)**			27365
Cropping Intensity (%)	164.60	**Irrigation Intensity (%)**			164.59
Surface Water Irrigation(%)	1.42	**Ground Water Irrigation (%)**			98.58
Canal Irrigation Area (Ha)	236	**State Govt. TW (Ha)**	57	**Private TW (Ha)**	16333

2. Hydrogeology of Chhaprauli block

Aquifer Groups and Depth of Occurrence as per Exploratory Drilling carried out by CGWB	1) Aquifer Gr.-I: I(A): 0.00 to (85-93)mbgl; I(B): (88-124) to (137-159) mbgl 2) Aquifer Group-II: 181 to (235 – 252) mbgl 3) Aquifer Group-III: (264 – 295) to (294–357) mbgl 4) Aquifer Group-IV: (336 – 375) to (423–448) mbgl(up to explored depth)				
Status of Ground Water Exploration	Exploratory Wells**: 07** Observation Wells**: 03** Slim Hole: **00** Piezometer**: 00**				
Aquifer Characteristics	Group-I(A)	Group-I(B)	Group-II	Group-III	Group-IV
SWL-Static Water Level(m bgl) Q – Discharge (lpm); DD – Drawdown (m); T – Transmissivity (m^2/day) S – Storativity	SWL: **11.1** to **19.3** Q: **809** to **2954** DD: **4.5** to **6.65** T: Sp. Yield: **0.06**	SWL: **18.90** Q: **2953** DD: **6.25** T: S:	SWL:**15.6** to **21.31** Q: **2000** to **2300** DD: **8.68** to **10.73** T: **627** to **837** S:**1.26 x 10^{-3}**to **1.25 x 10^{-4}**	SWL: Q: DD: T: S:	SWL: Q: DD: T: S:

<table>
<tr><td>GW Monitoring Stations</td><td colspan="5">Ground Water Monitoring Wells: 01 (NHNS)</td></tr>
<tr><td rowspan="2">Average Depth to Water Level (Pre-monsoon-2023)</td><td>Aq- I(A)</td><td>Aq- I(B)</td><td rowspan="2">Average Depth to Water Level (Post-monsoon-2023)</td><td>Aq- I(A)</td><td>Aq- I(B)</td></tr>
<tr><td>16.55</td><td>21.12</td><td>16.24</td><td>20.20</td></tr>
<tr><td>Ground Water Resource (2023)</td><td colspan="5">Dynamic Resource (2023): Aquifer Group - I(A)
1) Annual Extractable Ground Water Resources: 6300.77 Ham
2) Total Ground Water Extraction for all purposes: 4688.41 Ham
3) Annual GW Allocation for Domestic Use as on 2025: 343.72 Ham
4) Net Ground Water Availability for Future Use: 1604.96 Ham
5) Average Stage of Ground Water Extraction: 74.41 %
6) Category of Block: Semi-Critical
Static Resource of Aquifer Group - I(A): 7945.88 Ham
Static/In-Storage Resource of Aquifer Group – I(B): 1190.20 Ham</td></tr>
<tr><td>Existing and Future Drinking Water Demand</td><td colspan="5">Existing Demand @ 40 lpcd (2021): 2.7642 MCM
Future Demand @ 40 lpcd (2031): 3.0407 MCM</td></tr>
</table>

1. Aquifer Management Plan of Chhaprauli block

Table – 3.1 : Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam

Block	Total Population (Census: 2011)	Projected Population (2021) (Growth 10%)	Covered Population	No. of Total GPs	No. of Total GPs Covered	Population yet to be Covered by PWSS	Annual Water Resource required to Cater Uncovered Population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	**172120**	**189332**	**80024**	**26**	**11**	**109308**	**1.5959**

Table - 3.2 : **Proposed Plan for GW Draft from Aquifer Gr.–I(A) & Gr.-I(B) for Drinking Water**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Resource required for uncovered population @ 40 lpcd (MCM)	Annual Resource proposed to be utilized from Group-I(A) Aquifers (40% of Requirement) (MCM)	Annual Resource proposed to be utilized from Group-I(B) Aquifer (60 % of Requirement) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(A) Aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(B) Aquifer and 8 hours/day running)	No of TWs requi-red in Group-I(A) Aquifer (4)/(6)	No of TWs requi-red in Group-I(B) Aquifer (5)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Chhaprauli	**205.32**	**1.5959**	**0.6384**	**0.9575**	**0.1314**	**0.1533**	**5**	**6**

Table - 3.3 : Probable Impact of GW Draft for Drinking Water on Ground Water Level

Name of the Block	Geogra-phical Area (sq.km.)	Annual Water Resource propo-sed to be used from Group-I(A) Aquifer (MCM)	Annual Water Resource propo-sed to be used from Group-I(B) Aquifer (MCM)	Specific Yield (Sy) of Group I(A) Aquifers	Storativity (S) of Group I(B) Aquifers	Decline of Water Level in I(A) Aquifer (m)	Decline of Piezo-metric Surface in Group-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	**205.32**	**0.6384**	**0.9575**	**0.06**	**0.00057129**	**0.052**	**8.176**

Table – 3.4 : Cost Estimate of Tube Wells for Drinking & Domestic Water Supply to Projected Population (in 2031)

Block	Human Popula-tion in NAQUIM 2.0 area in 2011	Present Water Requir-ement for Human Popula-tion @ 70 lpcd for (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate as 10%)	Covered Human Popu-lation (2020-21)	Total Population to be Covered in 2031 excepting already covered Population (4) – (5)	Addi-tional Water Requ-irement for Human Populace @70 lpcd in 2031 (m^3/day)	Average Disch-arge of Group-I(B) Aqui-fers (m^3/ hour)	Ave-rage Hours of Run-ning of TW	Dis-charge of one TW in m^3/day for 8 hours of pump-ing per day (8) x (9)	No. of Additional Tube Wells to be Cons-tructed in I(B) Aquifers for catering Human Population in 2031 (7) / (10)	Cost of the Tube Wells of 200 m depth in I(B) aqui-fer 10”x 6" dia @ Rs. 10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Chhaprauli	**172120**	**12048.40**	**208265**	**80024**	**128241**	**8976.884**	**52.50**	**8**	**420.00**	**21**	**210**

Table–3.5: Cultivable Area, Net Irrigated Area & GW Availability (2023-24) and Scope & Necessity of Management Intervention

Block	Geographical Area (Ha)	Cultivable Area (Ha)	Net cultivated Area (Ha)	Culturable Command Area (CCA) (Current Irrigated Area as per MI Census-5 (Ha)	RemainingCultivable Area to bring under Irrigation (Ha) (3)-(5)	Net Irrigated Command Area by Ground Water (as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Command Area by Surface Water (as per MI Census-5 in 2020-21) (Ha)	Net Irrigated Command area by GW+ SW (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extraction (SoE) (%)	Net Ground Water Availability for Future Irrigation& Industrial Use (Ham)	Pre-Monsoon Water Level Trend 2010-2021 (Falling) (m/year)	Post-Monsoon Water Level Trend 2010-2021 (Falling) (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (mbgl) in 2023	Average Post-Monsoon Water Level (Aquifer wise) (mbgl) in 2023
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Chhaprauli	20532	17380	16662	16626	754	16390	236	16626	74.41	1604.96			16.55 (IA) 21.12 (IB)	16.24 (IA) 20.20 (IB)

Table - 3.6 (A): **Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present Ground Water Draft**

Additional area brought under coverage of other crops with the saved water from 10 % reduction of Sugarcane Cultivation						Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10 % Sugarcane Cultivation												Increase in Irrigation Area by reducing 10% of Sugarcane Cultivation	
Block	Present area under Sugarcane (Ha)	10% of Sugarcane Area (Ha)	Area under Sugarcane after 10% reduction(Ha)	Water Column for Sugarcane Irrigation(m)	Volume of Irrigation water saved (Ham)	Wheat (Rabi Season) (Maximum Delta factor: 45 cm)			'Boro' Rice (January-April) (Maximum Delta factor: 140 cm)			Vegetables (Rabi and Summer) (Maximum Delta factor: 40 cm)			Mustard (Rabi Season) (Maximum Delta factor: 45 cm)			Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)	Effective Increase in Area of Irrigation i.e. CCA(Ha) (19) – (3)
						Water (%)		Area	Water (%)		Area	Water (%)		Area	Water (%)		Area		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Chhaprauli	12416	1241.6	11174.4	2.4	2979.84	1340.93	45%	2979.84	595.97	20%	425.69	595.97	20%	1489.92	446.97	15%	993.28	5888.73	4647.13

Table - 3.6 (B): **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Prop-	Loss in	Monetary	Wheat (Rabi)			'Boro' Rice (Jan-April)			Vegetables(Rabi & Summer)			Mustard			Addi-	Total
	osedre duc-tion of Sugar -cane Culti-vation Area (Ha)	Produc-tion of Sugar-cane as per Avg. Yield Rate 80 MT /Ha in 2023-24 (MT)	Loss (in Crore) for 10 % Reduc-tion of Sugar-cane Cultiva-tion Area as per MSP of 2023-24 of Sugar -cane @ Rs. 3700/MT	Addi-tional Area to be Culti-vated&I rriga-ted from Table-3.6(A) (Ha)	Addi-tionalPro duc-tion expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21250 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated& Irri-gated from Table-3.6(A) (Ha)	Addi-tionalPr odu-ctionexp ec-ted as per Average Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21830 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated & Irri-gated for Veget-able from Table-3.6(A) (Ha)	Addi-tionalProd u-ction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated & Irri-gated From Table-3.6(A) (Ha)	Addi-tionalPr odu-ctionexp ec-ted as per Av-erage Yield Rate 1.980 MT/Ha in 2023 - 24 (MT)	Addi-tional Income as per Mini-mum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in Crore)	tional Income from growing alternat- ive crops with GW earlier being used by 10% Sugar- cane (Rs. in Crore) (7)+(10)+ (13)+(16)	Effective Increase in Income from Proposed Interven-tion through change in Cropping Pattern (Rs. in Crore) (17) – (4)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Chhap rauli	**1241.6**	**99328**	**36.7514**	**2979.84**	**10429.44**	**22.1626**	**425.69**	**1195.77**	**2.6104**	**1489.92**	**35758.08**	**107.274**	**993.3**	**1966.69**	**10.7185**	**142.7657**	**106.0143**

Table – 3.6 (C):**Impact of Reducing Sugarcane area and allotting that to Kharif Paddy and equally distributing to 3 low CWR crops in Rabi on Income & GW**

Block	Present Area of Sugarcane cultivation (Ha)	Present GW Draft for Sugarcane Cultivation (CWR = 2.4 m) (MCM)	Proposed 10 % Reduction of Sugarcane cultivation Area (Ha)	Amount of Ground Water Saved by reducing 10% of Sugar cane Cultivation Area (MCM)	Yield Rate of Sugar cane (MT /Ha)	Loss in Production of Sugarcane due to reduction of cultivation area (MT)	Loss in Income from Sugarcane @ Rs. 3700 per MT (as per MSP of 2023-24) (Rs. in Cr.)	Gain in Production of Kharif Rice @ existing Avg. Yield 2.809 MT/Ha grown in freed 10% sugarcane area due to Alternatecropping pattern (MT)	Gain in Income from Kharif Rice @ Rs. 21830 per M. Ton (as per MSP of 2023 -24) (Rs. in Cr)	Proposed Cropping of Mustard, Wheat, Vegetable (Low CWR & normallypracticed) in Rabi season in 1:1:1 Ratio in Lost Sugar cane Area (Ha)	Gain in Production of Mustard @ existing Average Yield Rate 1.980 MT/ Ha in NAQ -UIM Area due to Alternatecropp - ngpattern (MT)	Gain in Income from Mustard @ Rs. 54500 per M. Ton (as per MSP of 2023 -24) (Rs. in Cr	Gain in Production of Wheat @ existing Average Yield Rate 3.5 MT/ Ha in NAQ-UIM Area due to Alternate Cropping Pattern (MT)	Gain in Income from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore Rs.)	Gain in Production of Vegetables @ existing Avg. Yield Rate 24 MT /Ha due to alternate cropping atter (MT)	Gain in Income from Vegetable @ Rs. 30000 per MT (as per Farm Gate Price : 2023 -24) (Crore Rs.)	Individual Ground Water Draft for Additional Cultivation of Rice during Kharif period on the whole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10% sugarcane area as per Crop Water Requirement 0.60 m, 0.45 m, 0.45 m and 0.40 m respectively for Kharif Paddy, Mustard, Wheat and Vegetables (MCM)				Total Ground Water Draft for Additional Cultivation of Kharif Rice and Mustard, Wheat & Vegetables In Rabi season (MCM)	Effective Saving of Ground Water by Cropping Pattern Change MCM {(5) - (19)}	Effective Gain in Income for growing Kharif Rice and Rabi Mustard, Wheat & Vegetables in area freed by 10% Sugar -cane {(10) + (13) + (15) + (17)} – (8) (Rs. in Cr)	Existing Stage of Dyn -amic GW Extraction as per GW ResourceEstimation by GEC 2015 Method as on March 2023	AnnualExtractable GW Resource as per Dynamic Ground Water ResourceCalculated for 2023 MCM	Total Annual Ground Water Extraction for all purposes in respect of Dynamic GW resourcecalculation 2023 (MCM)	Improved Stage of GW Extraction by Saving of Dynamic GW esource (%) Considering that Irrigation water for Sugarcane is drawn from Shallow Aquifer Group-I(A)	Expected Rise in Pre -mon -soon Water Level (m) of Unconfined o Semi-Confined Aqufercalculated taking Avg p. Yield of Gr. -I(A) Aquifer as 0.06
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must.	Wheat	Veg								
Chhaprauli	12416	297.98	1241.6	29.7984	80	99328	36.75	3487.6	7.6135	413.87	819.46	4.466	1448.53	3.0781	9933	29.80	7.45	1.86	1.86	1.65	12.83	16.97	8.2048	74.41	63.01	46.884	58.62	1.38

Table – 3.7: **Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Block	Geographical Area (Ha)	Normal Monsoon Rainfall (m) (50 yrs data-data.gov.in)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvanarayana'1993 (Land slope, type of land and soil type) (Land Slope: 0 - 5%)	Major types of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt'= (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-committed) =Vnc(Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt'=(Rn x A x C)	'V'	'Vnc'	'Vf'
Chhaprauli	**20532**	**0.675**	**13859.10**	**0.5**	**Sandy loam & minor loam, Sand**	**Moderate to Well Drained**	**6929.55**	**5197.163**	**2598.581**	**1559.149**

Table – 3.8 : **Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geogra-phical Area (Sq. Km)	Non-Committed Surface Runoff available for whole Block Area (MCM)	Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A) & Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7) + (12) (MCM)	Total harvested Rain water/ surface run-off water actually needed for injection to Gr.-I(A) & Gr.-I(B) Aquifer (14)x(100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure of 100 sq. mt. roof (area* total avg. annual rainfall*0.8) (MCM)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr. - I(A) Aquifer (8/16)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr.-I(B) Aquifer (13/16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(Normal Annual Rainfall– 0.67476 m)			Average post-Monsoon Water Level (mbgl)	Formation Thickness between 15 mbgl and post-monsoon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2)x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7)x(100/75)	Avg. Post-Monsoon Water Level (mbgl)	Formation Thickness between 15 m bgl and Post-monsoon water level (m)	Storativity (S)	Storage Space for Recharge /Volume of Water to be stored (2) x(10)x(11)	Rain water to be harvested for Gr.-I(B) Aquifer (12) x (100/75)					
Chhaprauli	205.32	15.5915	16.24	1.24	0.06	15.2758	20.3677	20.20	5.20	0.000571	0.6096	0.8128	15.8854	21.1806	0.000054	377315	15058

Table – 3.9 : **Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime**

Name of the Block	Geographical Area (sq. km.)	No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined Aquifers (Table - 3.8 : 17)	Amount of water to be recharged in Aquifer Gr.-I(A) (Table - 3.8 : 7)	Impact on Water Level of Aquifer Gr.–I(A) (rise in m)	No. of RTRWH with Injection Well designed for Gr.-I(B) Confined Aquifers (Table - 3.8 : 18)	Amount of water to be recharged in Aq. Gr.-I(B) (Table- 3.8 : 12)	Impact on Piezometric Surface of Aquifer Gr.–I(B) (rise in m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	**205.32**	**377315**	**15.2758**	**1.24**	**15058**	**0.6096**	**5.20**

Table – 3.10: **Conservation of Surplus Non-Committed Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds after Artificial Recharge by Injection Wells**

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Committed Surface Runoff available (Calculated by Dhruvanarayan'1993 Method) (MCM)	Surface runoff/ water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% area by Injection Wells (75% efficiency) (MCM)	Surface runoff/ water to be utilized for partly filling storage space in Aquifer– I(B) over 100% area by Injection Wells (75% efficiency) (MCM)	Volume of Water Left for Conservation / Storage cum Irrigation Tanks (MCM)	Capacity of a single Conservation/ Irrigation Tank (MCM)	Feasible Numbers of Conservation/ Irrigation Tanks (6) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	205.32	15.59149	11.250	1.734	2.60749	0.1	26

Table – 3.11: **Additional Irrigation Potential to be Created from Storage cum Irrigation Tank**

Name of the Block	Geographical Area (Sq. Km.)	Non-Committed Surface Runoff Available (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)	Evaporation loss (25% of storage) (MCM)	Remaining Water can be utilized for Irrigation (MCM)	Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank considering average crop water requirement as 30 cm for Rabi crops: Wheat, Mustard, Vegetables etc.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Chhaprauli	**205.32**	**15.59149**	**2.60749**	**0.651873**	**1.955618**	**6.51873 sq. km.**	**651.873 Ha**

Table– 3.12:**Expected Improvement of GW Scenario due to Artificial Recharge of Unconfined Aquifers Gr.- I(A) in block area with part of Non-committed Surface Run-off (Supply Side Intervention) & Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extractable Ground Water Resource (Ham) {Table - 3.6(C)}	Total Current Annual Ground Water Extraction (SoE) (Ham) {Table - 3.6(C)}	Existing Stag of Dynamic GW Extraction as per GW Resource Estimation (GEC'15) as on March 2023 (%) {(3)/(2)} x 100	Part Storage Space for Recharge/ Volume of Water to be stored in to Aquifer-I(A) throughout the block area to Enhance Dynamic GW Resource (Ham) from Table - 3.8(7)	Allocated Source Water from Non-Committed Surface Runoff for Recharging Aquifer-I(A) (Ham) {Table-3.10: (4)}	Actual amount of water to be recharged in Aquifer Gr-I(A) (Ham) (75% of source water) (6) x 0.75	Improved Stage of Ground Water Extraction (%) singly through Artificial Recharge by Injection Well [(3) / {(7) + (2)}] x 100	Effective GW Saving by Cropping Pattern Change growing Kharif Rice on whole land freed from sugarcane and growing Mustard, wheat& vegetable in Rabi season on parts of 10% Sugarcane land divided in 1:1:1 ratio {Table-3.6(C)}	Improved SoE (%) singly by Saving of Dynamic GW Resource through Cropping Pattern Change assuming that Shallow Aquifer-I(A) is used fo Sugarcane [(3) / {(9) + (2)}] x 100	Total Effective Increase in Ground Water Reserve due to Artificial Recharge & Change in Cropping Pattern (Ham) {(7) + (9)}	Cumulative Improvement in SoE due to both Artificial Recharge and Saving GW through Change in Cropping Pattern (%) [(3) / {(2) + (11)}] x 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Chhaprauli	6300.77	4688.41	74.41	1527.58	1125.00	843.75	65.62	1696.85	58.62	2540.60	53.03

Table - 3.13 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geogr-aphical Area (Ha)	Total Culti-vable Area (Ha)	Total CCA (as Per MI Census -5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation (Ha)(3)–(4)	Additional Irrigation Potential Created by Harvesting Sur-face Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A) & I(B) aquifers assuming its feasib-ility in 100% area) and by Changing Cropping Pattern (Ha)			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Inter-vention {(8/5) x 100}	Percent of Total Cultivable Land where Irrigation Potential can be created in addition by Management Intervention {(8/3) x 100} (%)	Percent of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Manage-ment Intervention {(8/4) x 100}
					Irrigation Area Increase from Harvested Run-off Water in Irrigation Tanks (Ha) {Table-3.11: (8)}	Irrigation Area Increase from Water Saved by Cropping Pattern Change (Ha) {Table – 3.6(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Chhaprauli	**20532**	**17380**	**16626**	**754**	**651.873**	**4647.1314**	**5299.0044**	**> 100**	**30.49**	**31.87**

Table - 3.14 : **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Committed Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model – I)**

Name of the Block	Geogra - phical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge & Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate for Structures			Total Cost Estimate for constr-uction of artificial recharge &conser-vation Struc-tures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expendi-ture for Rechar-ging and Conserving 1 CuM(m^3) Harvested Source Water) (in Rs.) (14) x 105 /
				Allocation of 35 % of Source Water for Re-excavation of Existing Tanks with Recharge Shaft (REET) (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) to recharge Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Effi-ciency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% Efficiency of Rechar-ging (6) x 0.75/ 0.30	Nos. of Farm Ponds (7)/ 0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakh per unit (Rs. in Lakh)	Cost of Constru-ction of Injection Well (Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh)	Cost of Constr-uction of Farm Ponds @ Rs. 8 Lakh per unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Chhaprauli	205.32	Sandy loam & minor loam, Sand	15.59149	5.457022	4.677447	5.457022	41	12	55	328	60	440	828	5.31

Table-3.15: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in the block - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geogr-aphical Area (sq.km.)	Non-Co-mmitted Surface Run-off available (Calcu-lated by Dhruva-narayan' 93 Method) (MCM)	Total surface runoff/source water to be utilized for partly filling storage space in Aquifer-I(A) over 100% of Block area by Injection Wells (75% efficiency)	Total surface runoff/source water to be Uti-lized for partly filling the storage space in Aquifer–I(B) over 100% of Block area by Injection Wells (75% efficiency)	Volume of Water for Conser-vation /Storage cum Irriga-tion Tanks/ Farm Ponds	Numbers of Injection Wells to be constructed in Aquifer Group-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer Group-I(B) (5) / 0.3	Nos. of Conser-vation/ Storage cum Irri-gation Tanks/ Farm Pond @ 10 Ham Storage Capacity per unit	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh/unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-1(B) @ Rs.10 lakh/unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conser-vation/ Storage cum Irri-gation Tanks/ Farm Ponds @ Rs. 8 lakh/unit (in Lakh)	Total Cost of all Arti-ficial Recha-rge and Conser-vation Structure (Rs. in Lakh) (10) +	Cost-Benefit Ratio: (Expenditure of Recharging /Conserving 1 CuM (m^3) Harvested Source Water) (in Rs.) (13) x 10^5/
			(MCM)	(MCM)	(MCM)			(6) / 0.1			(9) x 8	(11)+(12)	(3) x 106
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Chha prauli	205.32	15.59149	11.250	1.734	2.60749	38	6	26	190	60	208	458	2.94

4. Chemical Quality of Ground Water in Chhaprauli block

Table – 4.1: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Pre-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO3**	**HCO3**	**Cl**	**F**	**NO3**	**SO4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO2**	**PO4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.81	649	0	281	14	0.18	7	20	220	32	12	41	5.1	25	0
Maximum	8.17	1747	0	708	106	0.76	12	170	430	88	58	255	7.5	29	0
Average	7.941	1116.43	0	488.143	49.43	0.433	9.12	87.71	304.3	65.14	34	124.43	6.357	26.43	0

Table – 4.2: **Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Pre-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.143	0.054	BDL	0.243	0.001	0.001	0.006
Maximum	BDL	5.753	0.139	BDL	3.904	0.001	0.002	0.057
Average	BDL	1.1875	0.0815	BDL	1.24266	0.001	0.0015	0.0297

Table – 4.3:**Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Post-monsoon Period**

Basic Elements	pH	EC (µS/cm at 25°C)	CO3	HCO3	Cl	F	NO3	SO4	TH	Ca	Mg	Na	K	SiO2	PO4
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.56	392	0	183	7	0.36	6	14	100	20	12	15	3.3	9	0
Maximum	8.11	1701	0	720	99	3.15	21	125	460	96	53	225	7.5	34	0
Average	7.81	1035.14	0	488	35	1.03	6	58	292.14	56.57	37	109	6.2	25.5	0

Table – 4.4:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Post-monsoon Period**

Heavy Metals	Chromium (Cr)	Iron (Fe)	Manganese (Mn)	Copper (Cu)	Zinc (Zn)	Arsenic (As)	Lead (Pb)	Uranium (U)
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.061	0.054	BDL	0.073	0.001	BDL	0.003
Maximum	BDL	6.803	0.119	BDL	3.257	0.001	BDL	0.061
Average	BDL	1.898	0.077	BDL	1.013	0.001	BDL	0.025

3. Geological and Geomorphological Maps, Depth to Wat er Level (Pre and Post-Monsoon) Maps in respect Aquifer–I(A) and Isopach Maps (Aquifer-IA & IB) of Chhaprauli block

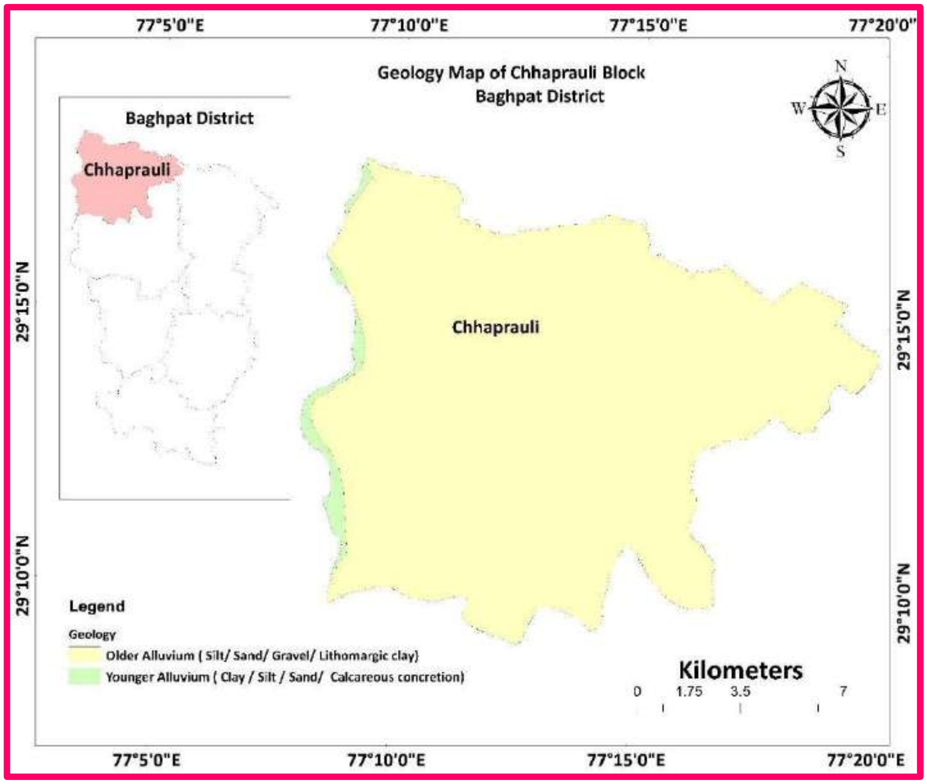


Fig. – 5.1: **Geological Map of Chhaprauli block, Baghpat district**

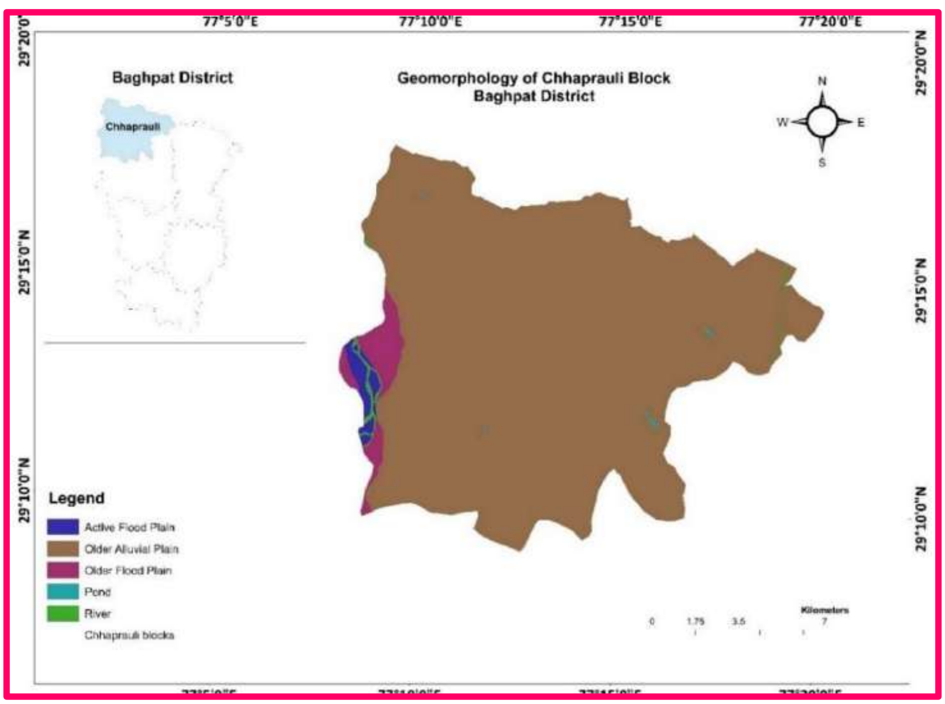


Fig. – 5.2: **Geomorphological Map of Chhaprauli block, Baghpat district**

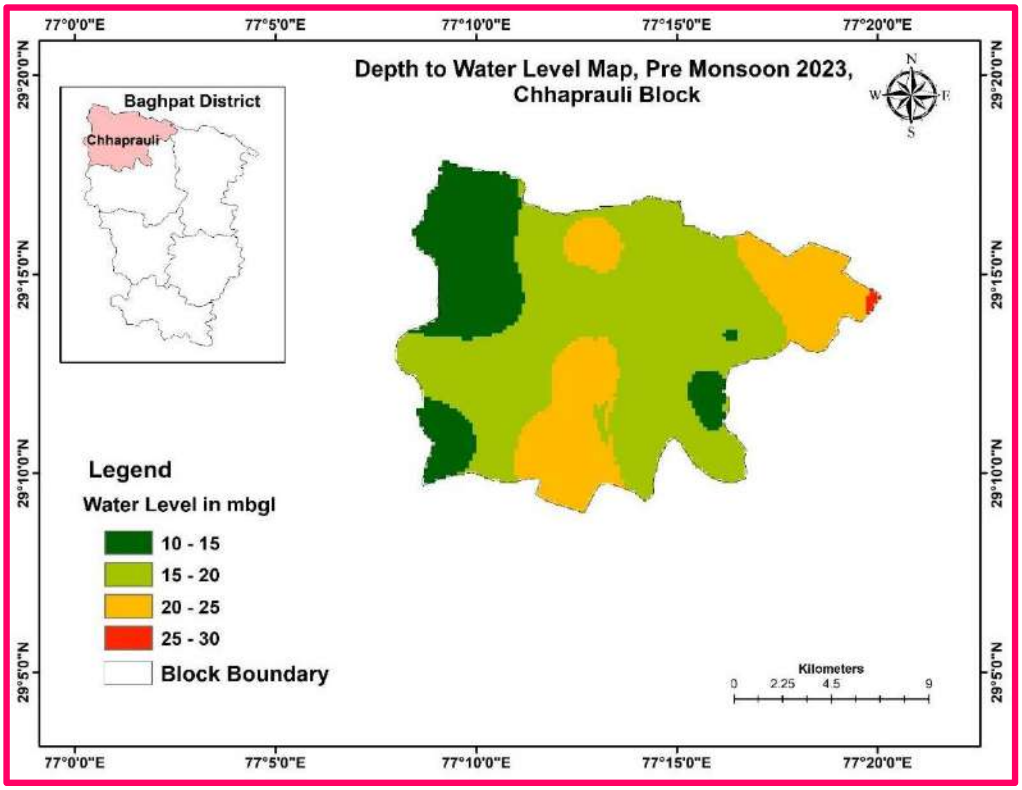


Fig. – 5.3:**Pre-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

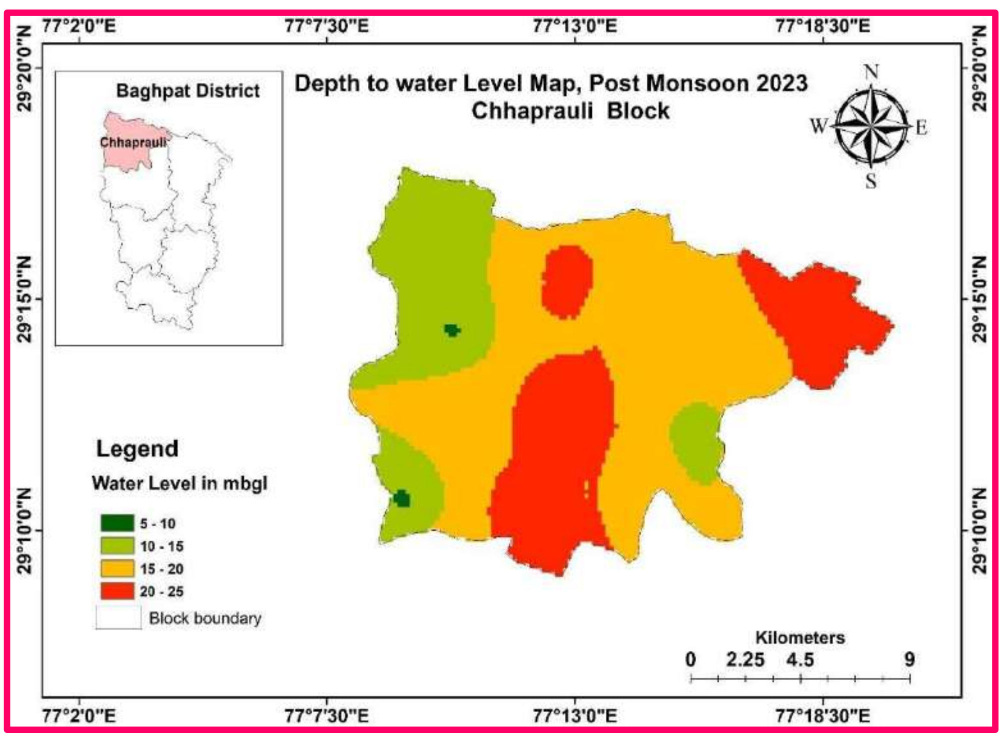


Fig. – 5.4:**Post-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

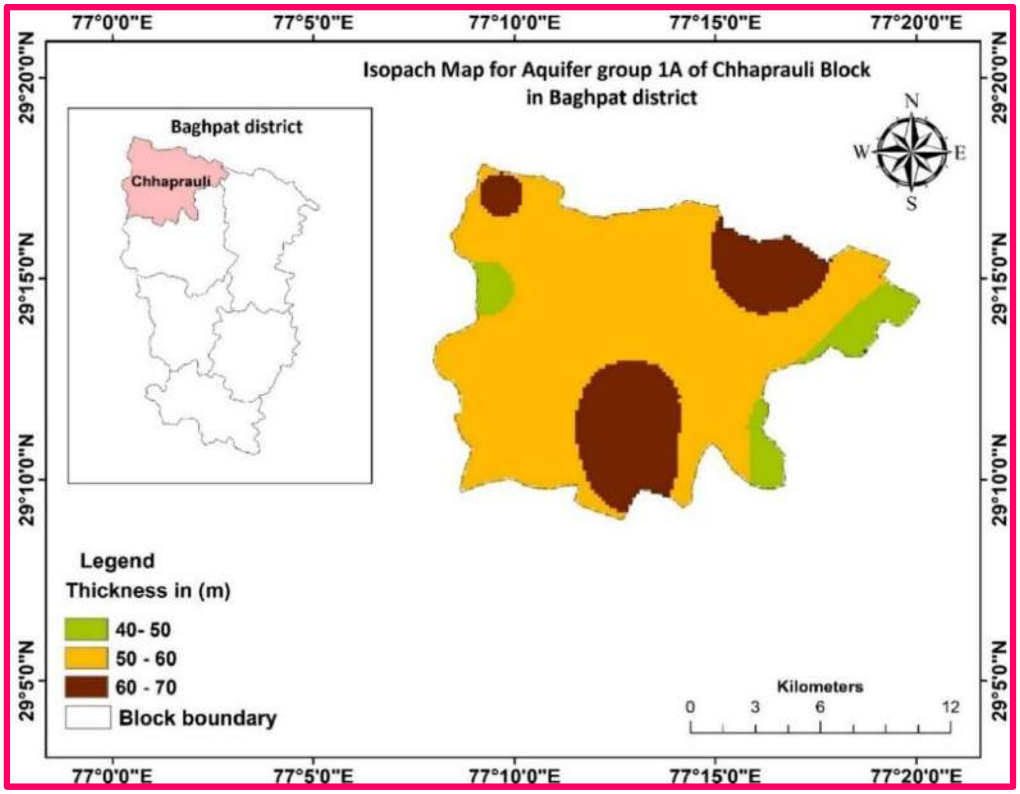


Fig. – 5.5: **Isopach Map of Chhaprauli block in respect of Aquifer - I(A)**

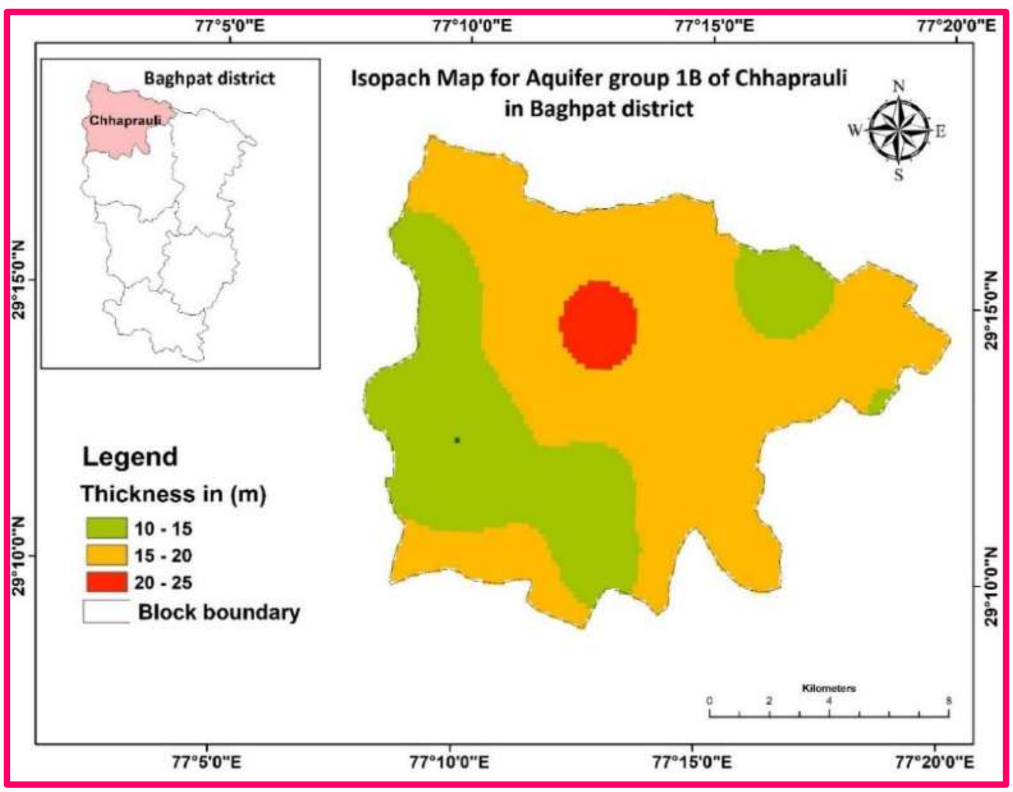


Fig. – 5.6: **Isopach Map of Chhaprauli block in respect of Aquifer - I(B)**

(ii) Aquifer Mapping and Management Plan of Baraut block, Baghpat district

1. General Information of Baraut block

District	Baghpat				
Block	**Baraut**				
Geographical Area (km^2)	276.86				
Population& Its Density	279430; 1010 persons/sq. km.				
Principal Aquifer System	Quaternary Alluvium				
Major Aquifer System	Older Alluvial (80%), Younger Alluvium				
Normal Annual Rainfall	674.76 mm				
Forest Area (Ha)	186	**Rural Area under Non-Agricultural Use (Ha)**			3180
Cultivable Area (Ha)	20664	**Culturable Waste Land (Ha)**			353
Net Sown Area (Ha)	20122	**Gross Sown Area (Ha)**			28384
Net Irrigated Area (Ha)	20098	**Gross Irrigated Area (Ha)**			28314
Cropping Intensity (%)	141.06	**Irrigation Intensity (%)**			140.88
Use of Surface Water (%)	1.14	**Use of Ground Water (%)**			98.86
Canal Irrigation Area (Ha)	230	**State Govt. TW (Ha)**	87	**Private TW (Ha)**	19781

2. Hydrogeology of Baraut block

Aquifer Groups and Depth of Occurrence as per Exploratory Drilling carried out by CGWB	1) Aquifer Gr.-I: I(A): 0.00 to (80-93)mbgl; I(B):(121-139) to (147-166) mbgl 2) Aquifer Group -II: 173to 278 mbgl 3) Aquifer Group-III: 305 to 370 mbgl 4) Aquifer Group-IV: 388 to 441 mbgl(up to maximum explored depth)				
Status of Ground Water Exploration	Exploratory Wells**: 09** **Observation** Wells**: 01** **Piezometer: 00** Slim Hole: **01**				
Aquifer Characteristics	**Group-I(A)**	**Group-I(B)**	**Group-II**	**Group-III**	**Group-IV**
SWL-Static Water Level (m bgl) Q – Discharge (lpm); DD – Drawdown (m); T – Transmissivity (m^2/day) S – Storativity	SWL: **9.50** to **21.0** Q: **636** to **2954** DD: **4.85** to **7.90** T: Sp. Yield: **0.06**	SWL: **3.10** Q: **3220** DD: **6.15** T: **1500** S: **2.05×10^{-3}**	SWL: Q: DD: T: S:	SWL: Q: DD: T: S:	SWL: **12.87** Q: **2200** DD: **22.62** T: **301** S: **2.1×10^{-4}**

GW Monitoring Stations	Ground Water Monitoring Wells: **02 (NHNS)**				
Average Depth to Water Level (Pre-monsoon-2023)	**Aq - I(A)**	**Aq - I(B)**	**Average Depth to Water Level (Post-monsoon-2023)**	**Aq - I(A)**	**Aq - I(B)**
	20.44	**21.33**		**19.95**	**20.50**
Ground Water Resources (2023)	**Dynamic Resource (2023): Aquifer Group - I(A)** 1) Annual Extractable Ground Water Resources: **7883.09 Ham** 2) Total Ground Water Extraction for all purposes: **6157.34 Ham** 3) Annual GW Allocation for Domestic Use as in 2025**: 499.50 Ham** 4) Net Ground Water Availability for Future Use: **1712.79 Ham** 5) Average Stage of Ground Water Extraction: **78.11 %** 6) Category of Block: **Semi-Critical** **Static Resource of Aquifer Group - I(A): 6744.31 Ham** **Static/In-Storage Resource of Aquifer Group – I(B): 1213.50 Ham**				
Existing and Future Drinking Water Demand	Existing Demand @ 40 lpcd (2021): **4.4876 MCM** Future Demand @ 40 lpcd (2031): **4.9364 MCM**				

3. Aquifer Management Plan of Baraut block

Table – 3.1 : **Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam**

Block	Total Population (Census: 2011)	Projected Population (2021) (Growth 10%)	Covered Population	No. of Total GPs	No. of Total GPs Covered	Population yet to be Covered by PWSS	Annual Water Resource required to Cater Uncovered Population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baraut	**279430**	**307373**	**124264**	**44**	**22**	**183109**	**2.6734**

Table - 3.2 : **Proposed Plan for GW Draft from Aquifer Gr.–I(A) & Gr.-I(B) for Drinking Water**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Resource required for uncovered population @ 40 lpcd (MCM)	Annual Resource proposed to be utilized from Group-I(A) Aquifers (40% of Requirement) (MCM)	Annual Resource proposed to be utilized from Group-I(B) Aquifer (60 % of Requirement) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(A) Aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(B) Aquifer and 8 hours/day running)	No of TWs requi-red in Group-I(A) Aquifer (4)/(6)	No of TWs requi-red in Group-I(B) Aquifer (5)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Baraut	**277**	**2.6734**	**1.0694**	**1.6040**	**0.1314**	**0.1703**	**8**	**10**

Table - 3.3 : **Probable Impact of GW Draft for Drinking Water on Ground Water Level**

Name of the Block	Geographical Area (sq.km.)	Annual Water Resource proposed to be used from Group-I(A) Aquifer (MCM)	Annual Water Resource proposed to be used from Group-I(B) Aquifer (MCM)	Specific Yield (Sy) of Group I(A) Aquifers	Storativity (S) of Group I(B) Aquifers	Decline of Water Level in I(A) Aquifer (m)	Decline of Piezo-metric Surface in Group-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baraut	**277**	**1.0694**	**1.6040**	**0.06**	**0.00057129**	**0.064**	**10.136**

Table–3.4: **Cost Estimate of Tube Wells for Drinking & Domestic Water Supply to Projected Population (in 2031)**

Block	Human Population in NAQUIM 2.0 area in 2011	Present Water Requirement for Human Population @ 70 lpcd for (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate as 10%)	Covered Human Population (2020-21)	Total Population to be Covered in 2031 excepting already covered Population (4) – (5)	Addi-tional Water Requirement for Human Populace @70 lpcd in 2031 (m^3/day)	Average Discharge of Group-I(B) Aqui-fers (m^3/hour)	Average Hours of Running of TW	Discharge of one TW in m^3/day for 8 hours of pumping per day (8) x (9)	No. of Additional Tube Wells to be Constructed in I(B) Aquifers for catering Human Population in 2031 (7) / (10)	Cost of the Tube Wells of 200 m depth in I(B) aquifer 10"x 6" dia @ Rs. 10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Baraut	**279430**	**19560.10**	**338110**	**124264**	**213846**	**14969.241**	**58.32**	**8**	**466.56**	**32**	**320**

Table – 3.5: **Cultivable Area, Net Irrigated Area & GW Availability (2023-24) and Scope & Necessity of Management Intervention**

Block	Geogra-phical Area (Ha)	Culti-vable Area (Ha)	Net culti-vated Area (Ha)	Cultur-able Comma-nd Area (CCA) (Current Irrigated Area as per MI Census-5 (Ha)	Rema-iningCulti-vable Area to bring under Irri-gation (Ha) (3)-(5)	Net Irrigated Comm-and Area by Ground Water (as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Comm-and Area by Surface Water (as per MI Census-5 in 2020-21) (Ha)	Net Irrigated Comm-and area by GW+ SW (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extrac-tion (SoE) (%)	Net Ground Water Avail-ability for Future Irriga-tion& Indus-trial Use (Ham)	Pre-Mon-soon Water Level Trend 2010-21 (Falling) (m/year)	Post-Mon-soon Water Level Trend 2010-21 (Falling) (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (mbgl) in 2023	Average Post-Monsoon Water Level (Aquifer wise) (mbgl) in 2023
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Baraut	**27686**	**20664**	**20122**	**20098**	**566**	**19868**	**230**	**20098**	**78.11**	**1712.79**			**20.44 (IA)** **21.33 (IB)**	**19.95 (IA)** **20.50 (IB)**

Table - 3.6 (A):**Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present Ground Water Draft**

Additional area brought under coverage of other crops with the saved water from 10 % reduction of Sugarcane Cultivation						Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10 % Sugarcane Cultivation											Increase in Irrigation Area by reducing 10% of Sugarcane Cultivation		
Block	Present area under Sugar-cane (Ha)	10% of Sugar-cane Area (Ha)	Area under Sugar-cane after 10% reducti-on(Ha)	Water Col-umn for Sugar-cane Irriga-tion (m)	Volume of Irriga-tion water saved (Ham)	Wheat (Rabi Season) (Maximum Delta factor: 45 cm)			'Boro' Rice (January-April) (Maximum Delta factor: 140 cm)			Vegetables (Rabi and Summer) (Maximum Delta factor: 40 cm)			Mustard (Rabi Season) (Maximum Delta factor: 45 cm)		Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)		Effective Increase in Area of Irriga-tion i.e. CCA(Ha) (19) – (3)
						Water (%)		Area	Water (%)		Area	Water (%)		Area	Water (%)	Area			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Baraut	**15492**	**1549.20**	**13942.8**	**2.4**	**3718.08**	**1673.14**	**45%**	**3718.08**	**557.71**	**15%**	**398.37**	**743.62**	**20%**	**1859.04**	**743.616**	**20%**	**1652.5**	**7627.97**	**6078.77**

Table - 3.6 (B): **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Prop-osedre duc-tion of Sugar -cane Culti-vation Area (Ha)	Loss in Produc-tion of Sugar-cane as per Avg. Yield Rate 80 MT /Ha in 2023-24 (MT)	Monetary Loss (in Crore) for 10 % Reduc-tion of Sugar-cane Cultiva-tion Area as per MSP of 2023-24 of Sugar -cane @ Rs. 3700/MT	Wheat (Rabi)			'Boro' Rice (Jan-April)			Vegetables(Rabi & Summer)			Mustard			Addi-tional Income from growing alternat-ive crops with GW earlier being used by 10% Sugar-cane (Rs. in Crore)	Total Effective Increase in Income from Proposed Interven -tion through change in Cropping Pattern (Rs. in Crore)
				Addi-tional Area to be Culti-vated&I rriga-ted from Table-3.6(A) (Ha)	Addi-tionalPro duc-tion expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21250 per MT (2023-24) (Rs. In Crore)	Addi-tional Area to be Culti-vated& Irri-gated from Table-3.6(A) (Ha)	Addi-tionalPr odu-ctionexp ec-ted as per Average Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21830 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated & Irri-gated for Veget -able from Table-3.6(A)	Addi-tionalProd u -ction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. In Crore	Addi-tional Area to be Culti-vated & Irri-gated From Table-3.6(A) (Ha)	Addi-tionalPr odu-ctionexp ec-ted as per Av-erage Yield Rate 1.980 MT/Ha in 2023 -24 (MT)	Addi-tional Income as per Mini-mum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Baraut	**1549.2**	**123936**	**45.8563**	**3718.08**	**13013.28**	**27.6532**	**398.37**	**1119.01**	**2.4428**	**1859.04**	**44616.96**	**133.85 1**	**1652.5**	**3271.91**	**17.8319**	**181.7788**	**135.9225**

Table – 3.6 (C):**Impact of Reducing Sugarcane area and allotting that to Kharif Paddy and equally distributing to 3 low CWR crops in Rabi on Income & GW**

Block	Present Area of Sugarcane cultivation (Ha)	Present GW Draft for Sugarcane Cultivation (CWR = 2.4 m) (MCM)	Proposed 10 % Reduction of Sugarcane cultivation Area (Ha)	Amount of Ground Water Saved by reducing 10% of Sugar cane Cultivation Area (MCM)	Yield Rate of Sugarcane (MT/Ha)	Loss in Production of Sugarcane due to reduction of cultivation area (MT)	Loss in Income from Sugarcane @ Rs. 3700 per MT (as per MSP of 2023-24) (Rs. in Cr.)	Gain in Production of Kharif Rice @ existing Avg. Yield 2.809 MT/Ha grown in freed 10% sugarcane area due to Alternatecropp-ing pattern (MT)	Gain in Income from Kharif Rice @ Rs. 21830 per M. Ton (as per MSP of 2023-24) (Rs. in Cr)	Proposed Cropping of Mustard, Wheat, Vegetable (Low CWR & normallypracticed) in Rabi season in 1:1:1 Ratio in Lost Sugar cane Area (Ha)	Gain in Production of Mustard @ existing Average Yield Rate 1.980 MT/Ha in NAQ-UIM Area due to Alternatecropping pattern (MT)	Gain in Income from Mustard @ Rs. 54500 per M. Ton (as per MSP of 2023-24) (Rs. in Cr	Gain in Production of Wheat @ existing Average Yield Rate 3.5 MT/Ha in NAQ-UIM Area due to Alternate Cropping Pattern (MT)	Gain in Income from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore Rs.)	Gain in Production of Vegetables @ existing Avg. Yield Rate 24 MT/Ha due to alternate cropping Pattern (MT)	Gain in Income from Vegetable @ Rs. 30000 per MT (as per Farm Gate Price : 2023-24) (Crore Rs.)	Individual Ground Water Draft for Additional Cultivation of Rice during Kharif period on the whole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10% sugarcane area as per Crop Water Requirement 0.60 m, 0.45 m, 0.45 m and 0.40 m respectively for Kharif Paddy, Mustard, Wheat and Vegetables (MCM)				Total Ground Water Draft for Additional Cultivation of Kharif Rice and Mustard, Wheat & Vegetables In Rabi season (MCM)	Effective Saving of Ground Water by Cropping Pattern Change MCM {(5) - (19)}	Effective Gain in Income for growing Kharif Rice and Rabi Mustard, Wheat & Vegetables in area freed by 10% Sugar-cane {(10) + (13) + (15) + (17)} – (8) (Rs. in Cr)	Existing Stage of Dynamic GW Extraction as per GW ResourceEstimation by GEC 2015 Method as on March 2023	AnnualExtractable GW Resource as per Dynamic Ground Water ResourceCalculated for 2023 MCM	Total Annual Ground Water Extraction for all purposes in respect of Dynamic GW resourcecalculation 2023 MCM	Improved Stage of GW Extraction by Saving of Dynamic GW esou-rce (%) Considering that Irrigation water for Sugarcane is drawn rom Shallow Aquifer Group-I(A)	Expected Rise in Pre-monsoon Water Level (m) of Unconfined o Semi-Confined Aquifercalculatedtaking Avg p. Yield of Gr.-I(A) Aquifer as 0.06
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must	Wheat	Veg								
Bar-aut	15492	371.808	1549.2	37.181	80	123936	45.86	4351.7	9.4998	516.40	1022.5	5.572	1807.40	3.8407	12394	37.181	9.295	2.324	2.324	2.066	16.008	21.17	10.237	78.11	78.831	61.573	61.57	1.27

Table – 3.7: **Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Block	Geographical Area (Ha)	Normal Monsoon Rainfall (m) (50 yrs data-data.gov.in)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvanarayana'1993 (Land slope, type of land and soil type) (Land Slope: 0 - 5%)	Major types of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt'= (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-committed) =Vnc (Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt'=(Rn x A x C)	'V'	'Vnc'	'Vf'
Baraut	**27686**	**0.675**	**18688.05**	**0.5**	**Sandy loam & minor loam, Sand**	**Moderate to Well Drained**	**9344.03**	**7008.019**	**3504.009**	**2102.406**

Table – 3.8 : **Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geographical Area (Sq. Km)	Non-Committed Surface Runoff available for whole Block Area (MCM)	Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A) & Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7) + (12) (MCM)	Total harvested Rain water/ surface run - off water actually needed for injection to Gr.-I(A) & Gr.-I(B) Aquifer (14)x(100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure of 100 sq. mt. roof (area* total avg. annual rainfall*0.8) (MCM)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr. - I(A) Aquifer (8/16)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr.-I(B) Aquifer (13/16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(Normal Annual Rainfall– 0.67476 m)			Average post-Monsoon Water Level (mbgl)	Formation Thickness between 15 mbgl and Post-monsoon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2)x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7)x(100/75)	Avg. Post-Monsoon Water Level (mbgl)	Formation Thickness between 15 m bgl and Post-monsoon water level (m)	Storativity (S)	Storage Space for Recharge /Volume of Water to be stored (2) x(10)x(11)	Rain water to be harvested for Gr.-I(B) Aquifer (12) x (100/75)					
Baraut	**276.86**	**21.0241**	**19.95**	**4.95**	**0.06**	**82.2274**	**109.6366**	**20.50**	**5.50**	**0.000571**	**0.8695**	**1.1593**	**83.0969**	**110.7959**	**0.000054**	**2031029**	**21476**

Table – 3.9 :**Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime**

Name of the Block	Geographical Area (sq. km.)	No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined	Amount of water to be recharged in Aquifer	Impact on Water Level of Aquifer Gr.–	No. of RTRWH with Injection Well designed for Gr.-I(B) Confined	Amount of water to be recharged in Aq. Gr.-I(B)	Impact on Piezometric Surface of Aquifer
		Aquifers (Table - 3.8 : 17)	Gr.-I(A) (Table - 3.8 : 7)	I(A) (rise in m)	Aquifers (Table - 3.8 : 18)	(Table- 3.8 : 12)	Gr.–I(B) (rise in m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baraut	276.86	2031029	82.2274	4.95	21476	0.8695	5.50

Table – 3.10: **Conservation of Surplus Non-Committed Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds after Artificial Recharge by Injection Wells**

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Committed Surface Runoff available (Calculated by Dhruvanarayan'1993 Method) (MCM)	Surface runoff/ water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% area by Injection Wells (75% efficiency) (MCM)	Surface runoff/ water to be utilized for partly filling storage space in Aquifer– I(B) over 100% area by Injection Wells (75% efficiency) (MCM)	Volume of Water Left for Conservation / Storage cum Irrigation Tanks (MCM)	Capacity of a single Conservation/ Irrigation Tank (MCM)	Feasible Numbers of Conservation/ Irrigation Tanks (6) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baraut	**276.86**	**21.02406**	**15.400**	**2.103**	**3.52106**	**0.1**	**36**

Table – 3.11: **Additional Irrigation Potential to be Created from Storage cum Irrigation Tank**

Name of the Block	Geographical Area (Sq. Km.)	Non-Committed Surface Runoff Available (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)	Evaporation loss (25% of storage) (MCM)	Remaining Water can be utilized for Irrigation (MCM)	Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank considering average crop water requirement as 30 cm for Rabi crops: Wheat, Mustard, Vegetables etc.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baraut	**276.86**	**21.02406**	**3.52106**	**0.880265**	**2.640795**	**8.80265 Sq. Km.**	**880.265 Ha.**

Table– 3.12:**Expected Improvement of GW Scenario due to Artificial Recharge of Unconfined Aquifers Gr.- I(A) in block area with part of Non-committed Surface Run-off (Supply Side Intervention) & Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extractable Ground Water Resource (Ham) {Table - 3.6(C)}	Total Current Annual Ground Water Extrac -tion (SoE) (Ham) {Table - 3.6(C)}	Existing Stag of Dynamic GW Extraction as per GW Resource Estimation (GEC'15) as on March 2023 (%) {(3)/(2)} x 100	Part Storage Space for Recharge/Volume o Water to be stored in to Aquifer-I(A) throughout the block area to Enhance Dynamic GW Resource (Ham) from Table - 3.8(7)	Allocated Source Water from Non-Committed Surface Runoff for Recharging Aquifer-I(A) (Ham) {Table-3.10: (4)}	Actual amount of water to be recharged in Aquifer Gr-I(A) (Ham) (75% of source water) (6) x 0.75	Improved Stage of Ground Water Extraction (%) singly through Artificial Recharge by Injec-tion Well [(3) / {(7) + (2)}] x 100	Effective GW Sav - ing by Cropping Pattern Change growing Kharif Rice on whole land freed from sugarcane and growing Mustard, wheat& vegetable in Rabi season on parts of 10% Sug-arcane land divided in 1:1:1 ratio {Table-3.6(C)}	Improved SoE (%) singly by Saving of Dynamic GW Resource through Cropping Pattern Change assuming that Shallow Aqui-fer-I(A) is used fo Sugarcane [(3) / {(9) + (2)}] x 100	Total Effective Increase in Ground Water Reserve due to Artificial Recharge & Change in Cropping Pattern (Ham) {(7) + (9)}	Cumulative Improvement in SoE due o both Artificia Recharge and Saving GW through Change in Cropping Pattern (%) (3) / {(2) + (11)} x 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Baraut	**7883.09**	**6157.34**	**78.11**	**8222.74**	**1540.00**	**1155.00**	**68.13**	**2117.24**	**61.57**	**3272.24**	**55.20**

Table - 3.13 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geographical Area (Ha)	Total Cultivable Area (Ha)	Total CCA (as per MI Census -5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation (Ha)(3)–(4)	Additional Irrigation Potential Created by Harvesting Sur-face Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A) & I(B) aquifers assuming its feasib-ility in 100% area) and by Changing Cropping Pattern (Ha)			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Inter-vention {(8/5) x 100}	Percent of Total Cultivable Land where Irrigation Potential can be created in addition by Management Intervention {(8/3) x 100} (%)	Percent of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Manage-ment Intervention {(8/4) x 100}
					Irrigation Area Increase from Harvested Run-off Water in Irrigation Tanks (Ha) {Table-3.11: (8)}	Irrigation Area Increase from Water Saved by Cropping Pattern Change (Ha) {Table – 3.6(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Baraut	27686	2066 4	2009 8	566	880.2650	6078.7657	6959.0307	> 100	33.68	34.63

Table - 3.14 : **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Committed Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model – I)**

Name of the Block	Geogra - phical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge & Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate for Structures			Total Cost Estimate for constr-uction of artificial recharge &conser-vation structures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expendi-ture for Rechar-ging and Conserving 1 CuM(m^3) Harvested Source Water) (in Rs.) (14) x 10^5 / (4) x 10^6
				Allocation of 35 % of Source Water for Re-excavation of Existing Tanks with Recharge Shaft (REET) (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) to recharge Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Effi-ciency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% Efficiency of Rechar-ging (6) x 0.75/ 0.30	Nos. of Farm Ponds (7)/ 0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakh per unit (Rs. in Lakh) (8) x 8	Cost of Constru-ction of Injection Well (Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh) (9) x 5	Cost of Constr-uction of Farm Ponds @ Rs. 8 Lakh per unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Baraut	**276.86**	**Sandy loam & minor loam, Sand**	**21.02406**	**7.358421**	**6.307218**	**7.358421**	**56**	**16**	**74**	**448**	**80**	**592**	**1120**	**5.33**

Table-3.15: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in the block - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geographical Area (sq.km.)	Non-Committed Surface Run-off available (Calculated by Dhruvanarayan'93 Method) (MCM)	Total surface runoff/source water to be tilized for partly filling storage space in Aquifer-I(A) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Total surface runoff/source water to be Utilized for partly filling the storage space in Aquifer–I(B) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks/ Farm Ponds (MCM)	Numbers of Injection Wells to be constructed in Aquifer Group-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer Group-I(B) (5) / 0.3	Nos. of Conservation/ Storage cum Irrigation Tanks/ Farm Pond @ 10 Ham Storage Capacity per unit (6) / 0.1	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh/unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-1(B) @ Rs.10 lakh/unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conservation/ Storage cum Irrigation Tanks/ Farm Ponds @ Rs. 8 lakh/unit (in Lakh) (9) x 8	Cost of all Artificial Recharge and ConservationStruc-ture (Rs. in Lakh) (10) + (11)+(12)	Cost-Benefit Ratio: (Expenditure of Recharging /Conserving 1 CuM (m^3) Harvested Source Water) (in Rs.) (13) x 10^5/ (3) x 10^6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Baraut	**276.86**	**21.02406**	**15.400**	**2.103**	**3.52106**	**52**	**7**	**36**	**260**	**70**	**288**	**618**	**2.94**

4. **Chemical Quality of Ground Water in Baraut block**

Table – 4.1: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Pre-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO3**	**HCO3**	**Cl**	**F**	**NO3**	**SO4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO2**	**PO4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.78	389	0	171	14	0.16	7.9	6	150	24	17	19	3	19	1
Maximum	8.15	2391	0	1159	78	2.40	12	165	360	64	63	480	20	31	1
Average	7.97	1208.10	0	547.82	47.73	0.87	10.63	69.27	242.72	44.72	32	164.82	7.01	25	1

Table – 4.2: **Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Pre-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.111	0.059	BDL	0.085	0.002	0.001	0.004
Maximum	BDL	10.125	0.16	BDL	1.232	0.002	0.003	0.043
Average	BDL	2.396	0.092	BDL	0.4459	0.002	0.002	0.0197

Table – 4.3: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Post-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO3**	**HCO3**	**Cl**	**F**	**NO3**	**SO4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO2**	**PO4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.67	330	0	146	7	0.30	6	22	140	20	12	10	3.5	18	1.22
Maximum	8.24	2250	0	1086	64	4.70	20	175	580	92	107	360	140	31	5.40
Average	7.945	1058.65	0	482.48	31.956	1.62	4.61	72.30	269.13	48.52	35.91	120.43	11.767	25.695	2.68

Table – 4.4: **Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Post-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	0.003	0.103	0.051	BDL	0.066	0.001	0.001	0.003
Maximum	0.003	4.434	0.12	BDL	3.457	0.001	0.003	0.08
Average	0.003	1.70	0.079	BDL	0.6454	0.001	0.002	0.01826

3. **Geological and Geomorphological Maps, Depth to Wat er Level (Pre and Post-Monsoon) Maps in respect Aquifer – I(A) and Isopach Maps (Aquifer - IA & IB) of Baraut block**

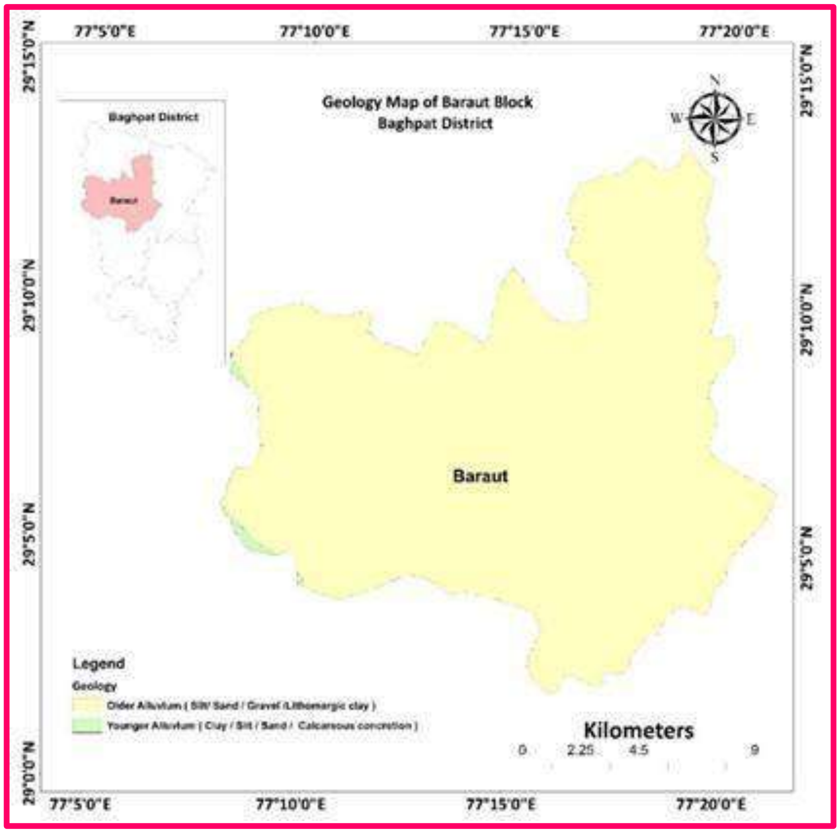


Fig. – 5.1: **Geological Map of Baraut block, Baghpat district**

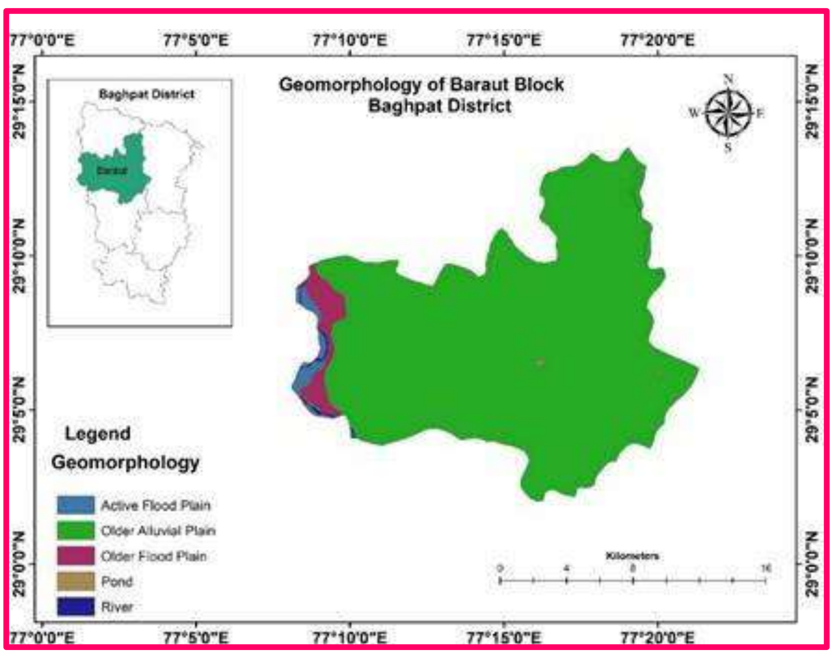


Fig. – 5.2: **Geomorphological Map of Baraut block,Baghpat district**

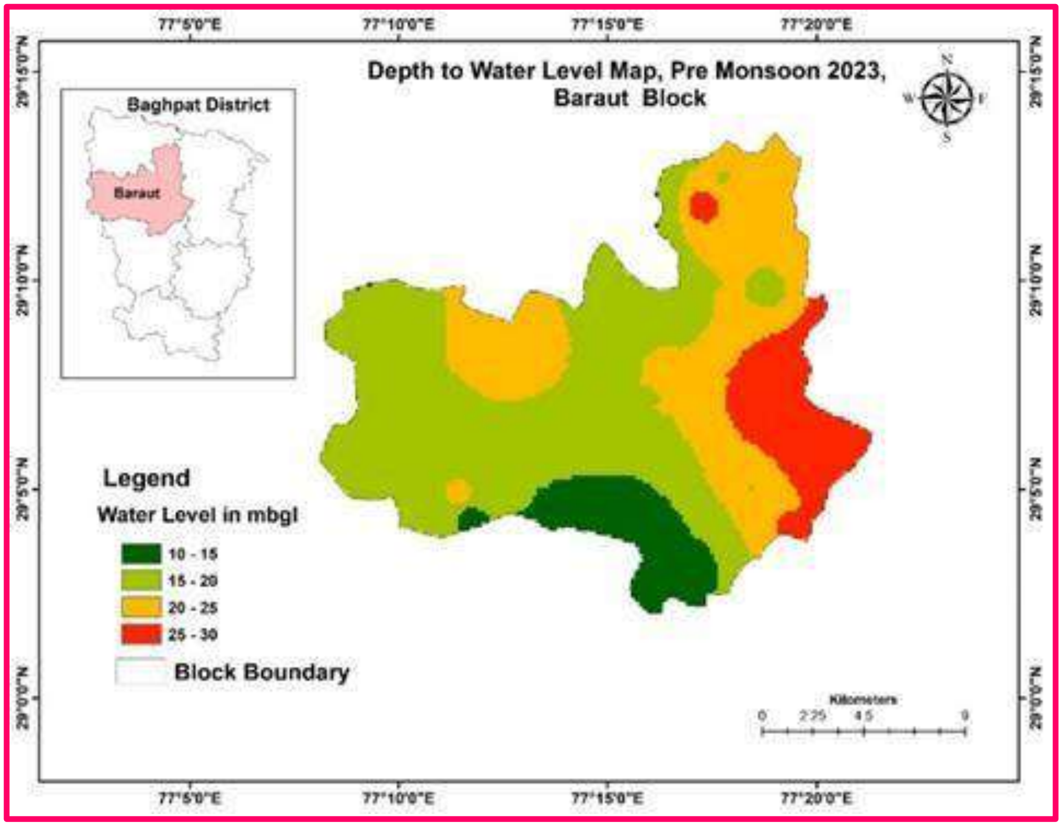


Fig. – 5.3:**Pre-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

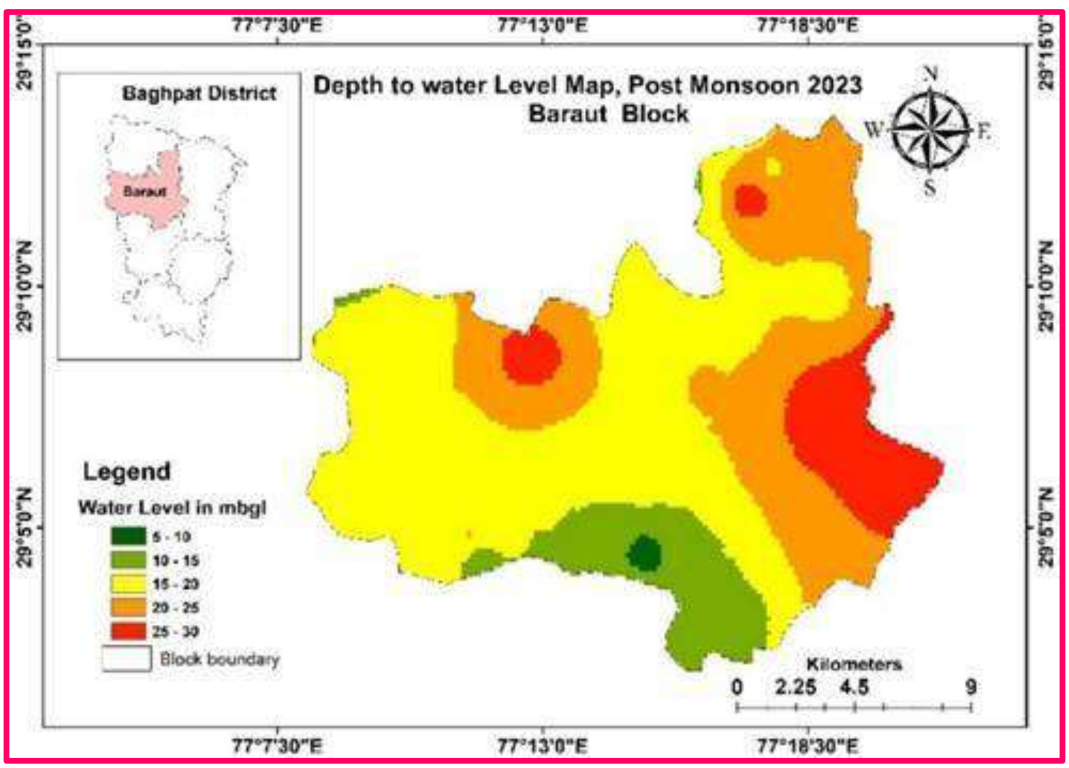


Fig. – 5.4:**Post-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

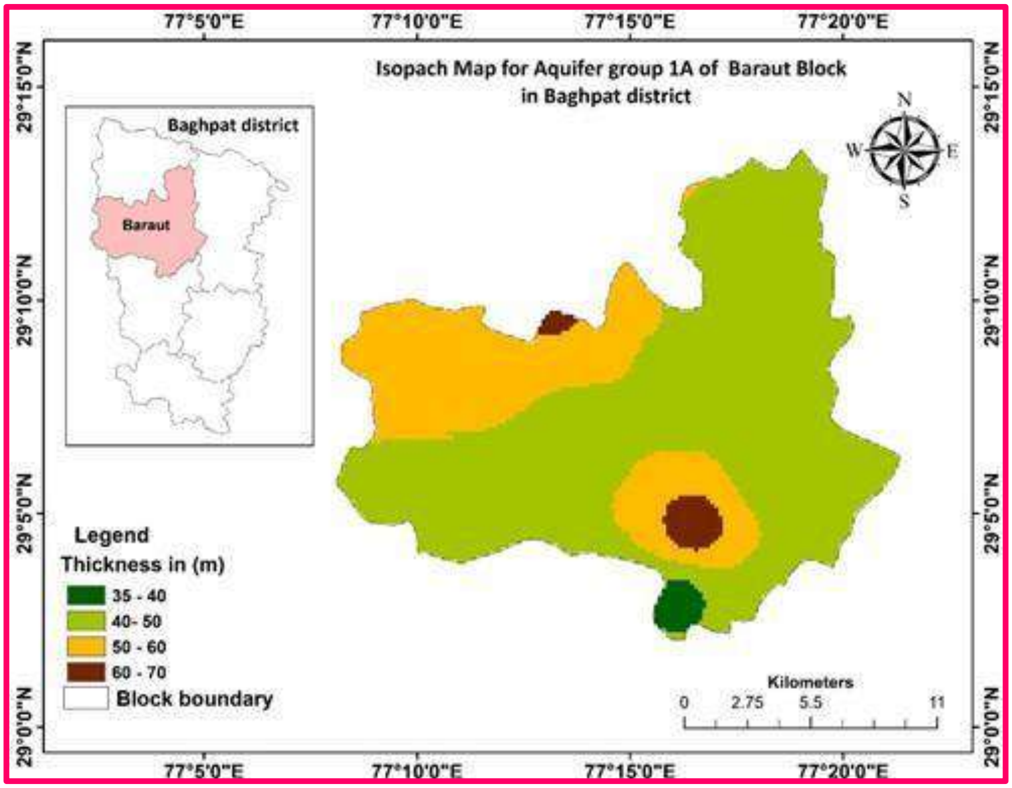


Fig. – 5.5:**Isopach Map of Barautblockin respect of Aquifer - I(A)**

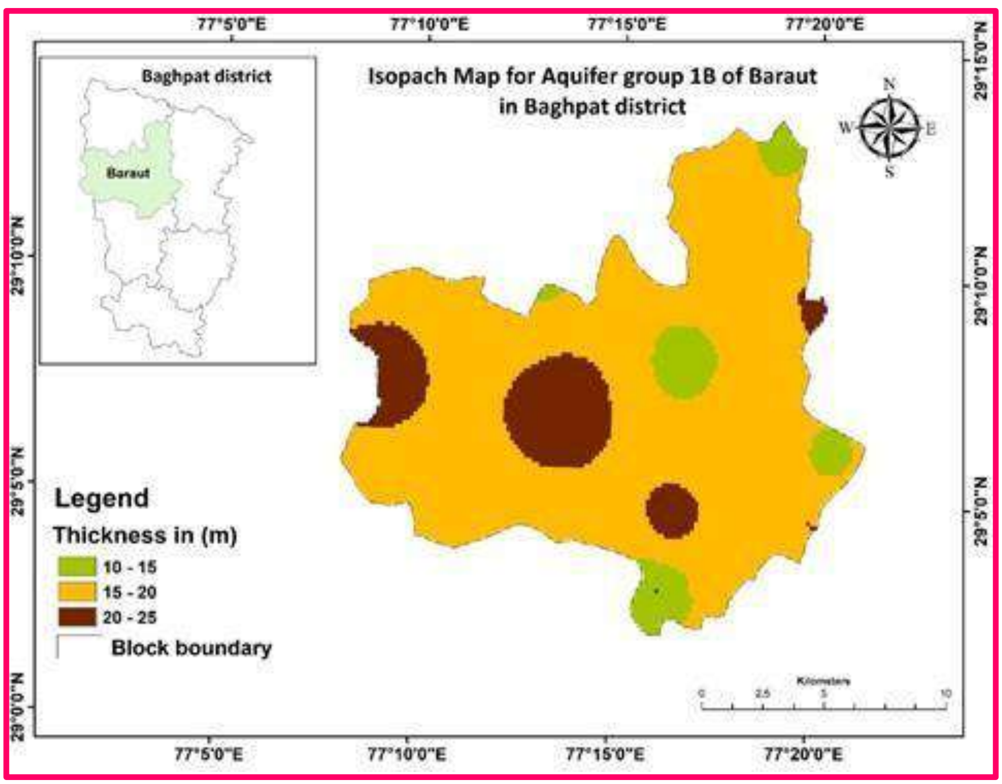


Fig. – 5.6:**Isopach Map of Baraut block in respect of Aquifer - I(B)**

(iii) Aquifer Mapping and Management Plan of Baghpat block, Baghpat district

1. General Information of Baghpat block

District	Baghpat				
Block	**Baghpat**				
Geographical Area (km^2)	210.63				
Population& Its Density	228208; 1084 persons/sq. km.				
Principal Aquifer System	Quaternary Alluvium				
Major Aquifer System	Older Alluvial (80%), Younger Alluvium				
Normal Annual Rainfall	674.76 mm				
Forest Area (Ha)	203	**Rural Area under Non-Agricultural Use (Ha)**			3257
Cultivable Area (Ha)	17002	**Culturable Waste Land**			338
Net Sown Area (Ha)	16448	**Gross Sown Area (Ha)**			25148
Net Irrigated Area (Ha)	16215	**Gross Irrigated Area (Ha)**			25133
Cropping Intensity (%)	152.89	**Irrigation Intensity (%)**			154.998
Use of Surface Water (%)	1.47	**Use of Ground Water (%)**			98.53
Canal Irrigation Area (Ha)	238	**State Govt. TW (Ha)**	83	**Private TW (Ha)**	15894

2. Hydrogeology of Baghpat block

Aquifer Groups and Depth of Occurrence as per Exploratory Drilling carried out by CGWB	1) Aquifer Gr.-I: I(A): 0.00 to (76-94) mbgl; I(B):(95-111) to (144-162) mbgl 2) Aquifer Group -II: 172to (250 – 258) mbgl 3) Aquifer Group-III: 289 to 370 mbgl(up to maximum explored depth)				
Status of Ground Water Exploration	Exploratory Wells**: 14** **Observation** Wells**: 00** **Piezometer: 01** Slim Hole: **01**				
Aquifer Characteristics	**Group-I(A)**	**Group-I(B)**	**Group-II**	**Group-III**	**Group-IV**
SWL-Static Water Level (m bgl) Q – Discharge (lpm); DD – Drawdown (m); T – Transmissivity (m^2/day) S – Storativity	SWL: **12.5** to **24.7** Q: **424** to **2955** DD: **2.90** to **9.10** T: Sp. Yield: **0.06**	SWL: **19.2** to **21.8** Q: **2954** DD: **6.85** to **6.95** T: S:	SWL: **12.26** Q: **1987** DD: **14.44** T: **705** S:**7.75 x 10^{-4}**	SWL: **3.98** Q: **1360** DD: **25.50** T: **345** S:**7.70 x 10^{-4}**	SWL: Q: DD: T: S:

GW Monitoring Stations	Ground Water Monitoring Wells: **01 (NHNS)**				
Average Depth to Water Level (Pre-monsoon-2023)	**Aq - I(A)**	**Aq - I(B)**	**Average Depth to Water Level (Post-monsoon-2023)**	**Aq - I(A)**	**Aq - I(B)**
	18.39	**24.80**		**17.20**	**24.00**
Ground Water Resources (2023)	**Dynamic Resource (2023): Aquifer Group - I(A)** 1) Annual Extractable Ground Water Resources: **5003.63Ham** 2) Total Ground Water Extraction for all purposes: **4420.10 Ham** 3) Annual GW Allocation for Domestic Use as in 2025**: 382.29 Ham** 4) Net Ground Water Availability for Future Use: **563.09 Ham** 5) Average Stage of Ground Water Extraction: **88.34 %** 6) Category of Block: **Semi-Critical** **Static Resource of Aquifer Group - I(A): 7089.81 Ham** **Static/In-Storage Resource of Aquifer Group – I(B): 717.2 Ham**				
Existing and Future Drinking Water Demand	Existing Demand @ 40 lpcd (2021): 3**.665 MCM** Future Demand @ 40 lpcd (2031): **4.0315 MCM**				

3. Aquifer Management Plan of Baghpat block

Table – 3.1: **Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam**

Block	Total Population (Census: 2011)	Projected Population (2021) (Growth 10%)	Covered Population	No. of Total GPs	No. of Total GPs Covered	Population yet to be Covered by PWSS	Annual Water Resource required to Cater Uncovered Population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baghpat	**228208**	**251028**	**30044**	**44**	**4**	**220984**	**3.2264**

Table - 3.2 : **Proposed Plan for GW Draft from Aquifer Gr.–I(A) & Gr.-I(B) for Drinking Water**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Resource required for uncovered population @ 40 lpcd (MCM)	Annual Resource proposed to be utilized from Group-I(A) Aquifers (40% of Requirement) (MCM)	Annual Resource proposed to be utilized from Group-I(B) Aquifer (60 % of Requirement) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(A) Aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(B) Aquifer and 8 hours/day running)	No of TWs requi-red in Group-I(A) Aquifer (4)/(6)	No of TWs requi-red in Group-I(B) Aquifer (5)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Baghpat	**210**	**3.2264**	**1.2905**	**1.9358**	**0.1314**	**0.1583**	**10**	**12**

Table - 3.3 : **Probable Impact of GW Draft for Drinking Water on Ground Water Level**

Name of the Block	Geographical Area (sq.km.)	Annual Water Resource propo-sed to be used from Group-I(A) Aquifer (MCM)	Annual Water Resource propo-sed to be used from Group-I(B) Aquifer (MCM)	Specific Yield (Sy) of Group I(A) Aquifers	Storativity (S) of Group I(B) Aquifers	Decline of Water Level in I(A) Aquifer (m)	Decline of Piezo-metric Surface in Group-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baghpat	**210**	**1.2905**	**1.9358**	**0.06**	**0.00057129**	**0.102**	**16.136**

Table–3.4: **Cost Estimate of Tube Wells for Drinking & Domestic Water Supply to Projected Population (in 2031)**

Block	Human Popula-tion in NAQUIM 2.0 area in 2011	Present Water Requir-ement for Human Popula-tion @ 70 lpcd for (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate as 10%)	Covered Human Popu-lation (2020-21)	Total Population to be Covered in 2031 excepting already covered Population (4) – (5)	Addi-tional Water Requ-irement for Human Populace @70 lpcd in 2031 (m^3/day)	Average Disch-arge of Group-I(B) Aqui-fers (m^3/ hour)	Ave-rage Hours of Run-ning of TW	Dis-charge of one TW in m^3/day for 8 hours of pump-ing per day (8) x (9)	No. of Additional Tube Wells to be Cons-tructed in I(B) Aquifers for catering Human Population in 2031 (7) / (10)	Cost of the Tube Wells of 200 m depth in I(B) aqui-fer 10"x 6" dia @ Rs. 10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Baghpat	**228208**	**15974.56**	**276132**	**30044**	**246088**	**17226.138**	**54.21**	**8**	**433.68**	**40**	**400**

Table – 3.5: **Cultivable Area, Net Irrigated Area & GW Availability (2023-24) and Scope & Necessity of Management Intervention**

Block	Geographical Area (Ha)	Cultivable Area (Ha)	Net cultivated Area (Ha)	Culturable Command Area (CCA) (Current Irrigated Area as per MI Census-5 (Ha)	RemainingCultivable Area to bring under Irrigation (Ha) (3)-(5)	Net Irrigated Command Area by Ground Water (as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Command Area by Surface Water (as per MI Census-5 in 2020-21) (Ha)	Net Irrigated Command area by GW+ SW (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extraction (SoE) (%)	Net Ground Water Availability for Future Irrigation& Industrial Use (Ham)	Pre-Monsoon Water Level Trend 2010-21 (Falling) (m/year)	Post-Monsoon Water Level Trend 2010-21 (Falling) (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (mbgl) in 2023	Average Post-Monsoon Water Level (Aquifer wise) (mbgl) in 2023
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Baghpat	**21063**	**17002**	**16448**	**16215**	**787**	**15977**	**238**	**16215**	**88.34**	**563.09**			**18.39 (IA)** **24.80 (IB)**	**17.20 (IA)** **24.00 (IB)**

Table - 3.6 (A):**Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present Ground Water Draft**

Additional area brought under coverage of other crops with the saved water from 10 % reduction of Sugarcane Cultivation						Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10 % Sugarcane Cultivation									Increase in Irrigation Area by reducing 10% of Sugarcane Cultivation				
Block	**Present area under Sugarcane (Ha)**	**10% of Sugarcane Area (Ha)**	**Area under Sugarcane after 10% reduction(Ha)**	**Water Column for Sugarcane Irrigation(m)**	**Volume of Irrigation water saved (Ham)**	**Wheat (Rabi Season) (Maximum Delta factor: 45 cm)**			**'Boro' Rice (January-April) (Maximum Delta factor: 140 cm)**			**Vegetables (Rabi and Summer) (Maximum Delta factor: 40 cm)**			**Mustard (Rabi Season) (Maximum Delta factor: 45 cm)**			**Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)**	**Effective Increase in Area of Irrigation i.e. CCA(Ha) (19) – (3)**
						Water (%)		**Area**	**Water (%)**		**Area**	**Water (%)**		**Area**	**Water (%)**		**Area**		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Baghpat	**10958**	**1095.8**	**9862.2**	**2.4**	**2629.92**	**1314.96**	**50%**	**2922.13**	**525.98**	**20%**	**375.70**	**394.5**	**15%**	**986.22**	**394.49**	**15%**	**876.64**	**5160.70**	**4064.90**

Table - 3.6 (B): **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Proposedreduction of Sugar-cane Cultivation Area (Ha)	Loss in Production of Sugar-cane as per Avg. Yield Rate 80 MT /Ha in 2023-24 (MT)	Monetary Loss (in Crore) for 10 % Reduction of Sugar-cane Cultivation Area as per MSP of 2023-24 of Sugar-cane @ Rs. 3700/MT	Wheat (Rabi)			'Boro' Rice (Jan-April)			Vegetables(Rabi & Summer)			Mustard			Additional Income from growing alternative crops with GW earlier being used by 10% Sugar-cane (Rs. in Crore) (7)+(10)+(13)+(16)	Total Effective Increase InIncome from Proposed Intervention through changein Cropping Pattern (Rs. in Crore) (17) – (4)
				Additional Area to be Cultivated&Irrigated from Table-3.6(A) (Ha)	AdditionalProduction expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price Rs. 21250 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated & Irrigated from Table-3.6(A) (Ha)	AdditionalProduction expected as per Average Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price Rs. 21830 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated & Irrigated for Vegetable from Table-3.6(A) (Ha)	AdditionalProdu-ction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Additional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated& Irrigated From Table-3.6(A) (Ha)	AdditionalProductionexpected as per Average Yield Rate 1.980 MT/Ha in 2023 -24 (MT)	Additional Income as per Minimum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in Crore)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Baghpat	**1095.8**	**87664**	**32.4357**	**2922.13**	**10227.47**	**21.7334**	**375.70**	**1055.35**	**2.3038**	**986.22**	**23669.28**	**71.0078**	**876.64**	**1735.75**	**9.4598**	**104.5048**	**72.0691**

Table – 3.6 (C):**Impact of Reducing Sugarcane area and allotting that to Kharif Paddy and equally distributing to 3 low CWR crops in Rabi on Income & GW**

Block	Present Area of Suga-rcane cult-iva-tion (Ha)	Present GW Draft for Sugar-cane Culti-vation (CWR = 2.4 m) (MCM)	Prop-osed 10 % Redu-ction of Suga-rcane culti-vat-ion Area (Ha)	Amo-unt of Gro-und Water Saved by red-ucing 10% of Sugar cane Culti-vation Area	Yie-ld Rate of Sug-ar cane (MT /Ha)	Loss in Produ-ction of Sugar-cane due to redu-ction of cultiv-ation area (MT)	Loss in Inc-ome from Suga-rcane @ Rs. 3700 per MT (as per MSP of 2023-	Gain in Prod-uction of Kharif Rice @ ex-isting Avg. Yield 2.809 MT/ Ha gro-wn in freed	Gain in In-come from Kharif Rice @ Rs. 21830 per M. Ton (as per MSP of 2023 -24)	Prop-osed Cro-pping of Mus-tard, Wheat, Vege -table (Low CWR & nor-mallypr ac-ticed)	Gain in Produ-ction of Mu-stard @ ex-isting Ave-rage Yield Rate 1.980 MT/ Ha in NAQ	Gain in Income from Mus tard @ Rs. 54500 per M. Ton (as per MSP	Gain in Produ-ction of Wheat @ exis-ting Ave-rage Yield Rate 3.5 MT/ Ha in	Gain in In-come from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore	Gain in Prod-ucti-on of Vege tab-les @ xis-ting Avg. Yield Rate 24 MT /Ha	Gain in Inc-ome from Vege-table @ Rs. 30000 per MT (as per Farm Gate Price	Individual Ground Water Draft for Additional Cultivation of Rice during Kharif period on the whole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10%				Total Gro-und Wat er Draf t for Add i-tion al Cult i-vati on of Kha rif Rice and Mus t-ard,	Effec-tive Sav-ing of Gro-und Water by Crop-ping Patt-ern Cha-nge	Effec-tive Gain in In-come for grow-ing Kharif Rice and Rabi Mus-tard, Wheat &	Exis Ting Stage of Dyn -amic GW Extrac-tion as per GW Reso-urceEst im-ation by	Ann-ualEx tr-act-able GW Reso-urce as per Dyn-amic Gro-und Water Reso-urceC	Total Ann-ual Gro-und Water Extrac -tion for all pur-poses in resp-ect of Dyn-amic GW	Impr-oved Stage of GW Extrac-tion by Saving of Dyn amic GW esou-rce (%) Consi-dering that Irriga-on water	Expe-ted Rise in Pre -mon -soon Water Level (m) of Un-onfi-ned o Semi-Con-fined Aqu-fercalcu -
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must.	Wheat	Veg								
Bagh -pat	10958	262.99	1095.8	26.299	80	87664	32.44	3078.1	6.7195	365.27	723.2	3.942	1278.43	2.7167	8766.5	26.30	6.575	1.644	1.644	1.461	11.323	14.976	7.2415	88.34	50.036	44.201	67.99	1.19

Table – 3.7: **Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Block	Geogra-phical Area (Ha)	Normal Monsoon Rainfall (m) (50 yrs data-data.gov.in)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvanarayana'1993 (Land slope, type of land and soil type) (Land Slope: 0 - 5%)	Major types of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt'= (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-committed) =Vnc (Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt'=(Rn x A x C)	'V'	'Vnc'	'Vf'
Baghpat	**21063**	**0.675**	**14217.53**	**0.5**	**Sandy loam & minor Loam, Sand**	**Moderate to Well Drained**	**7108.76**	**5331.572**	**2665.786**	**1599.472**

Table – 3.8 : **Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geogra-phical Area (Sq. Km)	Non-Committed Surface Runoff available for whole Block Area (MCM)	Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A) & Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7) + (12) (MCM)	Total harvested Rain water/ surface run-off water actually needed for injection to Gr.-I(A) & Gr.-I(B) Aquifer (14)x(100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure of 100 sq. mt. roof (area* total avg. annual rainfall*0.8) (MCM)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr. - I(A) Aquifer (8/16)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr.-I(B) Aquifer (13/16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(Normal Annual Rainfall– 0.67476 m)			Average post-Monsoon Water Level (mbgl)	Formation Thickness between 15 mbgl and Post-monsoon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2)x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7)x(100/75)	Avg. Post-Monsoon Water Level (mbgl)	Formation Thickness between 15 m bgl and Post-monsoon water level (m)	Storativity (S)	Storage Space for Recharge /Volume of Water to be stored (2) x(10)x(11)	Rain water to be harvested for Gr.-I(B) Aquifer (12) x (100/75)					
Baghpat	**210.63**	**15.9947**	**17.2**	**2.20**	**0.06**	**27.8032**	**37.0709**	**24.0**	**9.00**	**0.000571**	**1.0824**	**1.4432**	**28.8856**	**38.5141**	**0.000054**	**686742**	**26736**

Table – 3.9 :**Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime**

Name of the Block	Geographical Area (sq. km.)	No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined Aquifers (Table - 3.8 : 17)	Amount of water to be recharged in Aquifer Gr.-I(A) (Table - 3.8 : 7)	Impact on Water Level of Aquifer Gr.–I(A) (rise in m)	No. of RTRWH with Injection Well designed for Gr.-I(B) Confined Aquifers (Table - 3.8 : 18)	Amount of water to be recharged in Aq. Gr.-I(B) (Table- 3.8 : 12)	Impact on Piezometric Surface of Aquifer Gr.–I(B) (rise in m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baghpat	**210.63**	**686742**	**27.8032**	**2.20**	**26736**	**1.0824**	**9.00**

Table – 3.10: **Conservation of Surplus Non-Committed Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds after Artificial Recharge by Injection Wells**

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Committed Surface Runoff available (Calculated by Dhruvanarayan'1993 Method) (MCM)	Surface runoff/ water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% area by Injection Wells (75% efficiency) (MCM)	Surface runoff/ water to be utilized for partly filling storage space in Aquifer– I(B) over 100% area by Injection Wells (75% efficiency) (MCM)	Volume of Water Left for Conservation / Storage cum Irrigation Tanks (MCM)	Capacity of a single Conservation/ Irrigation Tank (MCM)	Feasible Numbers of Conservation/ Irrigation Tanks (6) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baghpat	**210.63**	**15.99472**	**10.750**	**2.079**	**3.16572**	**0.1**	**32**

Table – 3.11: **Additional Irrigation Potential to be Created from Storage cum Irrigation Tank**

Name of the Block	Geographical Area (Sq. Km.)	Non-Committed Surface Runoff Available (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)	Evaporation loss (25% of storage) (MCM)	Remaining Water can be utilized for Irrigation (MCM)	Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank considering average crop water requirement as 30 cm for Rabi crops: Wheat, Mustard, Vegetables etc.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baghpat	**210.63**	**15.99472**	**3.16572**	**0.79143**	**2.37429**	**7.9143**	**791.43**

Table– 3.12:**Expected Improvement of GW Scenario due to Artificial Recharge of Unconfined Aquifers Gr.- I(A) in block area with part of Non- committed Surface Run-off (Supply Side Intervention) & Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extractable Ground Water Resource (Ham) {Table - 3.6(C)}	Total Current Annual Ground Water Extraction (SoE) (Ham) {Table - 3.6(C)}	Existing Stag of Dynamic GW Extraction as per GW Resource Estimation (GEC'15) as on March 2023 (%) {(3)/(2)} x 100	Part Storage Space for Recharge/Volume o Water to be stored in to Aquifer-I(A) throughout the block area to Enhance Dynamic GW Resource (Ham) from Table - 3.8(7)	Allocated Source Water from Non-Committed Surface Runoff for Recharging Aquifer-I(A) (Ham) {Table-3.10: (4)}	Actual amount of water to be recharged in Aquifer Gr-I(A) (Ham) (75% of source water) (6) x 0.75	Improved Stage of Ground Water Extraction (%) singly through Artificial Recharge by Injection Well [(3) / {(7) + (2)}] x 100	Effective GW Saving by Cropping Pattern Change growing Kharif Rice on whole land freed from sugarcane and growing Mustard, wheat& vegetable in Rabi season on parts of 10% Sugarcane land divided in 1:1:1 ratio {Table-3.6(C)}	Improved SoE (%) singly by Saving of Dynamic GW Resource through Cropping Pattern Change assuming that Shallow Aquifer-I(A) is used fo Sugarcane [(3) / {(9) + (2)}] x 100	Total Effective Increase in Ground Water Reserve due to Artificial Recharge & Change in Cropping Pattern (Ham) {(7) + (9)}	Cumulative Improvement in SoE due to both Artificial Recharge and Saving GW through Change in Cropping Pattern (%) [(3) / {(2) + (11)}] x 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Baghpat	**5003.63**	**4420.10**	**88.34**	**2780.32**	**1075.00**	**806.25**	**76.08**	**1497.59**	**67.99**	**2303.84**	**60.49**

Table - 3.13 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geographical Area (Ha)	Total Cultivable Area (Ha)	Total CCA (as per MI Census -5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation (Ha)(3)–(4)	Additional Irrigation Potential Created by Harvesting Sur-face Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A) & I(B) aquifers assuming its feasib-ility in 100% area) and by Changing Cropping Pattern (Ha)			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Inter-vention {(8/5) x 100}	Percent of Total Cultivable Land where Irrigation Potential can be created in addition by Management Intervention {(8/3) x 100} (%)	Percent of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Manage-ment Intervention {(8/4) x 100}
					Irrigation Area Increase from Harvested Run-off Water in Irrigation Tanks (Ha) {Table-3.11: (8)}	Irrigation Area Increase from Water Saved by Cropping Pattern Change (Ha) {Table – 3.6(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Baghpat	21063	1700 2	16215	787	791.4300	4064.8962	4856.3262	> 100	28.56	29.95

Table - 3.14 : **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Committed Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model – I)**

Name of the Block	Geogra - phical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge & Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate for Structures			Total Cost Estimate for constr-uction of artificial recharge &conser-vation structures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expendi-ture for Rechar-ging and Conserving 1 CuM(m^3) Harvested Source Water) (in Rs.) (14) x 10^5 / (4) x 10^6
				Allocation of 35 % of Source Water for Re-excavation of Existing Tanks with Recharge Shaft (REET) (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) to recharge Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Effi-ciency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% Efficiency of Rechar-ging (6) x 0.75/ 0.30	Nos. of Farm Ponds (7)/ 0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakh per unit (Rs. in Lakh) (8) x 8	Cost of Constru-ction of Injection Well (Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh) (9) x 5	Cost of Constr-uction of Farm Ponds @ Rs. 8 Lakh per unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Baghpat	210.63	Sandy loam & minor loam, Sand	15.99472	5.598152	4.798416	5.59815	42	12	56	336	60	448	844	5.28

Table-3.15: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in the block - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geographical Area (sq.km.)	Non-Committed Surface Run-off available (Calculated by Dhruva-narayan' 93 Method) (MCM)	Total surface runoff/source water to be utilized for partly filling storage space in Aquifer-I(A) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Total surface runoff/source water to be Utilized for partly filling the storage space in Aquifer–I(B) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Volume of Water for Conservation /Storage cum Irriga-tion Tanks/ Farm Ponds (MCM)	Numbers of Injection Wells to be constructedin Aquifer Group-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer Group-I(B) (5) / 0.3	Nos. of Conservation/ Storage cum Irrigation Tanks/ Farm Pond @ 10 Ham Storage Capacity per unit (6) / 0.1	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh/unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-1(B) @ Rs.10 lakh/unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conservation/ Storage cum Irrigation Tanks/ Farm Ponds @ Rs. 8 lakh/unit (in Lakh) (9) x 8	Total Cost of all Artificial Recharge and Conservation Structure (Rs. in Lakh) (10) + (11)+(12)	Cost-Benefit Ratio: (Expenditure of Recharging /Conserving 1 CuM (m^3) Harvested Source Water) (in Rs.) (13) x 10^5/ (3) x 10^6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Baghpat	**210.63**	**15.9947**	**10.750**	**2.079**	**3.16572**	**36**	**7**	**32**	**180**	**70**	**256**	**506**	**3.16**

4. Chemical Quality of Ground Water in Baghpat block

Table – 4.1:**Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Pre-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO3**	**HCO3**	**Cl**	**F**	**NO3**	**SO4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO2**	**PO4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.82	570	0	305	7	0.11	5.40	9	220	24	7	17	4.4	21	0
Maximum	8.01	2390	0	634	220	0.82	12	370	420	84	60	385	10	27	0
Average	**7.895**	**1182.375**	**0**	**491**	**55.625**	**0.427**	**8.70**	**109.87**	**308.75**	**52.50**	**38.50**	**136.50**	**6.725**	**24.125**	**0**

Table – 4.2: **Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Pre-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	0.005	0.085	0.065	BDL	0.069	BDL	0.001	0.005
Maximum	0.005	1.513	0.136	BDL	3.507	BDL	0.013	0.041
Average	**0.005**	**0.4168**	**0.105**	**BDL**	**1.381**	**BDL**	**0.00425**	**0.019625**

Table – 4.3: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Post-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO_3**	**HCO_3**	**Cl**	**F**	**NO_3**	**SO_4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO_2**	**PO_4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.69	549	0	256	7	0.46	5	26	260	44	27	9	3.7	23	1.22
Maximum	8.11	2113	0	805	206	4.10	140	380	490	88	75	345	20	30	1.22
Average	**7.875**	**1254**	**0**	**540.06**	**51.40**	**1.112**	**21.75**	**89.13**	**344.67**	**61.067**	**46**	**136.93**	**7.645**	**26.93**	**1.22**

Table – 4.4: **Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Post-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	0.001	0.063	0.052	BDL	0.086	BDL	0.001	0.008
Maximum	0.001	0.806	0.137	BDL	2.906	BDL	0.001	0.037
Average	**0.001**	**0.4345**	**0.0802**	**BDL**	**0.9935**	**BDL**	**0.001**	**0.020643**

3. Geological and Geomorphological Maps, Depth to Wat er Level (Pre and Post-Monsoon) Maps in respect Aquifer – I(A) and Isopach Maps (Aquifer - IA & IB) of Baghpat block

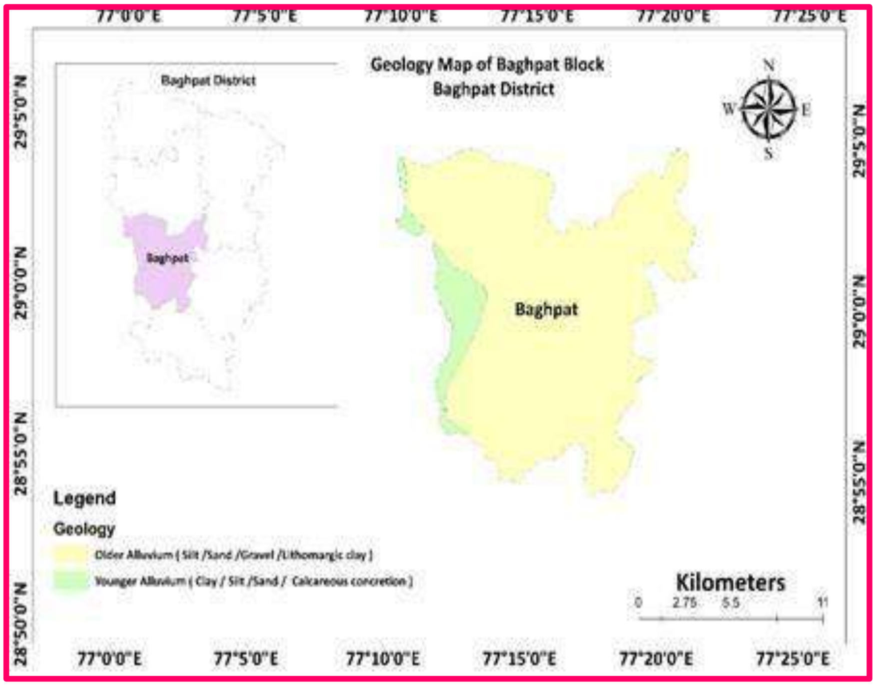


Fig. – 5.1: **Geological Map of Baghpat block, Baghpat district**

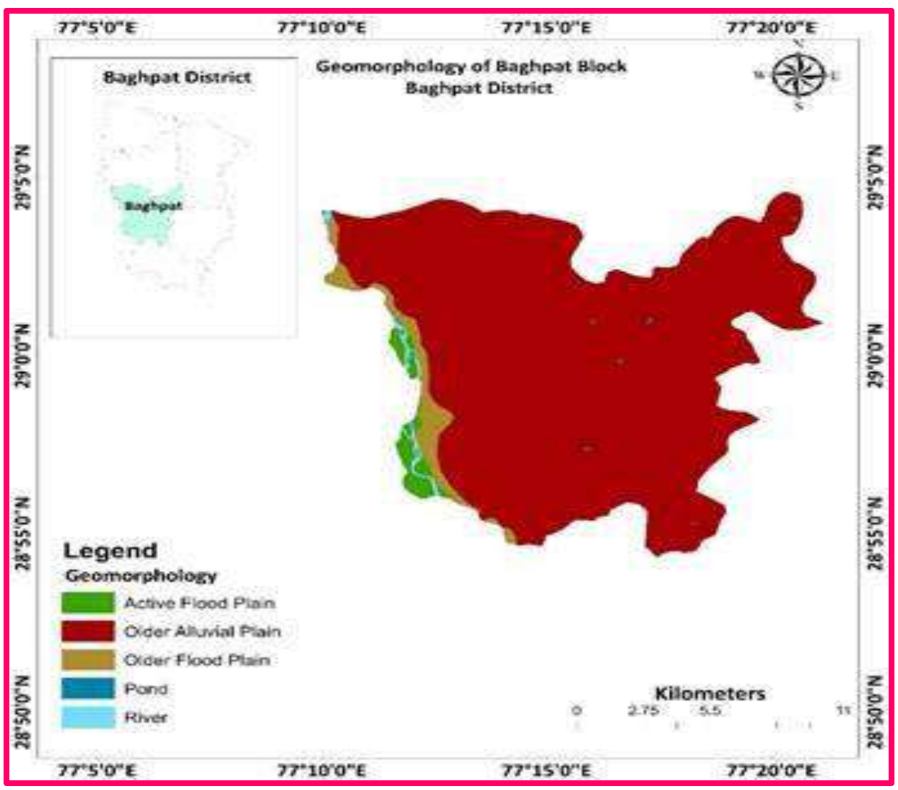


Fig. – 5.2: **Geomorphological Map of Baghpatblock,Baghpat district**

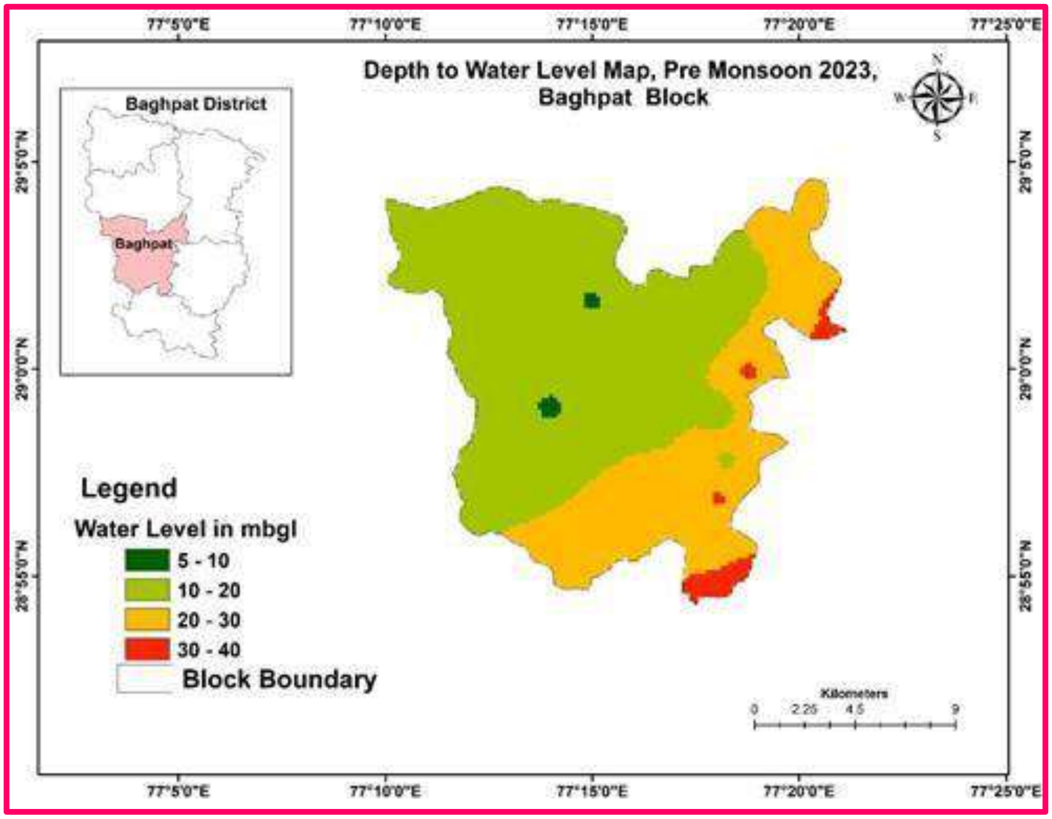


Fig. – 5.3:**Pre-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

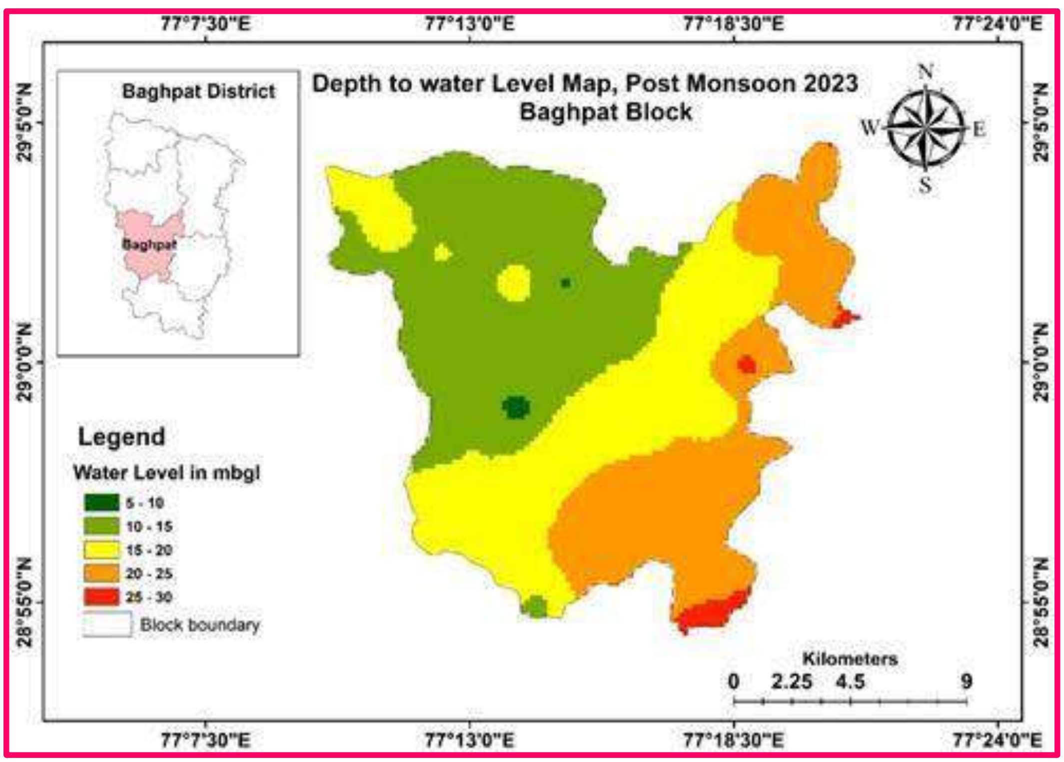


Fig. – 5.4:**Post-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

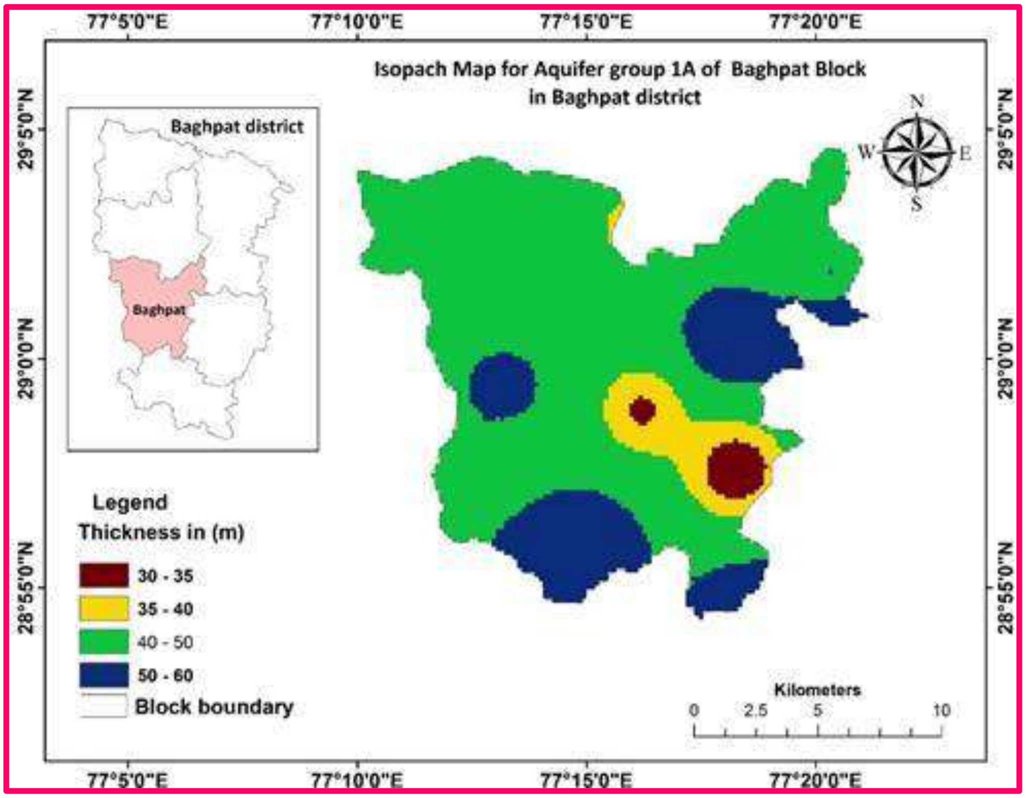


Fig. – 5.5:**Isopach Map of Baghpat block in respect of Aquifer - I(A)**

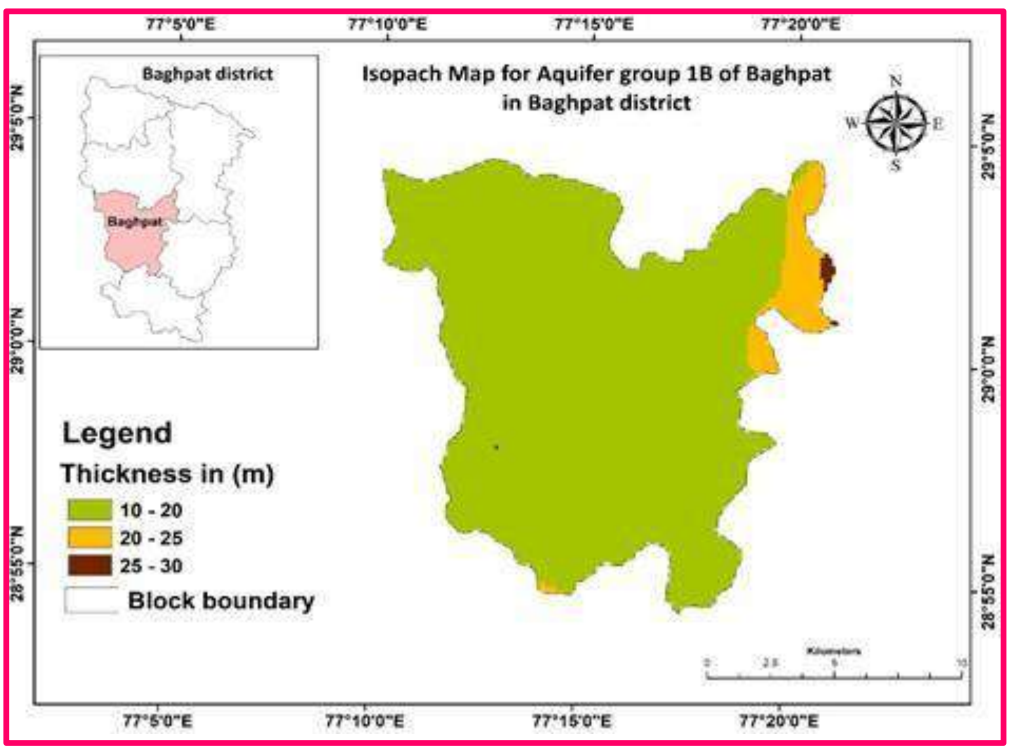


Fig. – 5.6:**Isopach Map of Baghpat block in respect of Aquifer - I(B)**

(iv) Aquifer Mapping and Management Plan of Khekra block, Baghpat district

1. General Information of Khekra block

District	Baghpat				
Block	**Khekra**				
Geographical Area (km^2)	160.37				
Population& Its Density	223619; 1395 persons/sq. km.				
Principal Aquifer System	Quaternary Alluvium				
Major Aquifer System	Older Alluvial (80%), Younger Alluvium				
Normal Annual Rainfall	674.76 mm				
Forest Area (Ha)	188	**Rural Area under Non-Agricultural Use**			2444
Cultivable Area (Ha)	17274	**Culturable Waste Land (Ha)**			421
Net Sown Area (Ha)	13245	**Gross Sown Area (Ha)**			22141
Net Irrigated Area (Ha)	13214	**Gross Irrigated Area (Ha)**			22131
Cropping Intensity (%)	167.16	**Irrigation Intensity (%)**			167.48
Use of Surface Water (%)	1.43	**Use of Ground Water (%)**			98.57
Canal Irrigation Area (Ha)	189	**State Govt. TW (Ha)**	85	**Private TW (Ha)**	12940

2. Hydrogeology of Khekra block

Aquifer Groups and Depth of Occurrence as per Exploratory Drilling carried out by CGWB	1) Aquifer Gr.-I: I(A): 0.00 to (70-85) mbgl; I(B):101 to 140 mbgl 2) Aquifer Group -II: 150to 191 mbgl 3) Aquifer Group-III: 258 to 293 mbgl 4) Aquifer Group-IV: 359 to 397 mbgl(up to maximum explored depth)				
Status of Ground Water Exploration	Exploratory Wells**: 05** **Observation** Wells**: 01** **Piezometer: 00** Slim Hole: **00**				
Aquifer Characteristics	**Group-I(A)**	**Group-I(B)**	**Group-II**	**Group-III**	**Group-IV**
SWL-Static Water Level (m bgl) Q – Discharge (lpm); DD – Drawdown (m); T – Transmissivity (m^2/day) S – Storativity	SWL: **6.05** to **21.16** Q: **2200** to **3500** DD: **6.05** to **6.54** T: **2458** Sp. Yield: **0.06**	SWL:**18.50** Q: **2954** DD:**6.05** to **6.10** T: S:**1.68 x 10^{-5}**	SWL: Q: DD: T: S:	SWL: Q: DD: T: S:	SWL: Q: DD: T: S:

GW Monitoring Stations	Ground Water Monitoring Wells: **00** (NHNS)				
Average Depth to Water	**Aq - I(A)**	**Aq - I(B)**	**Average Depth to Water**	**Aq - I(A)**	**Aq - I(B)**
Level (Pre-monsoon-2023)	**22.07**	**23.40**	**Level (Post-monsoon-2023)**	**20.83**	**22.00**
Ground Water Resources	**Dynamic Resource: Aquifer Group - I(A)** 1) Annual Extractable Ground Water Resources: **3762.30 Ham** 2) Total Ground Water Extraction for all purposes: **4554.84 Ham** 3) Annual GW Allocation for Domestic Use as in 2025**: 541.09 Ham** 4) Net Ground Water Availability for Future Use: **00** 5) Average Stage of Ground Water Extraction: **121.07 %** 6) Category of Block: **Over-Exploited** **Static Resource of Aquifer Group - I(A): 2626.86 Ham** **Static/In-Storage Resource of Aquifer Group – I(B): 20.10 Ham**				
Existing and Future Drinking Water Demand	Existing Demand @ 40 lpcd (2021): **3.5913 MCM** Future Demand @ 40 lpcd (2031): **3.95 MCM**				

3. Aquifer Management Plan of Khekra block

Table – 3.1 : **Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam**

Block	Total Population (Census: 2011)	Projected Population (2021) (Growth 10%)	Covered Population	No. of Total GPs	No. of Total GPs Covered	Population yet to be Covered by PWSS	Annual Water Resource required to Cater Uncovered Population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Khekra	**223619**	**245980**	**24402**	**37**	**3**	**221578**	**3.2350**

Table - 3.2 : **Proposed Plan for GW Draft from Aquifer Gr.–I(A) & Gr.-I(B) for Drinking Water**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Resource required for uncovered population @ 40 lpcd (MCM)	Annual Resource proposed to be utilized from Group-I(A) Aquifers (40% of Requirement) (MCM)	Annual Resource proposed to be utilized from Group-I(B) Aquifer (60 % of Requirement) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(A) Aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(B) Aquifer and 8 hours/day running)	No of TWs requi-red in Group-I(A) Aquifer (4)/(6)	No of TWs requi-red in Group-I(B) Aquifer (5)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Khekra	**160**	**3.2350**	**1.2940**	**1.9410**	**0.1314**	**0.16352**	**10**	**12**

Table - 3.3 : **Probable Impact of GW Draft for Drinking Water on Ground Water Level**

Name of the Block	Geographical Area (sq.km.)	Annual Water Resource propo-sed to be used from Group-I(A) Aquifer (MCM)	Annual Water Resource propo-sed to be used from Group-I(B) Aquifer (MCM)	Specific Yield (Sy) of Group I(A) Aquifers	Storativity (S) of Group I(B) Aquifers	Decline of Water Level in Aquifer-I(A) (m)	Decline of Piezo-metric Surface in Group-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Khekra	**160**	**1.2940**	**1.9410**	**0.06**	**0.00057129**	**0.135**	**21.235**

Table–3.4: **Cost Estimate of Tube Wells for Drinking & Domestic Water Supply to Projected Population (in 2031)**

Block	Human Popula-tion in NAQUIM 2.0 area in 2011	Present Water Requir-ement for Human Popula-tion @ 70 lpcd for (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate as 10%)	Covered Human Popu-lation (2020-21)	Total Population to be Covered in 2031 excepting already covered Population (4) – (5)	Addi-tional Water Requ-irement for Human Populace @70 lpcd in 2031 (m^3/day)	Average Disch-arge of Group-I(B) Aqui-fers (m^3/ hour)	Ave-rage Hours of Run-ning of TW	Dis-charge of one TW in m^3/day for 8 hours of pump-ing per day (8) x (9)	No. of Additional Tube Wells to be Cons-tructed in I(B) Aquifers for catering Human Population in 2031 (7) / (10)	Cost of the Tube Wells of 200 m depth in I(B) aqui-fer 10"x 6" dia @ Rs. 10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Khekra	**223619**	**15653.33**	**270579**	**24402**	**246177**	**17232.39**	**56.00**	**8**	**448.00**	**39**	**390**

Table – 3.5: **Cultivable Area, Net Irrigated Area & GW Availability (2023-24) and Scope & Necessity of Management Intervention**

Block	Geographical Area (Ha)	Cultivable Area (Ha)	Net cultivated Area (Ha)	Culturable Command Area (CCA) (Current Irrigated Area as per MI Census-5 (Ha)	RemainingCultivable Area to bring under Irrigation (Ha) (3)-(5)	Net Irrigated Command Area by Ground Water (as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Command Area by Surface Water (as per MI Census-5 in 2020-21) (Ha)	Net Irrigated Command area by GW+ SW (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extraction (SoE) (%)	Net Ground Water Availability for Future Irrigation& Industrial Use (Ham)	Pre-Monsoon Water Level Trend 2010-2021 (Falling) (m/year)	Post-Monsoon Water Level Trend 2010-21 (Falling) (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (mbgl) in 2023	Average Post-Monsoon Water Level (Aquifer wise) (mbgl) in 2023
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Khekra	**16037**	**17274**	**16765**	**16753**	**521**	**16524**	**229**	**16753**	**121.07**	**0**	**0.75**		**22.07 (IA)** **23.40 (IB)**	**20.83 (IA)** **22.00 (IB)**

Table - 3.6 (A):**Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present Ground Water Draft**

Additional area brought under coverage of other crops with the saved water from 10 % reduction of Sugarcane Cultivation						Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10 % Sugarcane Cultivation												Increase in Irrigation Area by reducing 10% of Sugarcane Cultivation	
Block	Present area under Sugarcane (Ha)	10% of Sugarcane Area (Ha)	Area under Sugarcane after 10% reduction(Ha)	Water Column for Sugarcane Irrigation(m)	Volume of Irrigation water saved (Ham)	Wheat (Rabi Season) (Maximum Delta factor: 45 cm)			'Boro' Rice (January-April) (Maximum Delta factor: 140 cm)			Vegetables (Rabi and Summer) (Maximum Delta factor: 40 cm)			Mustard (Rabi Season) (Maximum Delta factor: 45 cm)			Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)	Effective Increase in Area of Irrigation i.e. CCA(Ha) (19) – (3)
						Water (%)		Area	Water (%)		Area	Water (%)		Area	Water (%)		Area		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Khekra	7834	783.40	7050.60	2.4	1880.16	1034.09	55%	2297.97	282.02	15%	201.45	282.02	15%	705.06	282.024	15%	626.72	3831.20	3047.80

Table - 3.6 (B): **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Proposedre duction of Sugar -cane Cultivation Area (Ha)	Loss in Production of Sugarcane as per Avg. Yield Rate 80 MT /Ha in 2023-24 (MT)	Monetary Loss (in Crore) for 10 % Reduction of Sugarcane Cultivation Area as per MSP of 2023-24 of Sugar -cane	Wheat (Rabi)			'Boro' Rice (Jan-April)			Vegetables(Rabi & Summer)			Mustard			Additional Income from growing alternative crops with GW earlier being used by 10% Sugarcane (Rs. in Crore) (7)+(10)+	Total Effective Increase in Income from Proposed Intervention through change in Cropping Pattern (Rs. in Crore) (17) – (4)
				Additional Area to be Cultivated&Irriga-ted from Table-3.6(A) (Ha)	AdditionalProduc-tion expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price Rs. 21250 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated& Irrigated from Table-3.6(A) (Ha)	AdditionalProductionexpec-ted as per Average Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Additional Income as per Minimum Support Price Rs. 21830 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated & Irrigated for Vegetable from Table-3.6(A) (Ha)	AdditionalProdu -ction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Additional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. in Crore)	Additional Area to be Cultivated & Irrigated From Table-3.6(A) (Ha)	AdditionalProductionexpec-ted as per Average Yield Rate 1.980 MT/Ha in 2023 -24 (MT)	Additional Income as per Minimum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in Crore)		
			@ Rs. 3700/MT													(13)+(16)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Khekra	783.4	62672	23.1886	2297.97	8042.91	17.0912	201.45	565.86	1.2353	705.06	16921.44	50.7643	626.7	1240.91	6.7629	75.8537	52.6651

Table – 3.6 (C):**Impact of Reducing Sugarcane area and allotting that to Kharif Paddy and equally distributing to 3 low CWR crops in Rabi on Income & GW**

Block	Present Area of Sugarcane cultivation (Ha)	Present GW Draft for Sugarcane Cultivation (CWR = 2.4 m) (MCM)	Proposed 10 % Reduction of Sugarcane cultivation Area (Ha)	Amount of Ground Water Saved by reducing 10% of Sugar cane Cultivation Area (MCM)	Yield Rate of Sugarcane (MT/Ha)	Loss in Production of Sugarcane due to reduction of cultivation area (MT)	Loss in Income from Sugarcane @ Rs. 3700 per MT (as per MSP of 2023-24) (Rs. in Cr.)	Gain in Production of Kharif Rice @ existing Avg. Yield 2.809 MT/Ha grown in freed 10% sugarcane area due to Alternatecropping pattern (MT)	Gain in Income from Kharif Rice @ Rs. 21830 per M. Ton (as per MSP of 2023 -24) (Rs. in Cr)	Proposed Cropping of Mustard, Wheat, Vegetable (Low CWR & normallypracticed) in Rabi season in 1:1:1 Ratio in Lost Sugarcane Area (Ha)	Gain in Production of Mustard @ existing Average Yield Rate 1.980 MT/Ha in NAQ-UIM Area due to Alternatecropping-pattern (MT)	Gain in Income from Mustard @ Rs. 54500 per M. Ton (as per MSP of 2023 -24) (Rs. in Cr	Gain in Production of Wheat @ existing Average Yield Rate 3.5 MT/Ha in NAQ-UIM Area due to Alternate Cropping Pattern (MT)	Gain in Income from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore Rs.)	Gain in Production of Vegetables @ Existing Avg. Yield Rate 24 MT/Ha due to alternate cropping pattern (MT)	Gain in Income from Vegetable @ Rs. 30000 per MT (as per Farm Gate Price : 2023 -24) (Crore Rs.)	Individual Ground Water Draft for Additional Cultivation of Rice during Kharif period on the whole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10% sugarcane area as per Crop Water Requirement 0.60 m, 0.45 m, 0.45 m and 0.40 m respectively for Kharif Paddy, Mustard, Wheat and Vegetables (MCM)				Total Ground Water Draft for Additional Cultivation of Kharif Rice and Mustard, Wheat & Vegetables In Rabi season (MCM)	Effective Saving of Ground Water by Cropping Pattern Change MCM {(5) - (19)}	Effective Gain in Income for growing Kharif Rice and Rabi Mustard, Wheat & Vegetables in area freed by 10% Sugarcane {(10) + (13) + (15) + (17)} – (8) (Rs. in Cr)	Exis Ting Stage of Dyn -amic GW Devlopment as per GW ResourceEstimation by GEC 2015 Method as on March 2023	AnnualExtractable GW Resource as per Dynamic Ground Water Resource Calculated for 2023 MCM	Total Annual Ground Water Extraction for all purposes in respect of Dynamic GW resourcecalculation 2023 (MCM)	Improved Stage of GW Development by Saving of Dynamic GW esource (%) Considering that Irrigation water for Sugarcane is drawn from Aquifer Group-I(A)	Expected Rise in Pre-monsoon Water Level (m) of Unconfined o Semi-Confined Aquifercalculated taking Avg p. Yield of Gr. -I(A) Aquifer as 0.06
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must.	Wheat	Veg								
Khe-kra	7834	188.016	783.4	18.8016	80	62672	23.19	2200.6	4.8038	261.13	517	2.818	913.97	1.9422	6267	18.80	4.70	1.175	1.175	1.045	8.0951	10.71	5.1767	121.07	37.62	45.548	94.25	1.11

Table – 3.7: **Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Block	Geogra-phical Area (Ha)	Normal Monsoon Rainfall (m) (50 yrs data-data.gov.in)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvanarayana'1993 (Land slope, type of land and soil type) (Land Slope: 0 - 5%)	Major types of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt'= (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-committed) =Vnc (Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt'=(Rn x A x C)	'V'	'Vnc'	'Vf'
Khekra	**16037**	**0.675**	**10824.98**	**0.5**	Sandy loam, minor loam, Sand	Moderate to Well Drained	**5412.49**	**4059.366**	**2029.683**	**1217.81**

Table – 3.8: **Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geogra-phical Area (Sq. Km)	Non-Commi-tted Surface Runoff avail-able for whole Block Area (MCM)	Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A) & Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7 + 12) (MCM)	Total harvested Rain water/ surface run-off water actually needed for injection to Gr.-I(A) & Gr.-I(B) Aquifer (14)x(100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure of 100 sq. mt. roof (area* total avg. annual rainfall*0.8) (MCM)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr. - I(A) Aquifer (8/16)	No. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr.-I(B) Aquifer (13/16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Normal Annual Rainfall– 0.67476 m			Ave-rage post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 mbgl and Post-mon-soon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2)x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7)x(100/75)	Avg. Post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 m bgl and Post-monsoon water level (m)	Stora-tivity (S)	Storage Space for Recharge /Volume of Water to be stored (2) x(10)x(11)	Rain water to be harv-ested for Gr.-I(B) Aquifer (12) x (100/75)					
Khekra	**160.37**	**12.1781**	**20.83**	**5.83**	**0.06**	**56.0974**	**74.7966**	**22.00**	**7.00**	**0.00057**	**0.6410**	**0.8547**	**56.7384**	**75.6512**	**0.000054**	**1385614**	**15833**

Table – 3.9 :**Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime**

Name of the Block	Geographical Area (sq. km.)	No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined Aquifers (Table - 3.8 : 17)	Amount of water to be recharged in Aquifer Gr.-I(A) (Table - 3.8 : 7)	Impact on Water Level of Aquifer Gr.–I(A) (rise in m)	No. of RTRWH with Injection Well designed for Gr.-I(B) Confined Aquifers (Table - 3.8 : 18)	Amount of water to be recharged in Aq. Gr.-I(B) (Table- 3.8 : 12)	Impact on Piezometric Surface of Aquifer Gr.–I(B) (rise in m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Khekra	**160.37**	**1385614**	**56.0974**	**5.83**	**15833**	**0.6410**	**7.00**

Table – 3.10: **Conservation of Surplus Non-Committed Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds remained after Artificial Recharge by Injection Wells**

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Committed Surface Runoff available (Calculated by Dhruvanarayan'1993 Method) (MCM)	Surface runoff/ water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% area by Injection Wells (75% efficiency) (MCM)	Surface runoff/ water to be utilized for partly filling storage space in Aquifer– I(B) over 100% area by Injection Wells (75% efficiency) (MCM)	Volume of Water Left for Conservation / Storage cum Irrigation Tanks (MCM)	Capacity of a single Conservation/ Irrigation Tank (MCM)	Feasible Numbers of Conservation/ Irrigation Tanks (6) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Khekra	**160.37**	**12.17810**	**8.250**	**1.510**	**2.4181**	**0.1**	**25**

Table – 3.11: **Additional Irrigation Potential to be Created from Conservation cum Irrigation Tank**

Name of the Block	Geographical Area (Sq. Km.)	Non-Committed Surface Runoff Available (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)	Evaporation loss (25% of storage) (MCM)	Remaining Water can be utilized for Irrigation (MCM)	Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank considering average crop water requirement as 30 cm for Rabi crops: Wheat, Mustard, Vegetables etc.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Khekra	**160.37**	**12.17810**	**2.4181**	**0.604525**	**1.813575**	**6.04525**	**604.525**

Table– 3.12:**Expected Improvement of GW Scenario due to Artificial Recharge of Unconfined Aquifers Gr.- I(A) in block area with part of Non-committed Surface Run-off (Supply Side Intervention) & Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extractable Ground Water Resource (Ham) {Table - 3.6(C)}	Total Current Annual Ground Water Extraction (SoE) (Ham) {Table - 3.6(C)}	Existing Stag of Dynamic GW Extraction as per GW Resource Estimation (GEC'15) as on March 2023 (%) {(3)/(2)} x 100	Part Storage Space for Recharge/Volume o Water to be stored in to Aquifer-I(A) throughout the block area to Enhance Dynamic GW Resource (Ham) from Table - 3.8(7)	Allocated Source Water from Non-Committed Surface Runoff for Recharging Aquifer-I(A) (Ham) {Table-3.10: (4)}	Actual amount of water to be recharged in Aquifer Gr-I(A) (Ham) (75% of source water) (6) x 0.75	Improved Stage of Ground Water Extraction (%) singly through Artificial Recharge by Injection Well [(3) /{(7)+ (2)}] x 100	Effective GW Saving by Cropping Pattern Change growing Kharif Rice on whole land freed from sugarcane and growing Mustard, wheat& vegetable in Rabi season on parts of 10% Sugarcane land divided in 1:1:1 Ratio{Table-.6(C)}	Improved SoE (%) singly by Saving of Dynamic GW Resource through Cropping Pattern Change assuming that Shallow Aquifer-I(A) is used fo Sugarcane [(3) / {(9) + (2)}] x 100	Total Effective Increase in Ground Water Reserve due to Artificial Recharge & Change in Cropping Pattern (Ham) {(7) + (9)}	Cumulative Improvement in SoE due o both Artificia Recharge and Saving GW through Change in Cropping Pattern (%) (3) / {(2) + (11)} x 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	**(9)**	(10)	**(11)**	(12)
Khekra	3762.30	4554.84	121.07	5609.74	825.00	618.75	103.97	**1070.65**	94.25	**1689.40**	83.55

Table - 3.13 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geogr-aphical Area (Ha)	Total Culti-vable Area (Ha)	Total CCA (as per MI Cen-sus -5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation (Ha)(3)–(4)	Additional Irrigation Potential Created by Harvesting Sur-face Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A) & I(B) aquifers assuming its feasib-ility in 100% area) and by Changing Cropping Pattern (Ha)			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Inter-vention {(8/5) x 100}	Percent of Total Cultivable Land where Irrigation Potential can be created in addition by Management Intervention {(8/3) x 100} (%)	Percent of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Manage-ment Intervention {(8/4) x 100}
					Irrigation Area Increase from Harvested Run-off Water in Irrigation Tanks (Ha) {Table-3.11: (8)}	Irrigation Area Increase from Water Saved by Cropping Pattern Change (Ha) {Table – 3.6(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Khekra	16037	17274	16753	**521**	**604.5250**	**3047.7990**	**3652.324**	**> 100**	**21.14**	**21.80**

Table - 3.14 : **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Committed Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model – I)**

Name of the Block	Geogra - phical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge & Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate for Structures			Total Cost Estimate for const-ruction of artificial recharge &conser-vation structures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expendi-ture for Rechar-ging and Conserving 1 CuM(m^3) Harvested Source Water) (in Rs.) (14) x 105 /
				Allocation of 35 % of Source Water for Re-excavation of Existing Tanks with Recharge Shaft (REET) (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) to recharge Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Effi-ciency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% Effici-ency of Rechar-ging (6) x 0.75 /0.30	Nos. of Farm Ponds (7)/ 0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakh per unit (Rs. in Lakh) (8) x 8	Cost of Constru-ction of Injection Well (Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh)	Cost of Constr-uction of Farm Ponds @Rs.8 Lakh per unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Khekra	160.37	Sandy loam & minor loam, Sand	12.17810	4.262335	3.65343	4.262335	32	10	43	256	50	344	650	5.34

Table-3.15: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in the block - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geogr-aphical Area (sq.km.)	Non-Co-mmitted Surface Run-off available (Calcu-lated by Dhruva-narayan' 93 Method) (MCM)	Total surface runoff/source water to be utilized for partly filling storage space in Aquifer-I(A) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Total surface runoff/source water to be Uti-lized for partly filling the storage space in Aquifer–I(B) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Volume of Water for Conser-vation /Storage cum Irriga-tion Tanks/ Farm Ponds (MCM)	Numbers of Injection Wells to be construc-ted in Aquifer Group-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer Group-I(B) (5) / 0.3	Nos. of Conser-vation/ Storage cum Irri-gation Tanks/ Farm Pond @ 10 Ham Storage Capacity per unit (6) / 0.1	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh/unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-1(B) @ Rs.10 lakh/unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conser-vation/ Storage cum Irri-gation Tanks/ Farm Ponds @ Rs. 8 lakh/unit (in Lakh) (9) x 8	Total Cost of all Arti-ficial Recharge and Conser-vation Structure (Rs. in Lakh) (10) + (11)+(12)	Cost-Benefit Ratio: Expenditure of Recharging /Conserving 1 CuM (m^3) Harvested Source Water) (in Rs.) (13) x 10^5/
													(3) x 106
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Khek ra	160.37	12.1781	8.250	1.510	2.4181	28	5	25	140	50	200	390	3.20

4. Chemical Quality of Ground Water in Khekra block

Table – 4.1: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Pre-monsoon Period**

Basic Elements	pH	EC(µS/cm at 25°C)	CO3	HCO3	Cl	F	NO3	SO4	TH	Ca	Mg	Na	K	SiO2	PO4
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.40	650	0	354	7	0.19	6	23	90	16	12	48	2.4	21	0
Maximum	8.23	2330	0	634	425	1.06	36	380	610	124	110	335	17	34	0
Average	**7.937**	**1361**	**0**	**481.27**	**114.09**	**0.547**	**20.33**	**104.27**	**310**	**54.54**	**43.27**	**170.64**	**5.89**	**27.09**	**0**

Table – 4.2:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Pre-monsoon Period**

Heavy Metals	Chromium (Cr)	Iron (Fe)	Manganese (Mn)	Copper (Cu)	Zinc (Zn)	Arsenic (As)	Lead (Pb)	Uranium (U)
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	0.002	0.177	0.063	BDL	1.012	0.001	0.001	0.009
Maximum	0.002	2.195	0.125	BDL	2.54	0.001	0.011	0.027
Average	**0.002**	**0.6902**	**0.0927**	**BDL**	**1.5135**	**0.001**	**0.004**	**0.0149**

Table – 4.3:**Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Post-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO_3**	**HCO_3**	**Cl**	**F**	**NO_3**	**SO_4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO_2**	**PO_4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.23	630	0	305	7	0.07	7	30	190	44	19	23	4.1	22	0
Maximum	8.07	2131	0	610	340	1.39	58	400	700	232	58	350	7.1	35	0
Average	**7.751**	**1230.25**	**0**	**458.58**	**85.58**	**0.7016**	**17.55**	**96.08**	**369.16**	**88.33**	**36**	**118.83**	**5.685**	**29.25**	**0**

Table – 4.4:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Post-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.154	0.058	BDL	0.103	BDL	BDL	0.007
Maximum	BDL	6.301	0.118	BDL	1.074	BDL	BDL	0.023
Average	**BDL**	**1.745**	**0.079**	**BDL**	**0.503**	**BDL**	**BDL**	**0.0148**

3. **Geological and Geomorphological Maps, Depth to Wat er Level (Pre and Post-Monsoon) Maps in respect Aquifer – I(A) and Isopach Maps (Aquifer - IA & IB) of Khekra block**

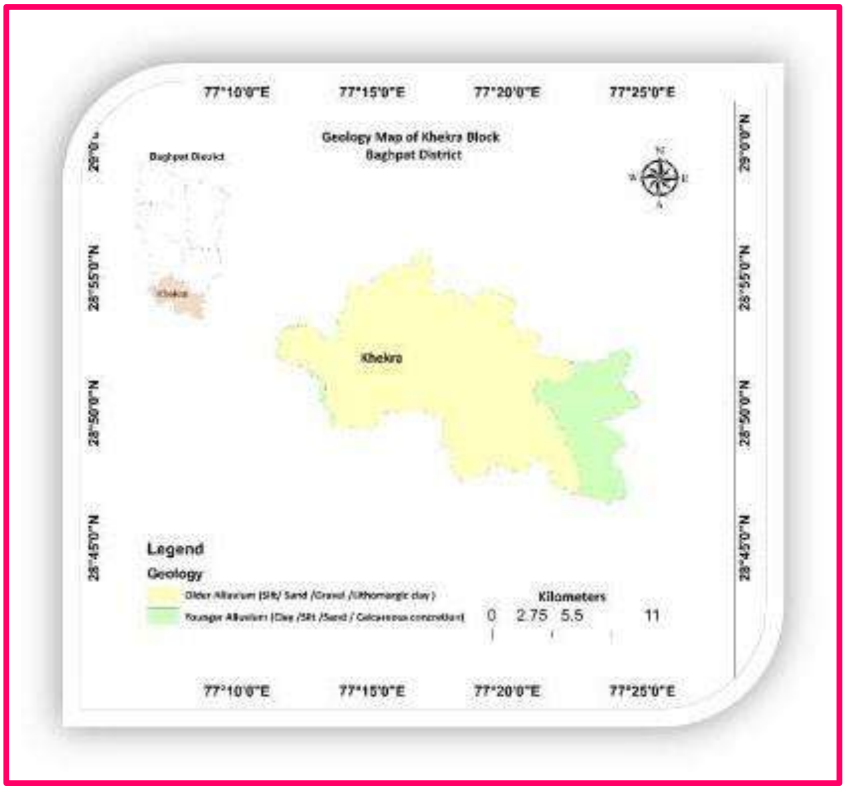


Fig. – 5.1: **Geological Map of Khekra block, Baghpat district**

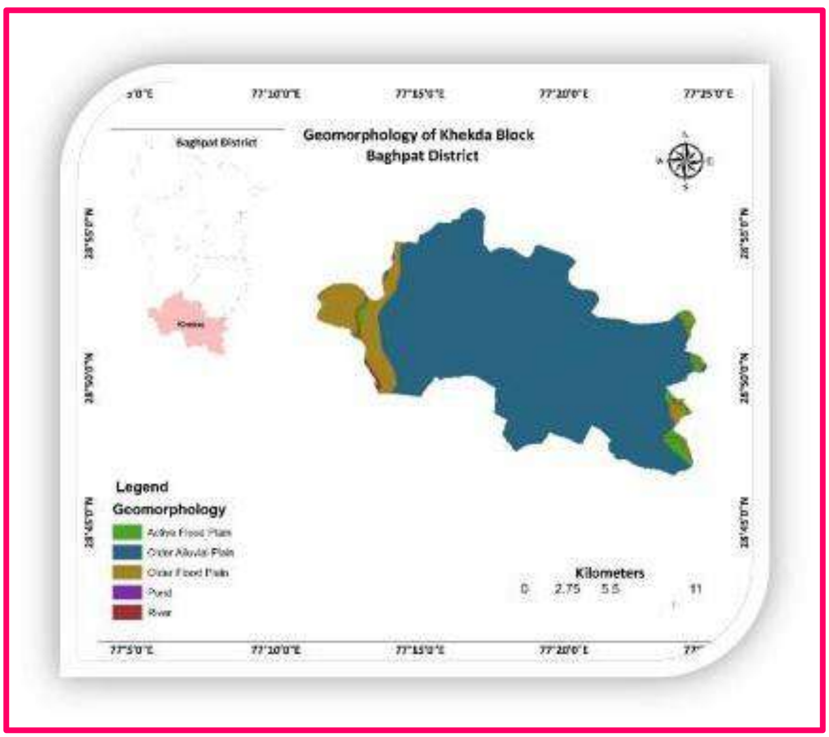


Fig. – 5.2: **Geomorphological Map of Khekrablock,Baghpat district**

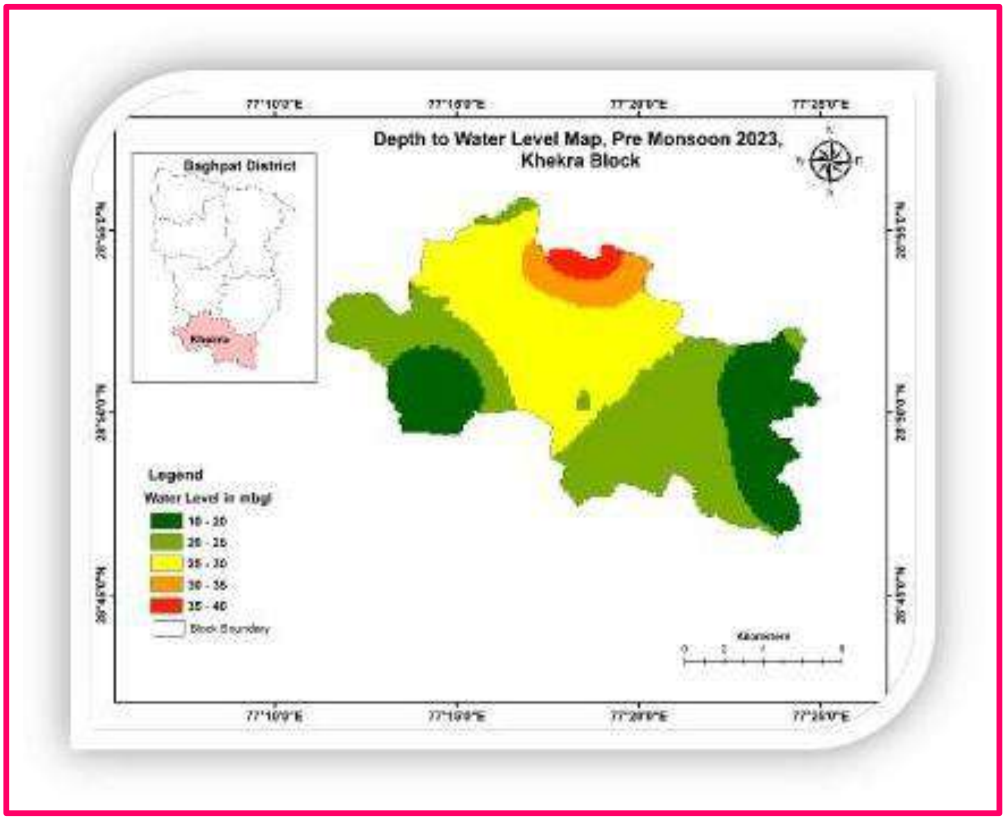


Fig. – 5.3:**Pre-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

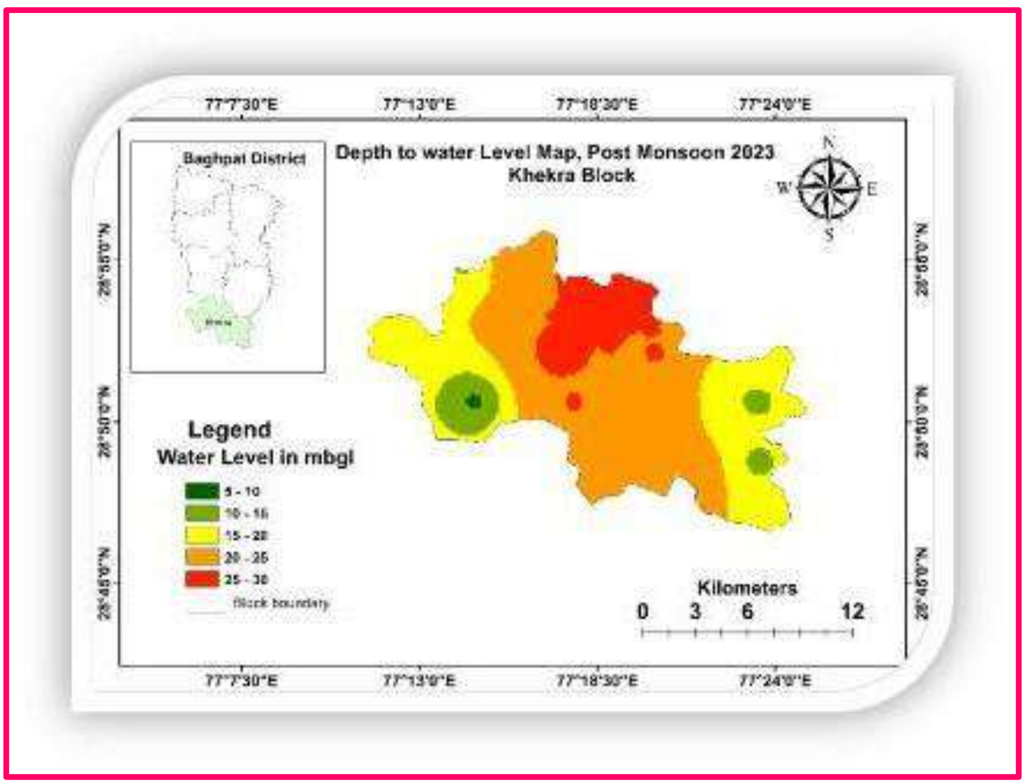


Fig. – 5.4:**Post-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

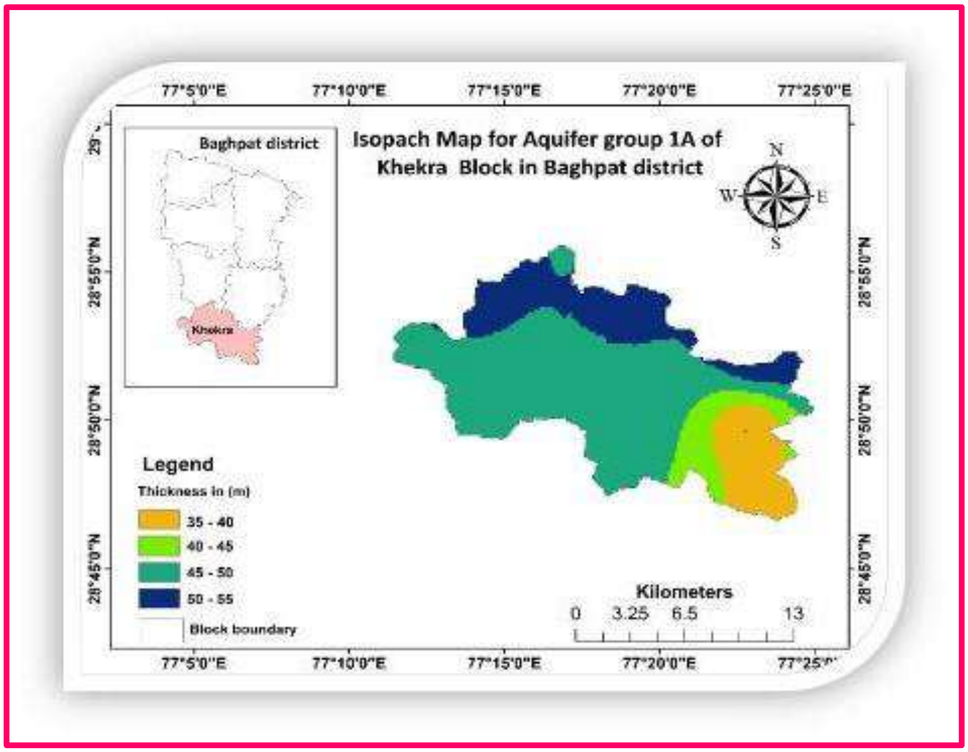


Fig. – 5.5:**Isopach Map of Khekra block in respect of Aquifer - I(A)**

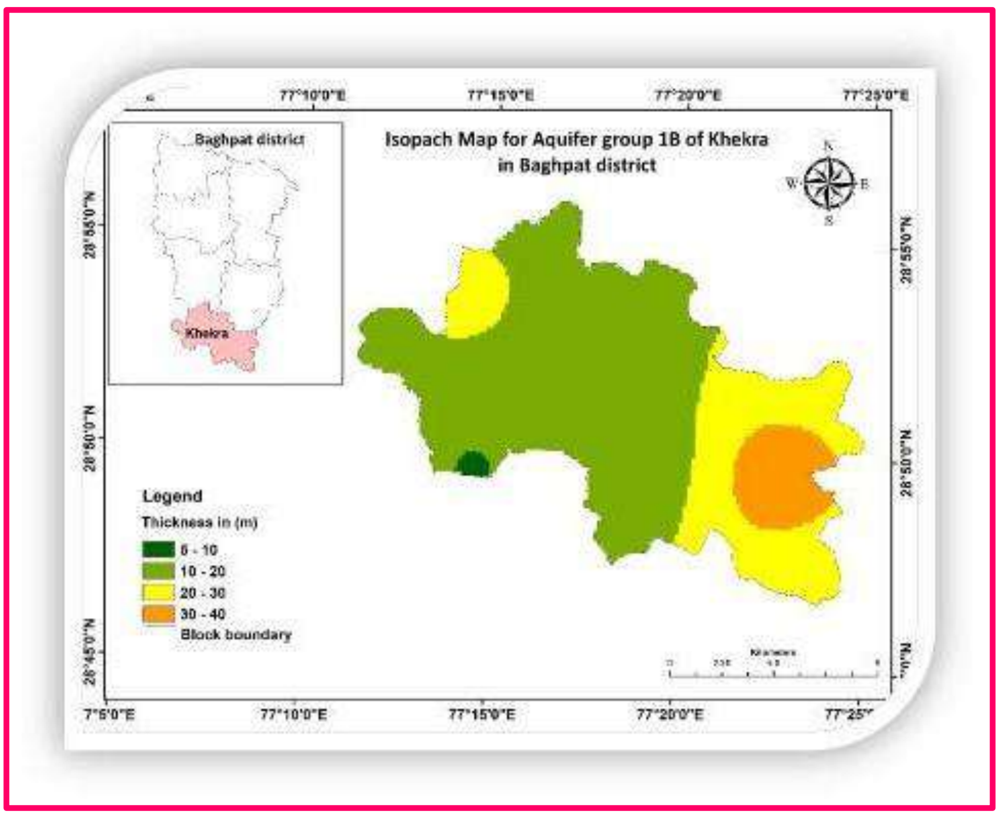


Fig. – 5.6:**Isopach Map of Khekra block in respect of Aquifer - I(B)**

(v) Aquifer Mapping and Management Plan of Pilana block, Baghpat district

1. General Information of Pilana block

District	Baghpat				
Block	**Pilana**				
Geographical Area (km^2)	207.14				
Population& its Density	167776; 810 persons/sq. km.				
Principal Aquifer System	Quaternary Alluvium				
Major Aquifer System	Older Alluvial (80%), Younger Alluvium				
Normal Annual Rainfall	674.76 mm				
Forest Area (Ha)	358	**Rural Area under Non-Agricultural Use (Ha)**			2273
Cultivable Area (Ha)	17274	**Culturable Waste Land (Ha)**			286
Net Sown Area (Ha)	16765	**Gross Sown Area (Ha)**			25945
Net Irrigated Area (Ha)	16753	**Gross Irrigated Area (Ha)**			25936
Cropping Intensity (%)	154.76	**Irrigation Intensity (%)**			154.81
Use of Surface Water (%)	1.37	**Use of Ground Water (%)**			98.63
Canal Irrigation Area (Ha)	229	**State Govt. TW (Ha)**	52	**Private TW (Ha)**	16472

2. Hydrogeology of Pilana block

Aquifer Groups and Depth of Occurrence as per Exploratory Drilling carried out by CGWB	1) Aquifer Gr.-I: I(A): 0.00 to (75-86)mbgl; I(B): (104-118) to (131-154)mbgl 2) Aquifer Group -II: 170to 224 mbgl 3) Aquifer Group-III: 272 to 304 mbgl 4) Aquifer Group-IV: 367 to 442 mbgl(up to maximum explored depth)				
Status of Ground Water Exploration	Exploratory Wells**: 07** **Observation** Wells**: 01** **Piezometer: 01** Slim Hole: **01**				
Aquifer Characteristics	**Group-I(A)**	**Group-I(B)**	**Group-II**	**Group-III**	**Group-IV**
SWL-Static Water Level (m bgl) Q – Discharge (lpm); DD – Drawdown (m); T – Transmissivity (m^2/day) S – Storativity	SWL: **16.25** to **22.80** Q: **850** to **2954** DD: **4.85** to **6.95** T: Sp. Yield: **0.06**	SWL:**21.85** to **28.15** Q: **1557** to **2954** DD: **4.84** to **6.90** T: **473** to **1712** S: **4.17×10^{-4}**to**2.44×10^{-5}**	SWL: Q: DD: T: S:	SWL: Q: DD: T: S:	SWL: Q: DD: T: S:

<table>
<tr><td>GW Monitoring Stations</td><td colspan="6">Ground Water Monitoring Wells: 02 (NHNS)</td></tr>
<tr><td rowspan="2">Average Depth to Water Level (Pre-monsoon-2023)</td><td>Aq - I(A)</td><td>Aq - I(B)</td><td rowspan="2">Average Depth to Water Level (Post-monsoon-2023)</td><td>Aq - I(A)</td><td>Aq - I(B)</td></tr>
<tr><td>28.98</td><td>24.51</td><td>22.97</td><td>22.68</td></tr>
<tr><td>Ground Water Resources (2023)</td><td colspan="5">Dynamic Resource (2023): Aquifer Group - I(A)
1) Annual Extractable Ground Water Resources: 4364.88 Ham
2) Total Ground Water Extraction for all purposes: 5700.20 Ham
3) Annual GW Allocation for Domestic Use as in 2025: 429.21 Ham
4) Net Ground Water Availability for Future Use: 00
5) Average Stage of Ground Water Extraction: 130.59 %
6) Category of Block: Over-Exploited
Static Resource of Aquifer Group - I(A): 795.42 Ham
Static/In-Storage Resource of Aquifer Group – I(B): 41.40 Ham</td></tr>
<tr><td>Existing and Future Drinking Water Demand</td><td colspan="5">Existing Demand @ 40 lpcd (2021): 2.6945 MCM
Future Demand @ 40 lpcd (2031): 2.9639 MCM</td></tr>
</table>

3. Aquifer Management Plan of Pilana block

Table – 3.1 : **Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam**

Block	Total Population (Census: 2011)	Projected Population (2021) (Growth 10%)	Covered Population	No. of Total GPs	No. of Total GPs Covered	Population yet to be Covered by PWSS	Annual Water Resource required to Cater Uncovered Population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pilana	**167776**	**184554**	**102354**	**41**	**17**	**82200**	**1.2001**

Table - 3.2 : **Proposed Plan for GW Draft from Aquifer Gr.–I(A) & Gr.-I(B) for Drinking Water**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Resource required for uncovered population @ 40 lpcd (MCM)	Annual Resource proposed to be utilized from Group-I(A) Aquifers (40% of Requirement) (MCM)	Annual Resource proposed to be utilized from Group-I(B) Aquifer (60 % of Requirement) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(A) Aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(B) Aquifer and 8 hours/day running)	No of TWs requi-red in Group-I(A) Aquifer (4)/(6)	No of TWs requi-red in Group-I(B) Aquifer (5)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pilana	**207.14**	**1.2001**	**0.4800**	**0.7201**	**0.1314**	**0.148**	**4**	**5**

Table - 3.3 : **Probable Impact of GW Draft for Drinking Water on Ground Water Level**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Water Resource propo-sed to be used from Group-I(A) Aquifer (MCM)	Annual Water Resource propo-sed to be used from Group-I(B) Aquifer (MCM)	Specific Yield (Sy) of Group I(A) Aquifers	Storativity (S) of Group I(B) Aquifers	Decline of Water Level in Aquifer-I(A) (m)	Decline of Piezo-metric Surface in Group-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pilana	**207.14**	**0.4800**	**0.7201**	**0.06**	**0.00057129**	**0.039**	**6.089**

Table–3.4: **Cost Estimate of Tube Wells for Drinking & Domestic Water Supply to Projected Population (in 2031)**

Block	Human Popula-tion in NAQUIM 2.0 area in 2011	Present Water Require-ment for Human Popula-tion @ 70 lpcd for (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate as 10%)	Covered Human Popu-lation (2020-21)	Total Population to be Covered in 2031 excepting already covered Population (4) – (5)	Addi-tional Water Requ-irement for Human Populace @70 lpcd in 2031 (m^3/day)	Average Disch-arge of Group-I(B) Aqui-fers (m^3/ hour)	Ave-rage Hours of Run-ning of TW	Dis-charge of one TW in m^3/day for 8 hours of pump-ing per day (8) x (9)	Nos. of Additional Tube Wells to be Cons-tructed in I(B) Aquifers for catering Human Population in 2031 (7) / (10)	Cost of the Tube Wells of 200 m depth in I(B) aqui-fer 10"x 6" dia @ Rs. 10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Pilana	**167776**	**11744.32**	**203009**	**102354**	**100655**	**7045.847**	**50.68**	**8**	**405.44**	**17**	**170**

Table – 3.5: **Cultivable Area, Net Irrigated Area & GW Availability (2023-24) and Scope & Necessity of Management Intervention**

Block	Geogra -phical Area (Ha)	Culti-vable Area (Ha)	Net culti-vated Area (Ha)	Cultur-able Comma-nd Area (CCA) (Current Irrigated Area as per MI Census-5 (Ha)	Rema-iningCulti-vable Area to bring under Irri-gation (Ha) (3)-(5)	Net Irrigated Comm-and Area by Ground Water (as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Comm-and Area by Surface Water (as per MI Census-5 in 2020-21) (Ha)	Net Irrigated Comm-and area by GW+ SW (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extrac-tion (SoE) (%)	Net Ground Water Avail-ability for Future Irriga-tion& Indus-trial Use (Ham)	Pre-Mon-soon Water Level Trend 2010-2021 (Falling) (m/year)	Post-Mon-soon Water Level Trend 2010-21 (Falling) (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (mbgl) in 2023	Average Post-Monsoon Water Level (Aquifer wise) (mbgl) in 2023
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Pilana	**20714**	**13876**	**13245**	**13214**	**662**	**13025**	**189**	**13214**	**130.59**	**0**	**0.80**		**28.98 (IA)** **24.51 (IB)**	**22.97 (IA)** **22.68 (IB)**

Table - 3.6 (A):**Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present Ground Water Draft**

Additional area brought under coverage of other crops with the saved water from 10 % reduction of Sugarcane Cultivation						**Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10 % Sugarcane Cultivation**												**Increase in Irriga-tion Area by reduc -ing 10% of Sugar-cane Cultivation**	
Block	**Present area under Sugar-cane (Ha)**	**10% of Sugar-cane Area (Ha)**	**Area under Sugar-cane after 10% reducti-on(Ha)**	**Water Col-umn for Sugar-cane Irrigat-ion(m)**	**Volume of Irriga-tion water saved (Ham)**	**Wheat (Rabi Season) (Maximum Delta factor: 45 cm)**			**'Boro' Rice (January-April) (Maximum Delta factor: 140 cm)**			**Vegetables (Rabi and Summer) (Maximum Delta factor: 40 cm)**			**Mustard (Rabi Season) (Maximum Delta factor: 45 cm)**			**Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)**	**Effective Increase in Area of Irriga-tion i.e. CCA(Ha) (19) – (3)**
						Water (%)		**Area**	**Water (%)**		**Area**	**Water (%)**		**Area**	**Water (%)**		**Area**		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Pilana	**11463**	**1146.30**	**10316.7**	**2.4**	**2751.12**	**1375.56**	**50%**	**3056.80**	**550.22**	**20%**	**393.02**	**412.67**	**15%**	**1031.67**	**412.668**	**15%**	**917.04**	**5398.53**	**4252.23**

Table-3.6 (B): **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Prop-osedre duc-tion of Sugar-cane Culti-vation Area (Ha)	Loss in Produc-tion of Sugar-cane as per Avg. Yield Rate 80 MT /Ha in 2023-24 (MT)	Monetary Loss (in Crore) for 10 % Reduc-tion of Sugar-cane Cultiva-tion Area as per MSP of 2023-24 of Sugar-cane @ Rs. 3700/MT	Wheat (Rabi)			'Boro' Rice (Jan-April)			Vegetables (Rabi & Summer)			Mustard			Addi-tional Income from growing alternat-ive crops with GW earlier being used by 10% Sugar-cane (Rs. in Crore) (7)+(10)+(13)+(16)	Total Effective Increase in Income from Proposed Interven-tion through change in Cropping Pattern (Rs. in Crore) (17) – (4)
				Addi-tional Area to be Culti-vated&Irriga-ted from Table-3.6(A) (Ha)	Addi-tionalProduc-tion expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21250 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated& Irri-gated from Table-3.6(A) (Ha)	Addi-tionalPr046odu-ctionexpec-ted as per Average Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21830 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated & Irri-gated for Veget-able from Table-3.6(A) (Ha)	Addi-tionalProdu-ction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated and Irri-gated From Table-3.6(A) (Ha)	Addi-tionalProdu-ctionexpec-ted as per Av-erage Yield Rate 1.980 MT/Ha in 2023 - 24 (MT)	Addi-tional Income as per Mini-mum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in Crore)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Pilana	**1146.3**	**91704**	**33.9305**	**3056.80**	**10698.80**	**22.7350**	**393.02**	**1103.99**	**2.4100**	**1031.67**	**24760.08**	**74.2802**	**917.04**	**1815.74**	**9.8958**	**109.321**	**75.3905**

Table – 3.6 (C):**Impact of Reducing Sugarcane area and allotting that to Kharif Paddy and equally distributing to 3 low CWR crops in Rabi on Income & GW**

Block	Present Area of Sugarcane cultivation (Ha)	Present GW Draft for Sugarcane Cultivation (CWR = 2.4 m) (MCM)	Proposed 10 % Reduction of Sugarcane cultivation Area (Ha)	Amount of Ground Water Saved by reducing 10% of Sugarcane Cultivation Area (MCM)	Yield Rate of Sugarcane (MT/Ha)	Loss in Production of Sugarcane due to reduction of cultivation area (MT)	Loss in Income from Sugarcane @ Rs. 3700 per MT (as per MSP of 2023-24) (Rs. in Cr.)	Gain in Production of Kharif Rice @ existing Avg. Yield 2.809 MT/Ha grown in freed 10% sugarcane area due to Alternatecropping pattern (MT)	Gain in Income from Kharif Rice @ Rs. 21830 per M. Ton (as per MSP of 2023-24) (Rs. in Cr)	Proposed Cropping of Mustard, Wheat, Vegetable (Low CWR & normallypracticed) in Rabi season in 1:1:1 Ratio in Lost Sugarcane Area (Ha)	Gain in Production of Mustard @ existing Average Yield Rate 1.980 MT/Ha in NAQ-UIM Area due to Alternatecropping pattern (MT)	Gain in Income from Mustard @ Rs. 54500 per M. Ton (as per MSP of 2023-24) (Rs. in Cr	Gain in Production of Wheat @ existing Average Yield Rate 3.5 MT/Ha in NAQ-UIM Area due to Alternate Cropping Pattern (MT)	Gain in Income from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore Rs.)	Gain in Production of Vegetables @ Existing Avg. Yield Rate 24 MT/Ha due to alternate cropping pattern (MT)	Gain in Income from Vegetable @ Rs. 30000 per MT (as per Farm Gate Price : 2023-24) (Crore Rs.)	Individual Ground Water Draft for Additional Cultivation of Rice during Kharif period on the whole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10% sugarcane area as per Crop Water Requirement 0.60 m, 0.45 m, 0.45 m and 0.40 m respectively for Kharif Paddy, Mustard, Wheat and Vegetables (MCM)				Total Ground Water Draft for Additional Cultivation of Kharif Rice and Mustard, Wheat & Vegetables In Rabi season (MCM)	Effective Saving of Ground Water by Cropping Pattern Change MCM {(5) - (19)}	Effective Gain in Income for growing Kharif Rice and Rabi Mustard, Wheat & Vegetables in area freed by 10% Sugarcane {(10) + (13) + (15) + (17)} – (8) (Rs. in Cr)	Existing Stage of Dynamic GW Extraction as per GW ResourceEstimation by GEC 2015 Method as on March 2023	AnnualExtractable GW Resource as per Dynamic Ground Water Resource Calculated for 2023 MCM	Total Annual Ground Water Extraction for all purposes in respect of Dynamic GW resourcecalculation 2023 (MCM)	Improved Stage of GW Extraction by Saving of Dynamic GW esou-rce (%) Considering that Irrigation water for Sugarcane is drawn from Aquifer Group-I(A)	Expeted Ris in Pre-mon-soon Water Level (m) of Un-onfi-nec o Semi-Confined Aqufercalculated taking Avg p. Yiel of Gr. -I(A) Aquifer as 0.06
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must.	Wheat	Veg								
Pil-ana	11463	275.112	1146.3	27.5112	80	91704	33.93	3219.9	7.0292	382.10	756.6	4.123	1337.35	2.8419	9170	27.51	6.878	1.719	1.719	1.528	11.845	15.67	7.575	130.59	43.65	57.002	96.10	1.26

Table – 3.7: **Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Block	Geogra-phical Area (Ha)	Normal Monsoon Rainfall (m) (50 yrs data-data.gov.in)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvanarayana'1993 (Land slope, type of land and soil type) (Land Slope: 0 - 5%)	Major types of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt'= (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-committed) =Vnc (Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt'=(Rn x A x C)	'V'	'Vnc'	'Vf'
Pilana	**20714**	**0.675**	**13981.95**	**0.5**	**Sandy loam & minor loam, Sand**	**Moderate to Well Drained**	**6990.98**	**5243.231**	**2621.616**	**1572.969**

Table – 3.8: **Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geogra-phical Area (Sq. Km)	Non-Commi-tted Surface Runoff avail-able for whole Block Area (MCM)	Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A) & Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7 + 12) (MCM)	Total harvested Rain water/ surface run - off water actually needed for injection to Gr.-I(A) & Gr.-I(B) Aquifer (14)x(100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure of 100 sq. mt. roof (area* total avg. annual rainfall*0.8) (MCM)	Nos. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr. - I(A) Aquifer (8/16)	Nos. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr.-I(B) Aquifer (13/16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Normal Annual Rainfall0. 67476 m			Ave-rage post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 mbgl and Post-mon-soon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2)x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7)x(100/75)	Avg. Post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 m bgl and Post-monsoon water level (m)	Stora-tivity (S)	Storage Space for Recharge /Volume of Water to be stored (2) x(10)x(11)	Rain water to be harv-ested for Gr.-I(B) Aquifer (12) x (100/75)					
Pilana	**207.14**	**15.7297**	**22.97**	**7.97**	**0.06**	**99.0543**	**132.0725**	**22.68**	**7.68**	**0.000571**	**0.9084**	**1.2112**	**99.9627**	**133.2836**	**0.000054**	**2446656**	**22437**

Table – 3.9 :**Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime**

Name of the Block	**Geographical Area (sq. km.)**	**No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined Aquifers** (Table - 3.8 : 17)	**Amount of water to be recharged in Aquifer Gr.-I(A)** (Table - 3.8 : 7)	**Impact on Water Level of Aquifer Gr.–I(A) (rise in m)**	**No. of RTRWH with Injection Well designed for Gr.-I(B) Confined Aquifers** (Table - 3.8 : 18)	**Amount of water to be recharged in Aq. Gr.-I(B)** (Table- 3.8 : 12)	**Impact on Piezometric Surface of Aquifer Gr.–I(B) (rise in m)**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pilana	**207.14**	**2446656**	**99.0543**	**7.97**	**22437**	**0.9084**	**7.68**

Table – 3.10: **Conservation of Surplus Non-Committed Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds remained after Artificial Recharge by Injection Wells**

Name of the Block	**Geogra-phical Area (Sq. Km.)**	**Non-Committed Surface Runoff available (Calculated by Dhruvanarayan'1993 Method) (MCM)**	**Surface runoff/ water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% area by Injection Wells (75% efficiency) (MCM)**	**Surface runoff/ water to be utilized for partly filling storage space in Aquifer– I(B) over 100% area by Injection Wells (75% efficiency) (MCM)**	**Volume of Water Left for Conservation / Storage cum Irrigation Tanks (MCM)**	**Capacity of a single Conservation/ Irrigation Tank (MCM)**	**Feasible Numbers of Conservation/ Irrigation Tanks (6) / (7)**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pilana	**207.14**	**15.72969**	**10.250**	**2.283**	**3.19669**	**0.1**	**32**

Table – 3.11: **Additional Irrigation Potential to be Created from Conservation cum Irrigation Tank**

Name of the Block	**Geogra-phical Area (Sq. Km.)**	**Non-Committed Surface Runoff Available (MCM)**	**Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)**	**Evaporation loss (25% of storage) (MCM)**	**Remaining Water can be utilized for Irrigation (MCM)**	**Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank considering average crop water requirement as 30 cm for Rabi crops: Wheat, Mustard, Vegetables etc.**	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pilana	**207.14**	**15.72969**	**3.19669**	**0.799173**	**2.397518**	**7.99173**	**799.173**

Table– 3.12:**Expected Improvement of GW Scenario due to Artificial Recharge of Unconfined Aquifers Gr.- I(A) in block area with part of Non-committed Surface Run-off (Supply Side Intervention) & Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extractable Ground Water Resource (Ham) {Table - 3.6(C)}	Total Current Annual Ground Water Extraction (SoE) (Ham) {Table - 3.6(C)}	Existing Stag of Dynamic GW Extraction as per GW Resource Estimation (GEC'15) as on March 2023 (%) {(3)/(2)} x 100	Part Storage Space for Recharge/Volume o Water to be stored in to Aquifer-I(A) throughout the block area to Enhance Dynamic GW Resource (Ham) from Table - 3.8(7)	Allocated Source Water from Non-Committed Surface Runoff for Recharging Aquifer-I(A) (Ham) {Table-3.10: (4)}	Actual amount of water to be recharged in Aquifer Gr-I(A) (Ham) (75% of source water) (6) x 0.75	Improved Stage of Ground Water Extraction (%) singly through Artificial Recharge by Injection Well [(3) /{(7)+ (2)}] x 100	Effective GW Sav - ing by Cropping Pattern Change growing Kharif Rice on whole land freed from sugarcane and growing Mustard, wheat& vegetable in Rabi season on parts of 10% Sugarcane land divided in 1:1:1 Ratio{Table-.6(C)}	Improved SoE (%) singly by Saving of Dynamic GW Resource through Cropping Pattern Change assuming that Shallow Aquifer-I(A) is used fo Sugarcane [(3) / {(9) + (2)}] x 100	Total Effective Increase in Ground Water Reserve due to Artificial Recharge & Change in Cropping Pattern (Ham) {(7) + (9)}	Cumulative Improvement in SoE due o both Artificia Recharge and Saving GW through Change in Cropping Pattern (%) (3) / {(2) + (11)} x 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Pilana	**4364.88**	**5700.20**	**130.59**	**9905.43**	**1025.00**	**768.75**	**111.04**	**1566.61**	**96.10**	**2335.36**	**85.07**

Table - 3.13 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geographical Area (Ha)	Total Cultivable Area (Ha)	Total CCA (as per MI Cen-sus -5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation (Ha)(3)–(4)	Additional Irrigation Potential Created by Harvesting Sur-face Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A) & I(B) aquifers assuming its feasib-ility in 100% area) and by Changing Cropping Pattern (Ha)			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Inter-vention {(8/5) x 100}	Percent of Total Cultivable Land where Irrigation Potential can be created in addition by Management Intervention {(8/3) x 100} (%)	Percent of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Management Intervention {(8/4) x 100}
					Irrigation Area Increase from Harvested Run-off Water in Irrigation Tanks (Ha) {Table-3.11: (8)}	Irrigation Area Increase from Water Saved by Cropping Pattern Change (Ha) {Table – 3.6(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Pilana	20714	13876	13214	**662**	**799.1730**	**4252.2271**	**5051.4001**	**> 100**	**36.40**	**38.23**

Table - 3.14 : **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Commited Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model – I)**

Name of the Block	Geogra - phical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge & Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate for Structures			Total Cost Estimate for const-ruction of artificial recharge &conser-vation structures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expendi-ture for Rechar-ging and Conserving 1 CuM(m^3) Harvested Source Water) (in Rs.) $(14) \times 10^5 / (4) \times 10^6$
				Allocation of 35 % of Source Water for Re-excavation of Existing Tanks with Recharge Shaft (REET) (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) to recharge Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Effi-ciency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% Effici-ency of Rechar-ging (6) x 0.75 /0.30	Nos. of Farm Ponds (7)/ 0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakh per unit (Rs. in Lakh) (8) x 8	Cost of Constru-ction of Injection Well (Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh) (9) x 5	Cost of Constr-uction of Farm Ponds @Rs.8 Lakh per unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Pilana	207.14	Sandy loam & minor loam, Sand	**15.72969**	**5.505392**	**4.718907**	**5.505392**	**42**	**12**	**55**	**336**	**60**	**440**	**836**	**5.31**

Table-3.15: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in the block - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geographical Area (sq.km.)	Non-Committed Surface Run-off available (Calculated by Dhruvanarayan' 93 Method) (MCM)	Total surface runoff/source water to be utilized for partly filling storage space in Aquifer-I(A) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Total surface runoff/source water to be Utilized for partly filling the storage space in Aquifer–I(B) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks/ Farm Ponds (MCM)	Numbers of Injection Wells to be constructed in Aquifer Group-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer Group-I(B) (5) / 0.3	Nos. of Conservation/ Storage cum Irrigation Tanks/ Farm Pond @ 10 Ham Storage Capacity per unit (6) / 0.1	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh/unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-1(B) @ Rs.10 lakh/unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conservation/ Storage cum Irrigation Tanks/ Farm Ponds @ Rs. 8 lakh/unit (in Lakh) (9) x 8	Total Cost of all Artificial Recharge and Conservation Structure (Rs. in Lakh) (10) + (11)+(12)	Cost-Benefit Ratio: Expenditure of Recharging /Conserving 1 CuM (m^3) Harvested Source Water) (in Rs.) (13) x 10^5/
													(3) x 10^6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Pilana	**207.14**	**15.72969**	**10.250**	**2.283**	**3.19669**	**35**	**8**	**32**	**175**	**80**	**256**	**511**	**3.25**

4. **Chemical Quality of Ground Water in Pilana block.**

Table – 4.1: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Pre-monsoon Period**

Basic Elements	**pH**	**EC(µS/cm at 25°C)**	**CO3**	**HCO3**	**Cl**	**F**	**NO3**	**SO4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO2**	**PO4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.88	594	0	354	7	0.23	6.8	28	180	28	22	37	3.9	21	0
Maximum	8.27	1860	0	805	142	3.50	34	115	410	104	82	260	20	35	0
Average	**8.064**	**1311.33**	**0**	**592.75**	**66.08**	**0.7883**	**17.75**	**62.09**	**312.50**	**48.33**	**46**	**160.33**	**6.8416**	**27.083**	**0**

Table – 4.2:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Pre-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.013	0.053	BDL	0.135	0.001	0.001	0.004
Maximum	BDL	2.135	0.47	BDL	3.803	0.0108	0.001	0.05
Average	**BDL**	**0.6905**	**0.1855**	**BDL**	**1.1599**	**0.0046**	**0.001**	**0.02275**

Table – 4.3:**Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Post-monsoon Period**

Basic Elements	pH	EC (µS/cm at 25°C)	CO_3	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2	PO_4
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.42	348	0	207	7	0.10	7	5	170	12	19	5	3.2	15	0
Maximum	8.23	2076	0	915	234	3.00	95	145	770	144	104	280	60.3	35	0
Average	**7.8592**	**1140.36**	**0**	**515.44**	**54.28**	**0.77717**	**23.81**	**50.29**	**338**	**59.52**	**45.40**	**109.56**	**8.816**	**26.64**	**0**

Table – 4.4:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Post-monsoon Period**

Heavy Metals	Chromium (Cr)	Iron (Fe)	Manganese (Mn)	Copper (Cu)	Zinc (Zn)	Arsenic (As)	Lead (Pb)	Uranium (U)
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.065	0.498	BDL	0.055	0.001	0.001	0.005
Maximum	BDL	3.843	0.052	BDL	3.514	0.032	0.002	0.037
Average	**BDL**	**1.5106**	**0.1694**	**BDL**	**0.9485**	**0.0165**	**0.001333**	**0.01936**

3. Geological and Geomorphological Maps, Depth to Wat er Level (Pre and Post-Monsoon) Maps in respect Aquifer – I(A) and Isopach Maps (Aquifer - IA & IB) of Pilana block

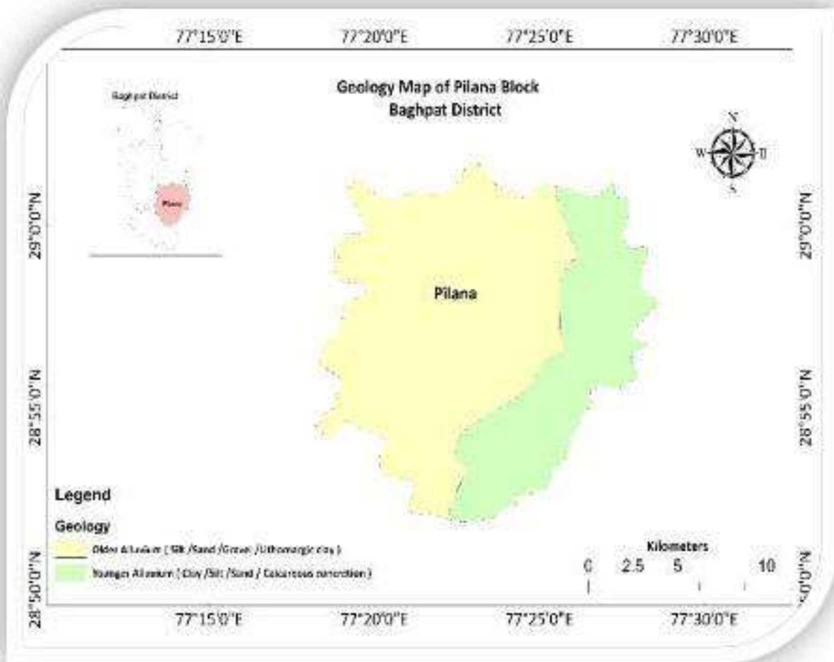


Fig. – 5.1: **Geological Map of Pilana block, Baghpat district**

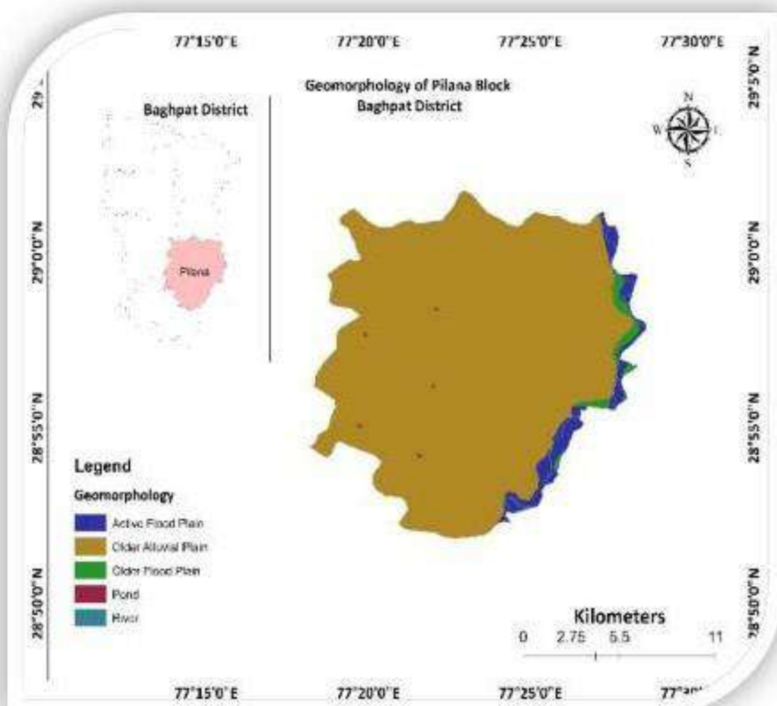


Fig. – 5.2: **Geomorphological Map of Pilana block,Baghpat district**

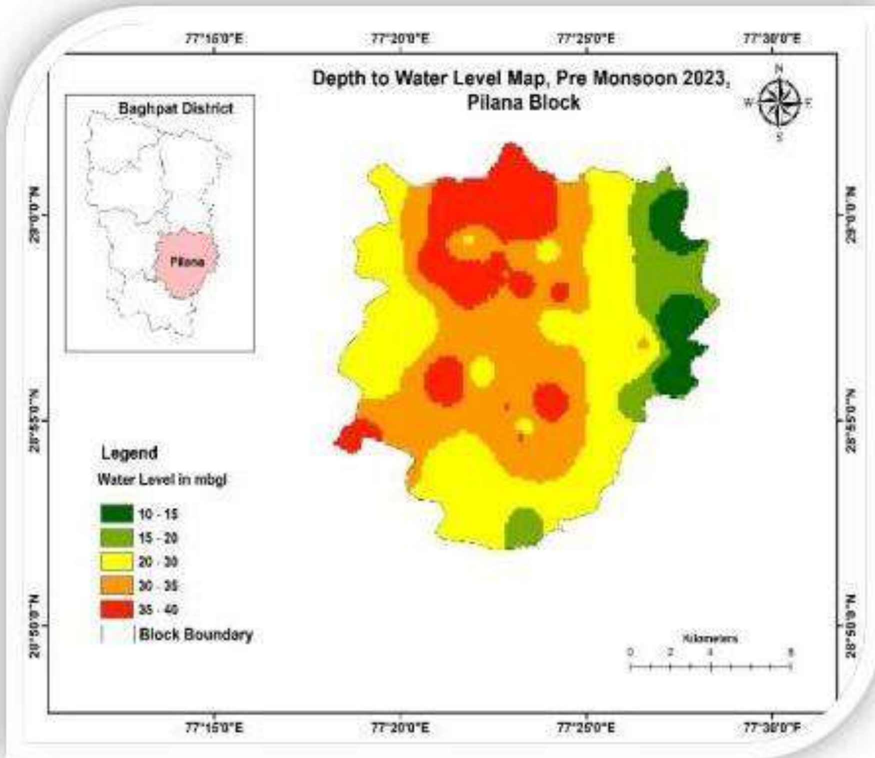


Fig. – 5.3:**Pre-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

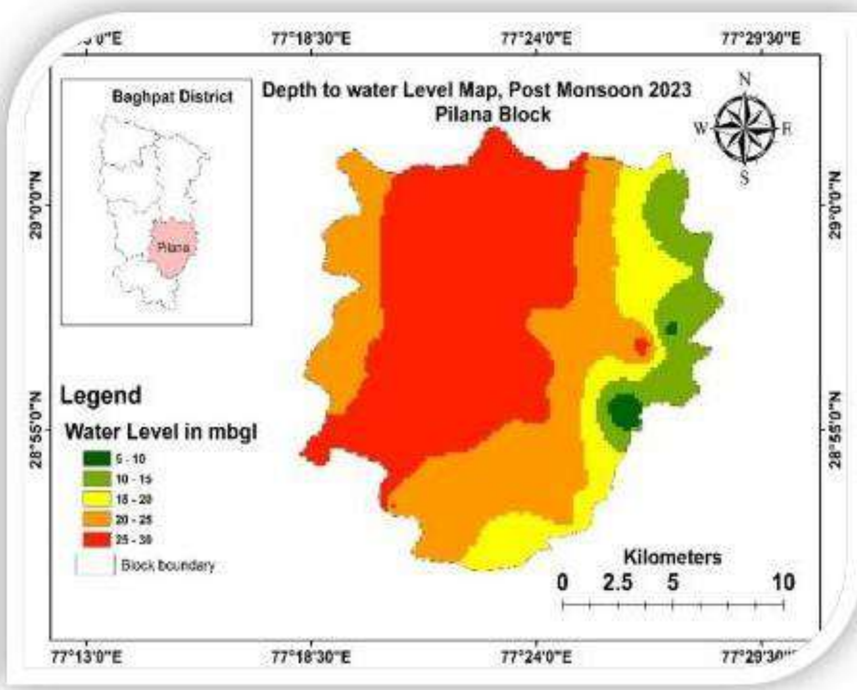


Fig. – 5.4:**Post-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

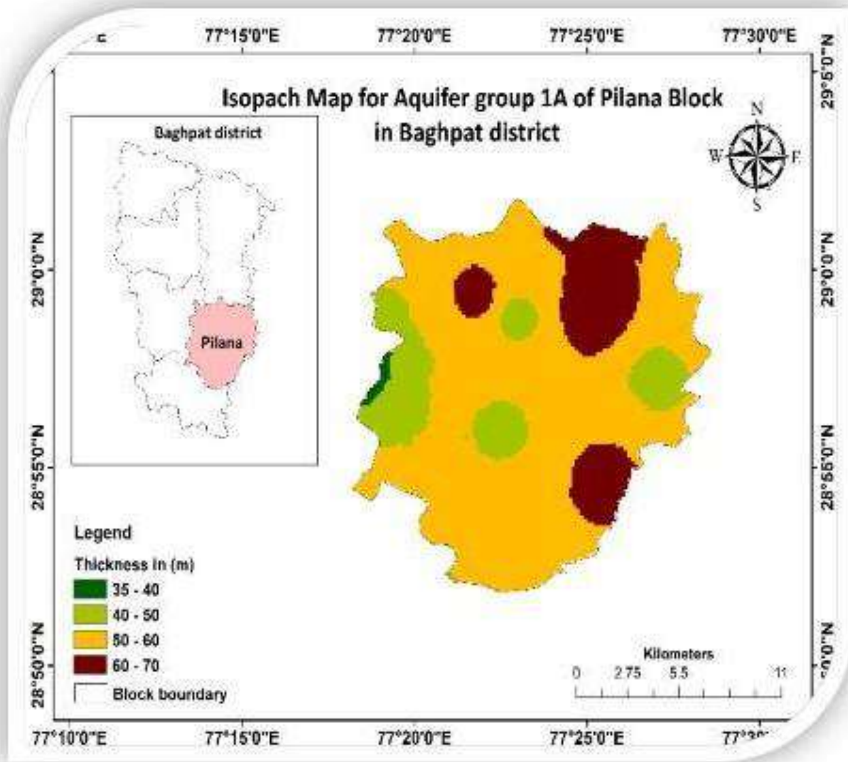


Fig. – 5.5:**Isopach Map of Pilana block in respect of Aquifer - I(A)**

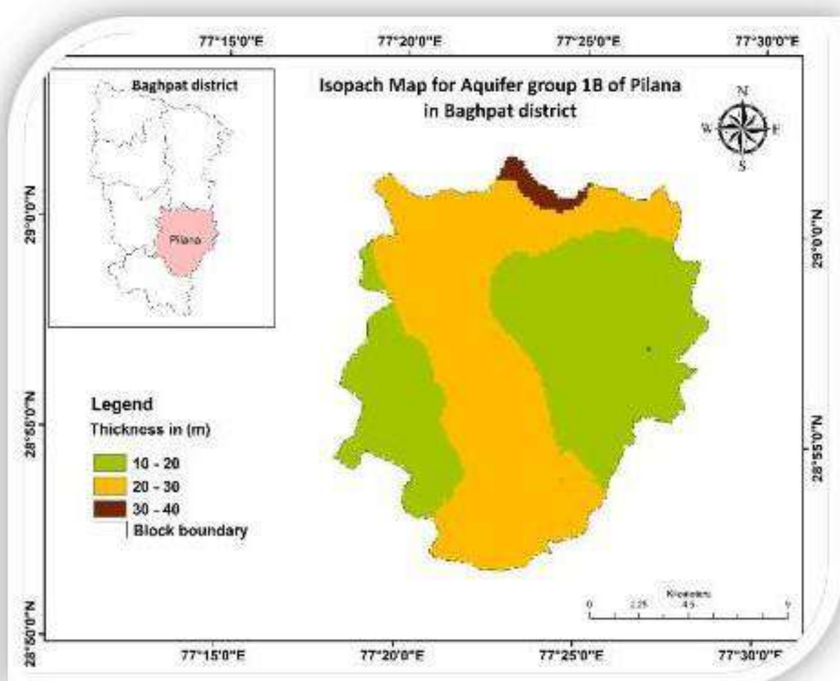


Fig. – 5.6:**Isopach Map of Pilana block in respect of Aquifer - I(B)**

Aquifer Mapping and Management Plan of Binauli block, Baghpat distr

1. General Information of Binauli block

District	Baghpat				
Block	**Binauli**				
Geographical Area (km^2)	290.00				
Population& its Density	231895; 800 persons/sq. km.				
Principal Aquifer System	Quaternary Alluvium				
Major Aquifer System	Older Alluvial (80%), Younger Alluvium				
Normal Annual Rainfall	674.76 mm				
Forest Area (Ha)	442	**Rural Area under Non-Agricultural Use (Ha)**			3473
Cultivable Area (Ha)	20494	**Culturable Waste Land (Ha)**			337
Net Sown Area (Ha)	19792	**Gross Sown Area (Ha)**			35769
Net Irrigated Area (Ha)	19724	**Gross Irrigated Area (Ha)**			35733
Cropping Intensity (%)	180.72	**Irrigation Intensity (%)**			181.17
Use of Surface Water (%)	1.34	**Use of Ground Water (%)**			98.66
Canal Irrigation Area (Ha)	265	**State Govt. TW (Ha)**	70	**Private TW (Ha)**	19389

2. Hydrogeology of Binauli block

Aquifer Groups and Depth of Occurrence as per Exploratory Drilling carried out by CGWB	1) Aquifer Gr-I:I(A): 0.00 to (76-92)mbgl; I(B): (102-111) to (144-166)mbgl 2) Aquifer Group -II: (187 - 213)to (245 - 275) mbgl 3) Aquifer Group-III: 290 to 328 mbgl 4) Aquifer Group-IV: (339-346) to 446 mbgl(up to max. explored depth)				
Status of Ground Water Exploration	Exploratory Wells**: 09** **Observation** Wells**: 03** **Piezometer: 02** Slim Hole: **00**				
Aquifer Characteristics	**Group-I(A)**	**Group-I(B)**	**Group-II**	**Group-III**	**Group-IV**
SWL-Static Water Level (m bgl) Q – Discharge (lpm); DD – Drawdown (m); T – Transmissivity (m^2/day) S – Storativity	SWL:**18.30** to **28.00** Q: **2303** to **3458** DD: **6.20** to**6.25** T: Sp. Yield: **0.06**	SWL: **14.25** to **31.00** Q: **1557** to **2954** DD: **4.84** to **7.15** T: **1712** - 2285 S: **4.17×10^{-4}**	SWL: **17.88** Q: **2210** DD: **6.30** T: **350** S: **1.26×10^{-4}**	SWL: **22.50** Q: **2200** DD: **9.22** T: **2285** S:	SWL: **12.08** Q: **2100** DD: **12.52** T: **763** S:**5.1×10^{-4}**

GW Monitoring Stations	Ground Water Monitoring Wells: **02 (NHNS)**				
Average Depth to Water Level (Pre-monsoon-2023)	**Aq - I(A)**	**Aq - I(B)**	**Average Depth to Water Level (Post-monsoon-2023)**	**Aq - I(A)**	**Aq - I(B)**
	28.98	**24.51**		**22.97**	**22.68**
Ground Water Resources (2023)	**Dynamic Resource (2023): Aquifer Group - I(A)** 1) Annual Extractable Ground Water Resources: **6235.91Ham** 2) Total Ground Water Extraction for all purposes: **7064.32 Ham** 3) Annual GW Allocation for Domestic Use as in 2025**: 401.36 Ham** 4) Net Ground Water Availability for Future Use: **00** 5) Average Stage of Ground Water Extraction: **1130.28 %** 6) Category of Block: **Over-Exploited** **Static Resource of Aquifer Group - I(A): 4210.80 Ham** **Static/In-Storage Resource of Aquifer Group – I(B): 1270.10 Ham**				
Existing and Future Drinking Water Demand	Existing Demand @ 40 lpcd (2021): **3.72425 MCM** Future Demand @ 40 lpcd (2031): **4.09666 MCM**				

3. Aquifer Management Plan of Binauli block

Table – 3.1 : **Block wise Population Coverage of Drinking Water Supply Schemes by Jal Nigam**

Block	Total Population (Census: 2011)	Projected Population (2021) (Growth 10%)	Covered Population	No. of Total GPs	No. of Total GPs Covered	Population yet to be Covered by PWSS	Annual Water Resource required to Cater Uncovered Population @ 40 lpcd (MCM)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Binauli	**231895**	**255086**	**160069**	**52**	**29**	**95017**	**1.3872**

Table - 3.2 : **Proposed Plan for GW Draft from Aquifer Gr.–I(A) & Gr.-I(B) for Drinking Water**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Resource required for uncovered population @ 40 lpcd (MCM)	Annual Resource proposed to be utilized from Group-I(A) Aquifers (40% of Requirement) (MCM)	Annual Resource proposed to be utilized from Group-I(B) Aquifer (60 % of Requirement) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(A) Aquifer and 8 hours/day running) (MCM)	Annual unit draft of one TW (taking avg. discharge of Group-I(B) Aquifer and 8 hours/day running)	No of TWs requi-red in Group-I(A) Aquifer (4)/(6)	No of TWs requi-red in Group-I(B) Aquifer (5)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Binauli	**290.00**	**1.3872**	**0.5549**	**0.8323**	**0.1314**	**0.1898**	**4**	**4**

Table - 3.3 : **Probable Impact of GW Draft for Drinking Water on Ground Water Level**

Name of the Block	Geogra-phical Area (sq.km.)	Annual Water Resource propo-sed to be used from Group-I(A) Aquifer (MCM)	Annual Water Resource propo-sed to be used from Group-I(B) Aquifer (MCM)	Specific Yield (Sy) of Group I(A) Aquifers	Storativity (S) of Group I(B) Aquifers	Decline of Water Level in Aquifer-I(A) (m)	Decline of Piezo-metric Surface in Group-I(B) Aquifer (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Binauli	**290.00**	**0.5549**	**0.8323**	**0.06**	**0.00057129**	**0.032**	**5.006**

Table–3.4: **Cost Estimate of Tube Wells for Drinking & Domestic Water Supply to Projected Population (in 2031)**

Block	Human Popula-tion in NAQUIM 2.0 area in 2011	Present Water Require-ment for Human Popula-tion @ 70 lpcd for (m^3/day)	Projected Human Population as in 2031 (taking average decadal growth rate as 10%)	Covered Human Popu-lation (2020-21)	Total Population to be Covered in 2031 excepting already covered Population (4) – (5)	Addi-tional Water Requ-irement for Human Populace @70 lpcd in 2031 (m^3/day)	Average Disch-arge of Group-I(B) Aqui-fers (m^3/hour)	Ave-rage Hours of Run-ning of TW	Dis-charge of one TW in m^3/day for 8 hours of pump-ing per day (8) x (9)	Nos. of Additional Tube Wells to be Cons-tructed in I(B) Aquifers for catering Human Population in 2031 (7) / (10)	Cost of the Tube Wells of 200 m depth in I(B) aqui-fer 10”x 6" dia @ Rs. 10 lakhs (in lakh) as per EFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Binauli	**231895**	**16232.65**	**280593**	**160069**	**120524**	**8436.677**	**65.00**	**8**	**520.00**	**16**	**160**

Table – 3.5: **Cultivable Area, Net Irrigated Area & GW Availability (2023-24) and Scope & Necessity of Management Intervention**

Block	Geographical Area (Ha)	Cultivable Area (Ha)	Net cultivated Area (Ha)	Culturable Command Area (CCA) (Current Irrigated Area as per MI Census-5 (Ha)	RemainingCultivable Area to bring under Irrigation (Ha) (3)-(5)	Net Irrigated Command Area by Ground Water (as per MI Census-5 in 2020-21 (Ha)	Net Irrigated Command Area by Surface Water (as per MI Census-5 in 2020-21) (Ha)	Net Irrigated Command area by GW+ SW (as per MI Census-5 in 2020-21) (Ha)	Stage of Ground Water Extraction (SoE) (%)	Net Ground Water Availability for Future Irrigation& Industrial Use (Ham)	Pre-Monsoon Water Level Trend 2010-2021 (Falling) (m/year)	Post-Monsoon Water Level Trend 2010-21 (Falling) (m/year)	Average Pre-Monsoon Water Level (Aquifer wise) (mbgl) in 2023	Average Post-Monsoon Water Level (Aquifer wise) (mbgl) in 2023
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Binauli	**29000**	**20494**	**19792**	**19724**	**770**	**19459**	**265**	**19724**	**113.28**	**0**			**28.08 (IA)** **28.80 (IB)**	**26.53 (IA)** **27.25 (IB)**

Table - 3.6 (A):**Proposed Intervention in Irrigation Practices to Increase Effective Irrigation Coverage with Maintaining Present Ground Water Draft**

Additional area brought under coverage of other crops with the saved water from 10 % reduction of Sugarcane Cultivation						Increase in Area under Irrigation Coverage for alternative crops in Lean Period (Rabi and Summer) by reducing 10 % Sugarcane Cultivation												Increase in Irrigationarea by reducing 10% Sugarcane Cultivation	
Block	Present area under Sugarcane (Ha)	10% of Sugarcane Area (Ha)	Area under Sugarcane after 10% reduction(Ha)	Water Column for Sugarcane Irrigation(m)	Volume of Irrigation water saved (Ham)	Wheat (Rabi Season) (Maximum Delta factor: 45 cm)			'Boro' Rice (January-April) (Maximum Delta factor: 140 cm)			Vegetables (Rabi and Summer) (Maximum Delta factor: 40 cm)			Mustard (Rabi Season) (Maximum Delta factor: 45 cm)			Alternative area of Irrigation in place of 10% Sugarcane Area (Ha) (9) + (12) + (15) + (18)	Effective Increase in Area of Irrigation i.e. CCA(Ha) (19) – (3)
						Water (%)		Area	Water (%)		Area	Water (%)		Area	Water (%)		Area		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Binauli	**15928**	**1592.80**	**14335.2**	**2.4**	**3822.72**	**1911.36**	**50%**	**4247.47**	**573.41**	**15%**	**409.58**	**764.54**	**20%**	**1911.36**	**573.408**	**15%**	**1274.24**	**7842.64**	**6249.84**

Table-3.6 (B): **Cost-Benefit Analysis of using Increased Effective Irrigation Coverage after Proposed Management Intervention in Cropping Pattern**

Block	Prop-osedre duc-tion of Sugar-cane Culti-vation Area (Ha)	Loss in Produc-tion of Sugar-cane as per Avg. Yield Rate 80 MT /Ha in 2023-24 (MT)	Monetary Loss (in Crore) for 10 % Reduc-tion of Sugar-cane Cultiva-tion Area as per MSP of 2023-24 of Sugar-cane	Wheat (Rabi)			'Boro' Rice (Jan-April)			Vegetables(Rabi & Summer)			Mustard			Addi-tional Income from growing alternat-ive crops with GW earlier being used by 10% Sugar-cane (Rs. in Crore) (7)+(10)+	Total Effective Increase in Income from Proposed Interven-tion through change in Cropping Pattern (Rs. in Crore) (17) – (4)
				Addi-tional Area to be Culti-vated&Irriga-ted from Table-3.6(A) (Ha)	Addi-tionalPro duc-tion expected as per Avg. Yield Rate 3.5 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21250 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated& Irri-gated from Table-3.6(A) (Ha)	Addi-tionalPr odu-ctionexp ec-ted as per Average Yield Rate 2.809 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Mini-mum Support Price Rs. 21830 per MT (2023-24) (Rs. in	Addi-tional Area to be Culti-vated & Irri-gated for Veget-able from Table-3.6(A) (Ha)	Addi-tionalProd u -ction expected as per Average Yield Rate 24 MT/Ha in 2023-24 (MT)	Addi-tional Income as per Farm Gate Price @ Rs. 30000 per MT (2023-24) (Rs. in Crore)	Addi-tional Area to be Culti-vated and Irri-gated From Table-3.6(A) (Ha)	Addi-tionalPr odu-ctionexp ec-ted as per Av-erage Yield Rate 1.980 MT/Ha in 2023 -24 (MT)	Addi-tional Income as per Mini-mum Support Price @ Rs. 54500 per MT (2023-24) (Rs. in		
			@ Rs. 3700/MT						Crore)						Crore)	(13)+(16)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Binauli	**1592.8**	**127424**	**47.1469**	**4247.47**	**14866.13**	**31.5905**	**409.58**	**1150.5**	**2.5115**	**1911.36**	**45872.64**	**137.618**	**1274.24**	**2523.0**	**13.7503**	**185.4702**	**138.3233**

Table – 3.6 (C):**Impact of Reducing Sugarcane area and allotting that to Kharif Paddy and equally distributing to 3 low CWR crops in Rabi on Income & GW**

Block	Present Area of Sugarcane cultivation (Ha)	Present GW Draft for Sugar-cane Cultivation (CWR = 2.4 m) (MCM)	Proposed 10 % Reduction of Sugarcane cultivation Area (Ha)	Amount of Ground Water Saved by reducing 10% of Sugar cane Cultivation Area (MCM)	Yield Rate of Sugarcane MT / Ha	Loss in Production of Sugarcane due to reduction of cultivation area (MT)	Loss in Income from Sugarcane @ Rs. 3700 per MT (as per MSP of 2023-24) (Rs. in Cr.)	Gain in Production of Kharif Rice @ existing Avg. Yield 2.809 MT/Ha grown in freed 10% sugarcane area due to Alternatecropping pattern (MT)	Gain in Income from Kharif Rice @ Rs. 21830 per M. Ton (as per MSP of 2023-24) (Rs. in Cr)	Proposed Cropping of Mustard, Wheat, Vegetable (Low CWR & normallypracticed) in Rabi season in 1:1:1 Ratio in Lost Sugarcane Area (Ha)	Gain in Production of Mustard @ existing Average Yield Rate 1.980 MT/Ha in NAQ-UIM Area due to Alternatecropping pattern (MT)	Gain in Income from Mustard @ Rs. 54500 per M. Ton (as per MSP of 2023-24) (Rs. in Cr	Gain in Production of Wheat @ existing Average Yield Rate 3.5 MT/Ha in NAQ-UIM Area due to Alternate Cropping Pattern (MT)	Gain in Income from Wheat @ Rs. 21250 Per MT (as per MSP: 2023-24) (Crore Rs.)	Gain in Production of Vegetables @ Existing Avg. Yield Rate 24 MT/Ha due to alternate cropping pattern (MT)	Gain in Inc-ome from Vegetable @ Rs. 30000 per MT (as per Farm Gate Price : 2023-24) (Crore Rs.)	Individual Ground Water Draft for Additional Cultivation of Rice during Kharif period on the whole agricultural land area released through 10% reduction of Sugarcane cultivation and growing Mustard, Wheat & Vegetables during Rabi period on 3 equally divided parts of released 10% sugarcane area as per Crop Water Requirement 0.60 m, 0.45 m, 0.45 m and 0.40 m respectively for Kharif Paddy, Mustard, Wheat and Vegetables (MCM)				Total Ground Water Draft for Additional Cultivation of Kharif Rice and Mustard, Wheat & Vegetables In Rabi season (MCM)	Effective Saving of Ground Water by Cropping Pattern Change MCM {(5) - (19)}	Effective Gain in Income for growing Kharif Rice and Rabi Mustard, Wheat & Vegetables in area freed by 10% Sugar-cane {(10) + (13) + (15) + (17)} – (8) (Rs. in Cr)	Existing Stage of Dynamic GW Extraction as per GW Resource Estimation by GEC 2015 Method as on March 2023	Annual Extractable GW Resource as per Dynamic Ground Water Resource Calculated for 2023 MCM	Total Annual Ground Water Extraction for all purposes in respect of Dynamic GW resource calculation 2023 (MCM)	Improved Stage of GW Extraction by Saving of Dynamic GW resource (%) Considering that Irrigation water for Sugarcane is drawn from Aquifer Group-I(A)	Expected Rise in Pre-monsoon Water Level (m) of Unconfi-ned o Semi-Confined Aquifer calculated taking Avg p. Yield of Gr.-I(A) Aquifer as 0.06
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)				(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
																	Rice	Must.	Wheat	Veg								
Binauli	15928	382.27	1593	38.2272	80	127424	47.147	4474.2	9.7671	530.93	1051	5.7293	1858.27	3.9488	12742	38.227	9.557	2.389	2.389	2.124	16.459	21.77	10.525	113.28	62.36	70.643	83.97	1.25

Table – 3.7: **Estimation of Non-Committed Surface Run-off from Rain Fall and Water Available for Artificial Recharge and Conservation**

Block	Geographical Area (Ha)	Normal Monsoon Rainfall (m) (50 yrs data-data.gov.in)	Annual Volume of Monsoon Rainfall (Ham)	Run-off co-efficient as Dhruvanarayana'1993 (Land slope, type of land and soil type) (Land Slope: 0 - 5%)	Major types of Soil available in the block		Total volume of Surface Runoff Available Annually 'Vt'= (Rn x A x C) (Ham)	75% of 'Vt=V (Ham)	50% of V (Non-committed) =Vnc (Ham)	60% of Vnc=Vf (Ham)
					Texture of the Soil	Draining Capacity				
	'A'	'Rn'	(Rn x A)	'C'			'Vt'=(Rn x A x C)	'V'	'Vnc'	'Vf'
Binauli	**29000**	**0.675**	**19575.00**	**0.5**	**Sandy loam & minor loam, Sand**	**Moderate to Well Drained**	**9787.50**	**7340.625**	**3670.313**	**2202.188**

Table – 3.8: **Water required to fill a part of Vacant Storage Space in Aquifers and Required Numbers of RWH Structures with Injection Wells (considering 75% efficiency of Injection Structures and 100% area is feasible for recharge through injection of water)**

Name of the Block	Geographical Area (Sq. Km)	Non-Commi-tted Surface Runoff avail-able for whole Block Area (MCM)	Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(A) Unconfined Aquifers (MCM)					Total surface runoff/harvested rain water i.e. source water required to fill a part of storage space in Gr - I(B) Confined Aquifers (MCM)					Collective storage space in Gr.-I(A) & Gr.-I(B) Aquifers to be filled by harvested rain water/ surface run-off water (7 + 12) (MCM)	Total harvested Rain water/ surface run - off water actually needed for injection to Gr.-I(A) & Gr.-I(B) Aquifer (14)x(100/75) (MCM)	Unit Volume of water harvested by one RTRWH structure of 100 sq. mt. roof (area* total avg. annual rainfall*0.8) (MCM)	Nos. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr. - I(A) Aquifer (8/16)	Nos. of RTRWH schemes (100 sq. mt. roof) with attached Injection Wells needed for recharging Gr.-I(B) Aquifer (13/16)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Normal Annual Rainfall0. 67476 m			Average post-Monsoon Water Level (mbgl)	Formation Thickness between 15 mbgl and Post-monsoon water Level (m)	Sp. Yield (S)	Storage Space for Recharge/ Amount of Water to be Stored (2)x(5)x(6)	Rain water to be harvested for Gr-I(A) Unconfined Aquifers (7)x(100/75)	Avg. Post-Mon-soon Water Level (mbgl)	Formation Thickness between 15 m bgl and Post-monsoon water level (m)	Stora-tivity (S)	Storage Space for Recharge /Volume of Water to be stored (2) x(10)x(11)	Rain water to be harv-ested for Gr.-I(B) Aquifer (12) x (100/75)					
Binauli	**290.0**	**22.02188**	**26.53**	**11.53**	**0.06**	**200.6220**	**267.4960**	**27.25**	**12.25**	**0.000571**	**2.0285**	**2.7046**	**202.6505**	**270.2006**	**0.000054**	**4955392**	**50104**

Table – 3.9 :**Expected Impact of RTRWH cum Injection Recharge on Ground Water Regime**

Name of the Block	Geographical Area (sq. km.)	No. of RTRWH with Injection Wells designed for Gr.-I(A) Unconfined Aquifers (Table - 3.8 : 17)	Amount of water to be recharged in Aquifer Gr.-I(A) (Table - 3.8 : 7)	Impact on Water Level of Aquifer Gr.–I(A) (rise in m)	No. of RTRWH with Injection Well designed for Gr.-I(B) Confined Aquifers (Table - 3.8 : 18)	Amount of water to be recharged in Aq. Gr.-I(B) (Table- 3.8 : 12)	Impact on Piezometric Surface of Aquifer Gr.–I(B) (rise in m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Binauli	**290.00**	**4955392**	**200.6220**	**11.53**	**50104**	**2.0285**	**12.25**

Table – 3.10: **Conservation of Surplus Non-Commited Surface Run-off in Surface Storage cum Irrigation Tanks/Ponds remained after Artificial Recharge by Injection Wells**

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Commited Surface Runoff available (Calculated by Dhruvanarayan'1993 Method) (MCM)	Surface runoff/ water to be utilized for partly filling the storage space in Aquifer-I(A) over 100% area by Injection Wells (75% efficiency) (MCM)	Surface runoff/ water to be utilized for partly filling storage space in Aquifer– I(B) over 100% area by Injection Wells (75% efficiency) (MCM)	Volume of Water Left for Conservation / Storage cum Irrigation Tanks (MCM)	Capacity of a single Conservation/ Irrigation Tank (MCM)	Feasible Numbers of Conservation/ Irrigation Tanks (6) / (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Binauli	**290.00**	**22.02188**	**15.000**	**3.799**	**3.22288**	**0.1**	**33**

Table – 3.11: Additional Irrigation Potential to be Created from Conservation cum Irrigation Tank

Name of the Block	Geogra-phical Area (Sq. Km.)	Non-Committed Surface Runoff Available (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks (MCM)	Evaporation loss (25% of storage) (MCM)	Remaining Water can be utilized for Irrigation (MCM)	Additional area which can be brought under irrigation utilizing water stored in Conservation cum Irrigation Tank considering average crop water requirement as 30 cm for Rabi crops: Wheat, Mustard, Vegetables etc.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Binauli	**290.00**	**22.02188**	**3.22288**	**0.80572**	**2.41716**	**8.0572**	**805.72**

Table– 3.12:**Expected Improvement of GW Scenario due to Artificial Recharge of Unconfined Aquifers Gr.- I(A) in block area with part of Non-committed Surface Run-off (Supply Side Intervention) & Change in Cropping Pattern (Demand Side Intervention)**

Block	Annual Extractable Ground Water Resource (Ham) {Table - 3.6(C)}	Total Current Annual Ground Water Extrac-tion (SoE) (Ham) {Table - 3.6(C)}	Existing Stag of Dynamic GW Extraction as per GW Resource Estimation (GEC'15) as on March 2023 (%) {(3)/(2)} x 100	Part Storage Space for Recharge/Volume o Water to be stored in to Aquifer-I(A) throughout the block area to Enhance Dynamic GW Resource (Ham) from Table - 3.8(7)	Allocated Source Water from Non-Committed Surface Runoff for Recharging Aquifer-I(A) (Ham) {Table-3.10: (4)}	Actual amount of water to be recharged in Aquifer Gr-I(A) (Ham) (75% of source water) (6) x 0.75	Improved Stage of Ground Water Extraction (%) singly through Artificial Recharge by Injec-tion Well [(3) /{(7)+ (2)}] x 100	Effective GW Sav - ing by Cropping Pattern Change growing Kharif Rice on whole land freed from sugarcane and growing Mustard, wheat& vegetable in Rabi season on parts of 10% Sug-arcane land divided in 1:1:1 Ratio{Table-.6(C)}	Improved SoE (%) singly by Saving of Dynamic GW Resource through Cropping Pattern Change assuming that Shallow Aqui-fer-I(A) is used fo Sugarcane [(3) / {(9) + (2)}] x 100	Total Effective Increase in Ground Water Reserve due to Artificial Recharge & Change in Cropping Pattern (Ham) {(7) + (9)}	Cumulative Improvement in SoE due o both Artificia Recharge and Saving GW through Change in Cropping Pattern (%) (3) / {(2) + (11)} x 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	**(9)**	(10)	**(11)**	(12)
Binauli	6235.91	7064.32	113.28	20062.20	1500.00	1125.00	95.97	**2176.83**	83.97	**3301.83**	74.07

Table - 3.13 : Total Additional Irrigation Potential to be created by Rain Water Harvesting & Storage and Cropping Pattern Change

Block	Geogr-aphi-cal Area (Ha)	Total Culti-vable Area (Ha)	Total CCA (as per MI Census -5) (Ha)	Remaining Cultivable Area to be brought under CCA i.e. under Irrigation (Ha)(3)–(4)	Additional Irrigation Potential Created by Harvesting Sur-face Runoff stored in surface tanks/ponds (after injection recharge to Group-I(A) & I(B) aquifers assuming its feasib-ility in 100% area) and by Changing Cropping Pattern (Ha)			Percent (%) of remaining (i.e. presently not under CCA) Cultivable Area can be brought under Irrigation by Management Inter-vention {(8/5) x 100}	Percent of Total Cultivable Land where Irrigation Potential can be created in addition by Management Intervention {(8/3) x 100} (%)	Percent of increase can be made in present Culturable Command (Irrigation) Area (CCA) by Manage-ment Intervention {(8/4) x 100}
					Irrigation Area Increase from Harvested Run-off Water in Irrigation Tanks (Ha) {Table-3.11: (8)}	Irrigation Area Increase from Water Saved by Cropping Pattern Change (Ha) {Table – 3.6(A) : (20)}	Total Increase in Irrigation Area (CCA) (Ha) (6) + (7)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Binauli	**29000**	**20494**	**19724**	**770**	**805.7200**	**6249.8438**	**7055.5638**	**> 100**	**34.43**	**35.77**

Table - 3.14 : **Proposal for construction of Recharge Structures (75% efficiency) and Conservation Structures allocating Non-Committed Surface Run-Off for various structures as per Standard Proportion and Cost Estimates for construction of Recharge Structures (Model – I)**

Name of the Block	Geogra - phical Area (Sq. Km.)	Soil Type	Net Non-Committed Surface Runoff available as Source Water for Artificial Recharge & Conservation by Recharge and Conservation Structures (MCM)	Source Water Allocation			Number of Structures			Cost Estimate for Structures			Total Cost Estimate for construction of artificial recharge &conservation structures (Rs.in Lakh) (11) +(12) + (13)	Cost-Benefit Ratio: (Expenditure for Recharging and Conserving 1 CuM(m^3) Harvested Source Water) (in Rs.) (14) x 105 /
				Allocation of 35 % of Source Water for Re-excavation of Existing Tanks with Recharge Shaft (REET) (MCM) (4) x 0.35	Allocation of 30 % of Source Water for Injection Well (IW) to recharge Group-I(A) Aquifer (MCM) (4) x 0.30	Allocation of 35 % of Source Water for Farm Pond (FP) to Store and Irrigate Crops (MCM) (4) x 0.35	Nos. of Re-excavated Existing Tanks with Recharge Shaft with 75% Efficiency of Recharging (5) x 0.75/ 0.10	Nos. of Injection Wells with 75% Effici-ency of Rechar-ging (6) x 0.75 /0.30	Nos. of Farm Ponds (7)/ 0.10	Cost of Re-excavation of Existing Tanks with Recharge Shaft @ Rs. 8 Lakh per unit (Rs. in Lakh) (8) x 8	Cost of Constru-ction of Injection Well (Depth 100 m) @ Rs. 5 Lakh per unit (Rs. in Lakh)	Cost of Constr-uction of Farm Ponds @Rs.8 Lakh per unit (Rs. in Lakh) (10) x 8		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Binauli	290.00	Sandy loam & minor loam, Sand	22.02188	7.707658	6.606564	7.707658	58	17	77	464	85	616	1165	5.29

Table-3.15: **Proposal for construction of Recharge & Conservation Structures taking the whole area as recharge worthy and allocating Non-Committed Surface Run-Off for two most suitable structures in the block - Injection Well (75 % efficiency) & Farm Pond and Cost Estimates (Model-II)**

Name of the Block	Geographical Area (sq.km.)	Non-Committed Surface Run-off available (Calculated by Dhruvanarayan' 93 Method) (MCM)	Total surface runoff/source water to be utilized for partly filling storage space in Aquifer-I(A) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Total surface runoff/source water to be Utilized for partly filling the storage space in Aquifer–I(B) over 100% of Block area by Injection Wells (75% efficiency) (MCM)	Volume of Water for Conservation /Storage cum Irrigation Tanks/ Farm Ponds (MCM)	Numbers of Injection Wells to be constructed in Aquifer Group-I(A) (4) / 0.3	Numbers of Injection Wells to be constructed in Aquifer Group-I(B) (5) / 0.3	Nos. of Conservation/ Storage cum Irrigation Tanks/ Farm Pond @ 10 Ham Storage Capacity per unit (6) / 0.1	Cost of Injection Wells in Aquifer-I(A) @ Rs.5 Lakh/unit for 100 m well depth (Rs. in Lakh) (7) x 5	Cost of Injection Wells in Aquifer-1(B) @ Rs.10 lakh/unit for 200 m well depth (Rs. in Lakh) (8) x 10	Cost of Conservation/ Storage cum Irrigation Tanks/ Farm Ponds @ Rs. 8 lakh/unit (in Lakh) (9) x 8	Total Cost of all Artificial Recharge and Conservation Structure (Rs. in Lakh) (10) + (11)+(12)	Cost-Benefit Ratio: Expenditure of Recharging /Conserving 1 CuM (m^3) Harvested Source Water) (in Rs.) (13) x 10^5/
													(3) x 10^6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Binauli	**290.00**	**22.02188**	**15.000**	**3.799**	**3.22288**	**50**	**13**	**33**	**250**	**130**	**264**	**644**	**2.92**

4. Chemical Quality of Ground Water in Binauli block

Table – 4.1: **Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Pre-monsoon Period**

Basic Elements	pH	EC(µS/cm	CO3	HCO3	Cl	F	NO3	SO4	TH	Ca	Mg	Na	K	SiO2	PO4
		at 25°C)	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.65	634	0	317	14	0.30	7.4	10	100	28	2	46	3.2	20	0
Maximum	8.20	1190	0	622	50	0.84	8.0	90	480	92	77	140	6.8	32	0
Average	**7.993**	**871.416**	**0**	**438**	**25.167**	**0.585**	**7.70**	**38.75**	**259.17**	**58.33**	**27.167**	**84.167**	**5.3167**	**24.75**	**0**

Table – 4.2:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Pre-monsoon Period**

Heavy Metals	Chromium (Cr)	Iron (Fe)	Manganese (Mn)	Copper (Cu)	Zinc (Zn)	Arsenic (As)	Lead (Pb)	Uranium (U)
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	BDL	0.07	0.034	BDL	0.184	0.001	0.001	0.004
Maximum	BDL	7.857	0.105	BDL	1.862	0.002	0.003	0.052
Average	**BDL**	**1.9487**	**0.065**	**BDL**	**0.81944**	**0.001667**	**0.001375**	**0.017667**

Table – 4.3:**Results of Basic Chemical Analysis of Ground Water from Aquifer Group – I(A) during Post-monsoon Period**

Basic Elements	**pH**	**EC (µS/cm at 25°C)**	**CO_3**	**HCO_3**	**Cl**	**F**	**NO_3**	**SO_4**	**TH**	**Ca**	**Mg**	**Na**	**K**	**SiO_2**	**PO_4**
			mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	6.5 - 8.5	750	-	-	250	1.0	45	200	200	75	30	-	-	-	-
Maximum Permissible Limit	6.5 - 8.5	3000	-	-	1000	1.5	45	400	600	200	100	-	-	-	-
Minimum	7.55	613	0	268	14	0.35	6	25	60	20	2	26	2.4	22	5.4
Maximum	8.25	1477	0	781	85	1.16	45	63	460	108	65	235	16.5	35	5.4
Average	**7.937**	**1040.895**	**0**	**501.42**	**33.05**	**0.7358**	**20.15**	**41.31**	**313.68**	**65.47**	**36.79**	**100.84**	**6.19**	**29.26**	**---**

Table – 4.4:**Results of Heavy Metals Analysis of Ground Water from Aquifer Group–I(A) during Post-monsoon Period**

Heavy Metals	**Chromium (Cr)**	**Iron (Fe)**	**Manganese (Mn)**	**Copper (Cu)**	**Zinc (Zn)**	**Arsenic (As)**	**Lead (Pb)**	**Uranium (U)**
	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt	mg/lt
Desirable Limit (BIS: 2012)	0.05	0.3	0.1	0.05	5	0.01	0.01	0.03
Maximum Permissible Limit	0.05	0.3	0.3	1.5	15	0.05	0.01	0.03
Minimum	0.002	0.086	0.058	0.049	0.051	0.001	0.002	0.004
Maximum	0.002	3.972	0.128	0.049	3.746	0.003	0.003	0.045
Average	**----**	**1.73225**	**0.093**	**----**	**1.004**	**0.002**	**0.002667**	**0.02259**

- **Geological and Geomorphological Maps, Depth to Wat er Level (Pre and Post-Monsoon) Maps in respect Aquifer – I(A) and Isopach Maps (Aquifer - IA & IB) of Binauli block**

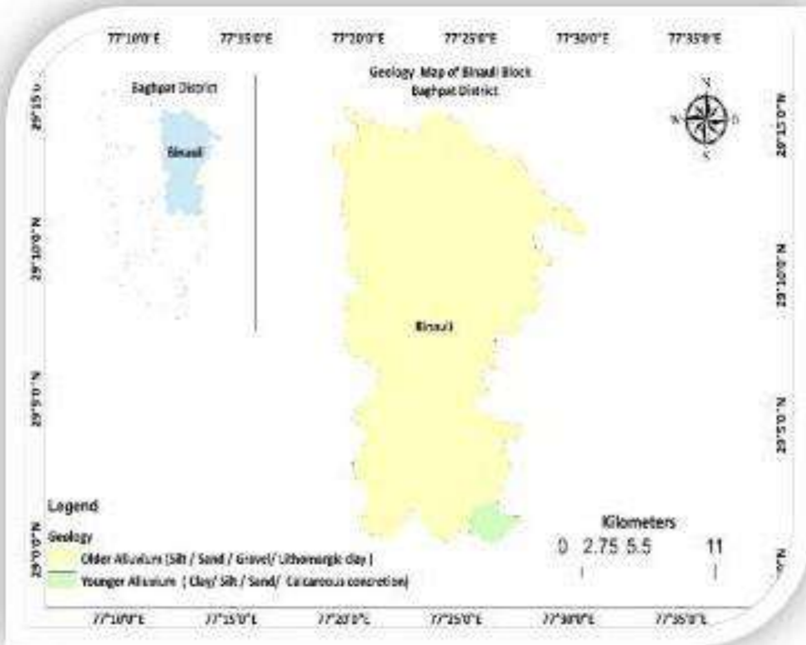


Fig. – 5.1: **Geological Map of Binauli block, Baghpat district**

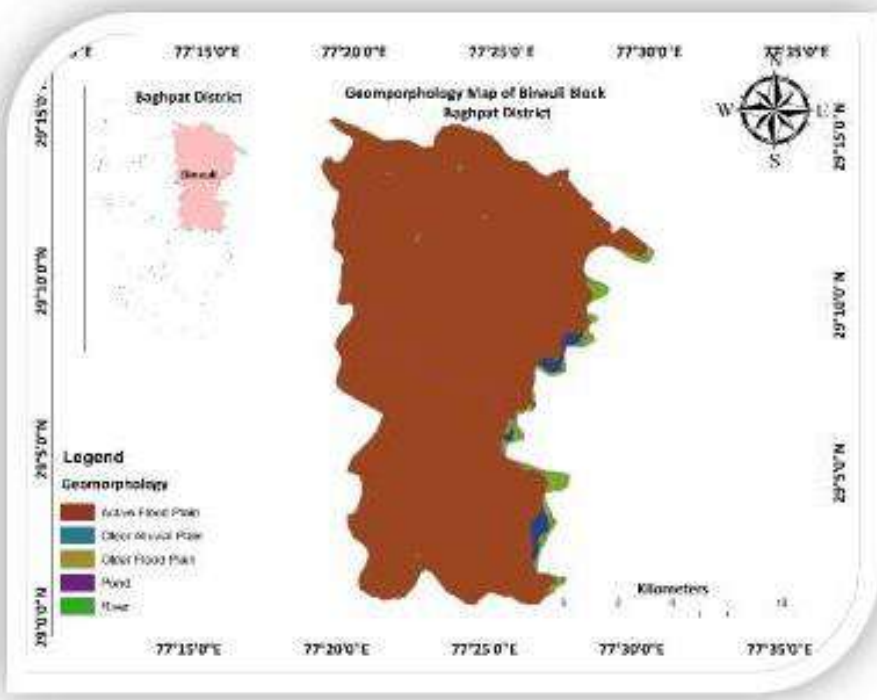


Fig. – 5.2: **Geomorphological Map of Binauliblock,Baghpat district**

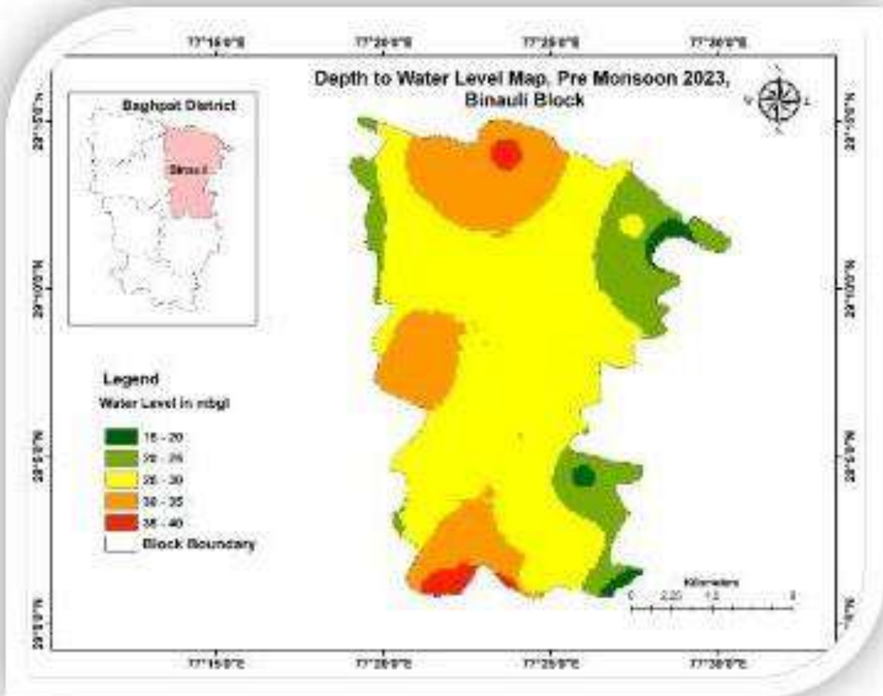


Fig. – 5.3:**Pre-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

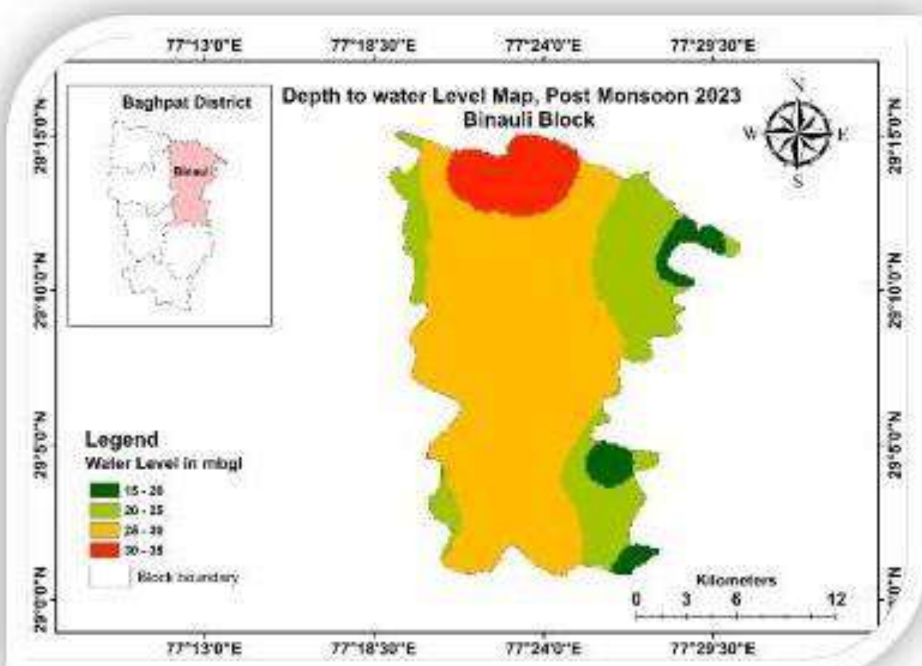


Fig. – 5.4:**Post-Monsoon (2023) Depth to Water Level Map in respect of Aquifer - I(A)**

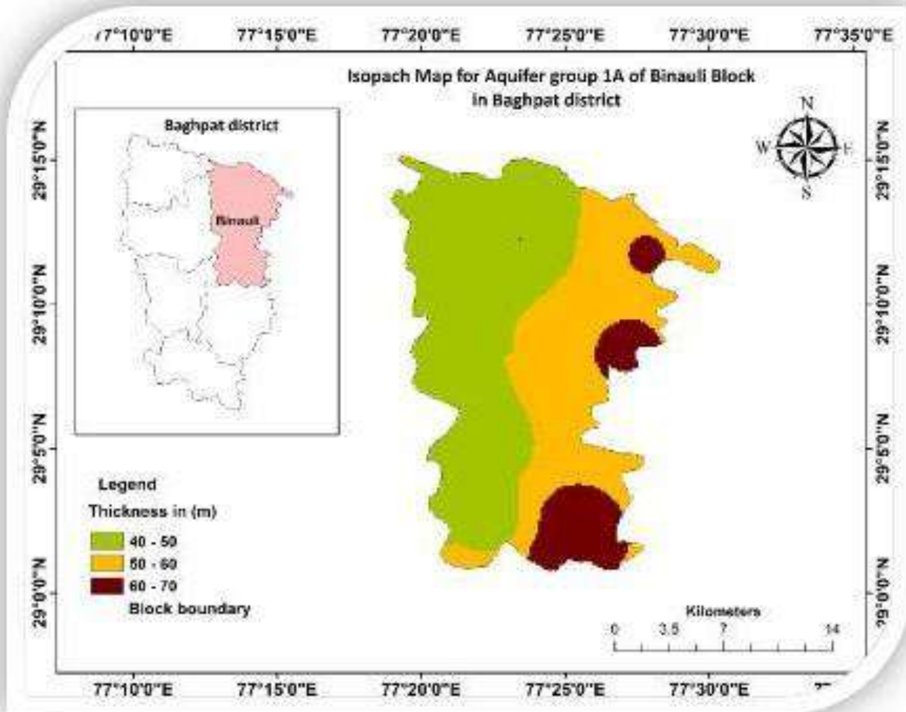


Fig. – 5.5:**Isopach Map of Binauli block in respect of Aquifer - I(A)**

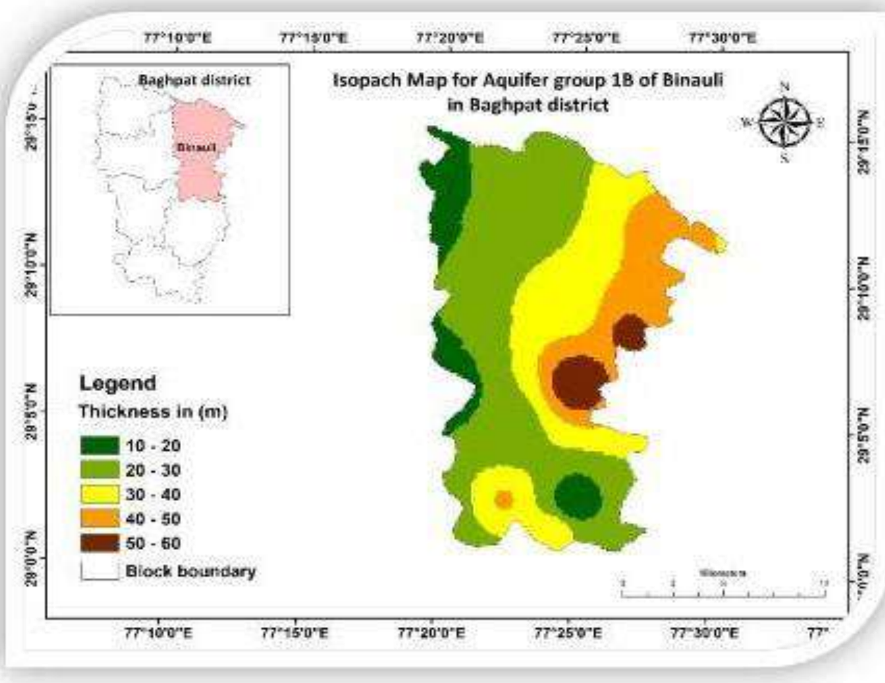


Fig. – 5.6:**Isopach Map of Binauli block in respect of Aquifer - I(B)**

References

1. Aquifer Mappimg and Management (NAQUIM) in NCR Area, Uttar Pardesh, 2017

2. Hydrogeology and Ground Water Potential of Baghpat District, Uttar Pradesh, 2002-03

3. Report on Ground Water Management Studies (Reappraisal Hydrogeological Surveys), District –Baghpat, Uttar Pradesh, 2006-2007

4. District Brochure of Baghpat District, 2013-2014

5. Basic Data Report of Exploratory Tube Well at Aminagar Sarai, Block - Pilana, District -Baghpat, 1999-2000

6. Basic Data Report of Exploratory Tube Well at Khekra, Block - Khekra, District - Baghpat, 1999-2000.

ANNEXURE - I

Depth to Water Level Data collected from the Key Wells established under NAQUIM 2.0

Sl. NO.	BLOCK	KEYWELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	PRE-MON-SOON WATER LEVEL (mbgl)	POST-MONSOON WATER LEVEL (mbgl)	SEASONAL FLUCTUA-TION (m)
1.	Chhaprauli	**Kishanpur**	29.189628	77.265747	Piezometer (Pz)	14.22	13.97	0.25
2.	Chhaprauli	**Kurdi**	29.239167	77.171389	Piezometer (Pz)	10.73	9.80	0.93
3.	Chhaprauli	**Ramala**	29.224444	77.272778	Piezometer (Pz)	14.76	15.10	-0.34
4.	Chhaprauli	**Rathaura**	29.210833	77.210833	Piezometer (Pz)	22.02	25.42	-3.40
5.	Chhaprauli	**Chhaprauli**	29.207773	77.178725	Piezometer (Pz)	18.47	18.48	-0.01
6.	Chhaprauli	**Tanda**	29.273889	77.159444	Pz (DWLR)	11.52	10.92	0.60
7.	Chhaprauli	**Janta College**	29.250016	77.210556	Pz (DWLR)	19.59	20.40	-0.81
8.	Chhaprauli	**Tanda**	29.27029	77.15601	Mark-II HPTW	11.52	10.57	0.95
9.	Chhaprauli	**Lumb**	29.26029	77.21324	Mark-II HPTW	21.98	20.83	1.15
10.	Chhaprauli	**Asara**	29.24877	77.30312	Mark-II HPTW	23.25	22.36	0.89
11.	Chhaprauli	**Soop**	29.20138	77.26443	Mark-II HPTW	12.65	11.35	1.30
12.	Chhaprauli	**Kakor Kalan**	29.17799	77.15315	Mark-II HPTW	11.03	9.70	1.33
13.	Chhaprauli	**Chandan Hedi**	29.17468	77.19856	Mark-II HPTW	23.45	22.26	1.19
14.	Baraut	**Barwala**	29.163889	77.248611	Piezometer (Pz)	17.43	16.88	0.55
15.	Baraut	**Bijrol**	29.196667	77.288056	Piezometer (Pz)	28.37	28.45	-0.08
16.	Baraut	**Fatehpur**	29.206944	77.295833	Piezometer (Pz)	19.81	19.75	0.06
17.	Baraut	**Sinauli**	29.142778	77.212778	Piezometer (Pz)	24.60	27.95	-3.35
18.	Baraut	**Baoli**	29.134261	77.272527	Piezometer (Pz)	20.62	20.40	0.22
19.	Baraut	**Shahpur Barauli**	29.074505	77.252151	Piezometer (Pz)	10.59	8.86	1.73
20.	Baraut	**Gurana**	29.084167	77.307501	Pz (DWLR)	19.94	20.24	-0.30
21.	Baraut	**Kandera**	29.163056	77.314444	Pz (DWLR)	18.52	17.95	0.57
22.	Baraut	**Luhari**	29.072778	77.194722	Pz (DWLR)	13.04	13.49	-0.45
23.	Baraut	**Shabga**	29.14943	77.16921	Mark-II HPTW	19.28	18.49	0.79
24.	Baraut	**Kotana**	29.1027	77.16688	Mark-II HPTW	17.89	16.52	1.37
25.	Baraut	**Luhari**	29.08064	77.19142	Mark-II HPTW	22.08	20.22	1.86
26.	Baraut	**Bijrol**	29.12186	77.31845	Mark-II HPTW	31.97	30.82	1.15
27.	Baraut	**Angadpur**	29.10151	77.33168	Mark-II HPTW	31.59	30.44	1.15
28.	Baraut	**Kidwai nagar**	29.10247	77.25223	Mark-II HPTW	19.10	17.93	1.17
29.	Baraut	**Baoli**	29.15471	77.27305	Mark-II HPTW	16.30	15.40	0.90
30.	Baraut	**Biharipur**	29.03733	77.20663	Mark-II HPTW	16.29	15.39	0.90
31.	Baghpat	**Gadhi**	29.037500	77.258333	Piezometer (Pz)	14.85	14.34	0.51
32.	Baghpat	**Sujra**	29.014167	77.270000	Piezometer (Pz)	12.95	13.58	-0.63

Depth to Water Level Data collected from the Key Wells established under NAQUIM 2.0

Sl. NO.	BLOCK	KEYWELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	PRE-MON-SOON WATER LEVEL (mbgl)	POST-MONSOON WATER LEVEL (mbgl)	SEASONAL FLUCTUA-TION (m)
33.	Baghpat	**Tyodhi**	29.051155	77.239846	Piezometer (Pz)	9.99	11.33	-1.34
34.	Baghpat	**Faizullapur**	29.019371	77.204956	Piezometer (Pz)	12.86	12.53	0.33
35.	Baghpat	**Baghu**	28.971653	77.253092	Piezometer (Pz)	17.19	18.55	-1.36
36.	Baghpat	**Pali**	28.914519	77.239637	Piezometer (Pz)	28.43	14.32	14.11
37.	Baghpat	**Dojha**	29.043255	77.314091	Piezometer (Pz)	19.72	21.65	-1.93
38.	Baghpat	**Bichapadi**	29.018313	77.298371	Piezometer (Pz)	14.73	15.65	-0.92
39.	Baghpat	**Chopada Maheshpur**	28.998960	77.312820	Piezometer (Pz)	30.99	25.65	5.34
40.	Baghpat	**Padda Ahmad Shahpur**	28.983620	77.301160	Piezometer (Pz)	17.11	17.07	0.04
41.	Baghpat	**Ahera**	28.931780	77.266310	Piezometer (Pz)	22.59	24.32	-1.73
42.	Baghpat	**Surajpur Mahanawa**	28.940720	77.275260	Piezometer (Pz)	21.73	22.84	-1.11
43.	Baghpat	**Chouhalda**	28.938360	77.285470	Piezometer (Pz)	21.07	23.27	-2.20
44.	Baghpat	**Pawala Begmabaad**	28.908961	77.300000	Piezometer (Pz)	41.51	26.34	15.17
45.	Baghpat	**Puthathi Brahaman**	28.982481	77.273166	Piezometer (Pz)	15.64	16.87	-1.23
46.	Baghpat	**Gauripur Habibpur**	28.948001	77.300655	Piezometer (Pz)	31.14	23.39	7.75
47.	Baghpat	**Sarurpur Kalan**	29.027652	77.233036	Piezometer (Pz)	15.61	16.55	-0.94
48.	Baghpat	**Sisana**	28.963979	77.217723	Piezometer (Pz)	15.79	15.12	0.67
49.	Baghpat	**DM Office, Baghpat**	28.984317	77.233444	Pz (DWLR)	8.75	8.83	-0.08
50.	Baghpat	**Faizpur Naina**	29.029167	77.202500	Pz (DWLR)	11.47	12.94	-1.47
51.	Baghpat	**College Mithali**	28.963056	77.304167	Pz (DWLR)	19.32	20.37	-1.05
52.	Baghpat	**Noorjpur Gujar**	28.995000	77.253889	Pz (DWLR)	13.94	14.93	-0.99
53.	Baghpat	**Pawla Begmabad**	28.92626	77.29758	Mark-II HPTW	24.77	23.65	1.12
54.	Baghpat	**Khera Hatana**	29.04523	77.19071	Mark-II HPTW	17.09	15.71	1.38
55.	Baghpat	**Tyothi**	29.05335	77.24262	Mark-II HPTW	13.25	11.58	1.67
56.	Baghpat	**Budhera**	29.03116	77.30811	Mark-II HPTW	18.29	16.66	1.63
57.	Baghpat	**Norozpur Gurjar**	28.99725	77.24979	Mark-II HPTW	15.86	14.85	1.01
58.	Baghpat	**Faizullapur**	29.02129	77.20521	Mark-II HPTW	13.79	12.48	1.31
59.	Baghpat	**Osikka**	29.04606	77.28238	Mark-II HPTW	11.25	10.48	0.77
60.	Baghpat	**Tatiri**	28.94734	77.26757	Mark-II HPTW	23.72	22.80	0.92
61.	Baghpat	**Tatiri**	28.95017	77.26659	Mark-II HPTW	23.89	22.19	1.70
62.	Baghpat	**Sarorpur Kalan**	29.027543	77.249858	Pz (DWLR)	9.03	9.65	-0.62
63.	Khekra	**Fakharpur**	28.869486	77.288208	Piezometer (Pz)	26.82	26.57	0.25
64.	Khekra	**Fulhera**	28.812778	77.391111	Piezometer (Pz)	14.20	14.00	0.20

Depth to Water Level Data collected from the Key Wells established under NAQUIM 2.0

Sl. NO.	BLOCK	KEYWELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	PRE-MON-SOON WATER LEVEL (mbgl)	POST-MONSOON WATER LEVEL (mbgl)	SEASONAL FLUCTUA-TION (m)
65.	Khekra	**Laliyana**	28.858333	77.39361	Piezometer (Pz)	18.81	18.39	0.42
66.	Khekra	**Firojpur**	28.837500	77.30750	Pz (DWLR)	24.88	24.93	-0.05
67.	Khekra	**Khekara**	28.870004	77.28778	Pz (DWLR)	27.70	25.24	2.46
68.	Khekra	**Shabbanpur**	28.84548	77.39098	Mark-II HPTW	15.05	13.20	1.85
69.	Khekra	**Bhagot**	28.80731	77.35987	Mark-II HPTW	23.02	21.47	1.55
70.	Khekra	**Fakharpur**	28.84336	77.2975	Mark-II HPTW	26.82	25.44	1.38
71.	Khekra	**Noorpur Khalsa**	28.84394	77.24519	Mark-II HPTW	11.23	9.46	1.77
72.	Khekra	**Bhagout**	28.80552	77.36007	Mark-II HPTW	23.88	22.11	1.77
73.	Khekra	**Nagla Badi**	28.81936	77.32734	Mark-II HPTW	23.08	21.82	1.26
74.	Khekra	**Firojpur**	28.84094	77.30791	Mark-II HPTW	24.88	23.00	1.88
75.	Khekra	**Badagaon**	28.86856	77.33906	Mark-II HPTW	26.48	25.15	1.33
76.	Pilana	**Poothar**	28.971074	77.389145	Piezometer (Pz)	36.08	27.27	8.81
77.	Pilana	**Lohara**	28.994596	77.396064	Piezometer (Pz)	40.23	28.71	11.52
78.	Pilana	**Singhawali Ahir**	28.968110	77.404440	Piezometer (Pz)	36.66	27.05	9.61
79.	Pilana	**Tilpani**	29.015726	77.396654	Piezometer (Pz)	41.16	28.06	13.10
80.	Pilana	**Fatehpur**	28.998141	77.358298	Piezometer (Pz)	39.46	27.54	11.92
81.	Pilana	**Khindora**	29.006160	77.366183	Piezometer (Pz)	40.01	27.50	12.51
82.	Pilana	**Roshangarh**	28.941825	77.387406	Piezometer (Pz)	34.14	28.76	5.38
83.	Pilana	**Basoud**	28.981870	77.322935	Piezometer (Pz)	24.94	21.12	3.82
84.	Pilana	**Daulatpur**	28.935106	77.387806	Piezometer (Pz)	34.72	26.25	8.47
85.	Pilana	**Saidpur Khurd**	28.922939	77.399571	Piezometer (Pz)	39.62	25.63	13.99
86.	Pilana	**Rasoolpur Sankalputi**	28.933760	77.355252	Piezometer (Pz)	42.51	28.53	13.98
87.	Pilana	**Pathhouli**	28.922192	77.381486	Piezometer (Pz)	35.15	27.54	7.61
88.	Pilana	**Basatikri**	28.941040	77.312023	Piezometer (Pz)	22.18	24.23	-2.05
89.	Pilana	**Mukundpur Ogti**	28.910443	77.387686	Piezometer (Pz)	36.86	24.89	11.97
90.	Pilana	**Ghatauli**	28.924504	77.435944	Piezometer (Pz)	18.55	5.87	12.68
91.	Pilana	**Salawatpur Kheri**	28.908443	77.311862	Piezometer (Pz)	42.03	26.49	15.54
92.	Pilana	**Kaharka**	28.900350	77.394748	Piezometer (Pz)	33.55	19.96	13.59
93.	Pilana	**Hisawada**	28.973344	77.362872	Piezometer (Pz)	39.59	27.65	11.94
94.	Pilana	**Doula**	28.956931	77.336159	Piezometer (Pz)	22.86	24.27	-1.41
95.	Pilana	**Gouspur**	28.980241	77.347789	Piezometer (Pz)	38.60	28.35	10.25
96.	Pilana	**Habibpur Nagala**	28.947690	77.442887	Piezometer (Pz)	31.46	26.78	4.68
97.	Pilana	**Pura Mahadeo**	28.997908	77.450225	Piezometer (Pz)	14.18	14.91	-0.73
98.	Pilana	**Chamrawal**	28.875278	77.389167	Pz (DWLR)	16.71	17.15	-0.44

Depth to Water Level Data collected from the Key Wells established under NAQUIM 2.0

Sl. NO.	BLOCK	KEYWELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	PRE-MON-SOON WATER LEVEL (mbgl)	POST-MONSOON WATER LEVEL (mbgl)	SEASONAL FLUCTUA-TION (m)
99.	Pilana	**Dhikoli**	28.899722	77.362500	Pz (DWLR)	23.93	24.77	-0.84
100.	Pilana	**DolchaPilana**	28.935000	77.453055	Pz (DWLR)	10.13	10.09	0.04
101.	Pilana	**Pilana**	28.936389	77.369722	Pz (DWLR)	26.21	28.29	-2.08
102.	Pilana	**Daula**	28.95639	77.33937	Mark-II HPTW	27.55	25.90	1.65
103.	Pilana	**Aminagar Sarai**	28.98622	77.39894	Mark-II HPTW	25.99	24.97	1.02
104.	Pilana	**Pura Mahadev**	28.99857	77.45588	Mark-II HPTW	11.06	9.95	1.11
105.	Pilana	**Murkandpur**	28.91309	77.38867	Mark-II HPTW	24.26	22.92	1.34
106.	Pilana	**Baleni**	28.95401	77.45491	Mark-II HPTW	12.06	10.00	2.06
107.	Pilana	**Shobhapur**	28.98994	77.36318	Mark-II HPTW	28.96	27.25	1.71
108.	Pilana	**Singhawali Ahir**	28.95702	77.40273	Mark-II HPTW	24.52	23.08	1.44
109.	Pilana	**Baleni**	28.954014	77.454909	Dug Well (DW)	9.47	9.38	0.09
110.	Binauli	**Galheta**	29.073611	77.432222	Piezometer (Pz)	19.02	16.85	2.17
111.	Binauli	**Bamnauli**	29.144722	77.347778	Piezometer (Pz)	31.68	28.08	3.60
112.	Binauli	**Sirsali**	29.124167	77.345556	Piezometer (Pz)	32.42	29.85	2.57
113.	Binauli	**Binauli**	29.093111	77.399615	Piezometer (Pz)	29.42	29.27	0.15
114.	Binauli	**Sanjarpur Kaidwa**	29.021112	77.404722	Pz (DWLR)	26.07	27.27	-1.20
115.	Binauli	**Nirpura**	29.2333	77.39426	Mark-II HPTW	35.76	34.25	1.51
116.	Binauli	**Khaprana**	29.19062	77.47066	Mark-II HPTW	16.23	14.98	1.25
117.	Binauli	**Edrishpur School**	29.17278	77.35722	Mark-II HPTW	28.94	27.71	1.23
118.	Binauli	**Barawad**	29.06852	77.32256	Mark-II HPTW	25.86	24.12	1.74
119.	Binauli	**Binauli**	29.09306	77.40051	Mark-II HPTW	30.36	28.64	1.72
120.	Binauli	**Tikri**	29.22982	77.36198	Mark-II HPTW	34.92	33.22	1.70
121.	Binauli	**Tabelgarhi**	29.19698	77.45937	Mark-II HPTW	26.02	24.53	1.49
122.	Binauli	**Kambala**	29.04828	77.40305	Mark-II HPTW	28.29	26.14	2.15

ANNEXURE– II

(A) Basic Chemical Analysis Results of Ground Water Samples collected during Pre-Monsoon

Sl. NO	BLOCK	KEY WELL LOCA-TION /VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	pH	EC µS/cm 25°C	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2
1.	Chhaprauli	**Tanda**	29.2703	77.1560	HP (M-II)	23.6.23	7.87	1090	403	64	0.33	12	110	220	56	19	150	7.5	25
2.	Chhaprauli	**Lumb**	29.2603	77.2132	HP (M-II)	23.6.23	7.81	1100	415	99	0.18	8.7	64	430	76	58	61	7.3	27
3.	Chhaprauli	**Asara**	29.2488	77.3031	HP (M-II)	23.6.23	7.85	649	281	14	0.56	BDL	100	270	72	22	41	5.1	25
4.	Chhaprauli	**Soop**	29.2014	77.2644	HP (M-II)	23.6.23	7.93	1089	622	21	0.30	7	20	270	88	12	135	7.1	29
5.	Chhaprauli	**Badarkha**	29.1891	77.1576	HP (M-II)	23.6.23	7.87	1230	500	28	0.19	8	170	340	48	53	140	6.3	28
6.	Chhaprauli	**Chandan Hedi**	29.1691	77.1955	HP(STW)	23.7.23	8.09	1747	708	106	0.71	BDL	120	320	84	26	255	5.6	26
7.	Chhaprauli	**Mukandpur**	29.2043	77.2285	SBTW	23.7.23	8.17	910	488	14	0.76	9.9	30	280	32	48	89	5.6	25
8.	Baraut	**Luhari**	29.0806	77.1914	HP (M-II)	24.6.23	7.98	1384	573	78	0.16		105	360	56	53	156	7.7	21
9.	Baraut	**Luhari**	29.0996	77.1852	HP (M-II)	24.6.23	8.04	1334	451	57	0.50		165	220	64	19	195	5.5	26
10.	Baraut	**Luhari**	29.0798	77.1920	DTW(JN)	23.7.23	7.83	1308	488	57	0.40	7.9	154	350	36	63	140	5.9	27
11.	Baraut	**Shabga**	29.1494	77.1692	HP (M-II)	24.6.23	7.93	782	403	28	0.55	BDL	28	220	52	22	82	8.3	27
12.	Baraut	**Kotana**	29.1027	77.1669	HP (M-II)	24.6.23	7.89	1494	732	57	0.18	BDL	6	240	60	22	210	5.4	30
13.	Baraut	**Malakpur**	29.1059	77.2523	HP(STW)	23.7.23	8.15	788	403	14	1.22		41	170	24	26	105	4.7	20
14.	Baraut	**Baoli**	29.1547	77.2730	HP(STW)	23.7.23	7.89	389	171	14	2.40		27	150	28	19	19	2.6	19
15.	Baraut	**Bijrol**	29.1219	77.3185	HP (M-II)	24.6.23	7.95	843	451	21	0.85	BDL	28	200	52	17	101	20	27
16.	Baraut	**Angadpur**	29.1015	77.3317	HP (M-II)	24.6.23	7.78	1369	634	71		12	48	350	56	51	155	8.3	31
17.	Baraut	**Saroorpur**	29.0341	77.2315	DcB TW	23.7.23	8.14	1207	561	50	0.64		60	230	36	34	170	5.7	24
18.	Baraut	**Biharipur**	29.0373	77.2066	HP(STW)	25.7.23	8.13	2391	1159	78	1.80	12	100	180	28	26	480	3	23
19.	Baghpat	**Pawla Begmabad**	28.9308	77.2946	HP (M-II)	25.6.23	7.92	1131	586	28		5.4	34	350	52	53	100	8.5	26
20.	Baghpat	**Khera Hatana**	29.0452	77.1907	HP (M-II)	25.06.23	7.95	1753	634	113	0.11	BDL	200	290	56	36	280	6.2	26
21.	Baghpat	**Tyothi**	29.0534	77.2426	HP (M-II)	25.06.23	7.82	570	305	28	0.35	BDL	9	220	32	34	37	4.4	27
22.	Baghpat	**Budhera**	29.0312	77.3081	HP (M-II)	25.06.23	8.01	943	476	7	0.57	BDL	74	260	28	46	103	7	23
23.	Baghpat	**Norozpur Gurjar**	28.9973	77.2498	HP (M-II)	25.06.23	7.94	930	439	14	0.37	BDL	91	250	24	46	105	7.3	24
24.	Baghpat	**Tatiri**	28.9502	77.2666	HP(STW)	25.07.23	7.86	1103	573	21	0.45		60	420	68	60	65	10	23
25.	Baghpat	**Osikka**	29.0461	77.2824	HP(STW)	25.07.23	7.84	639	329	14	0.82		41	300	76	26	17	4.6	21
26.	Baghpat	**Fazulapur**	29.0213	77.2052	HP(STW)	25.07.23	7.82	2390	586	220	0.32	12	370	380	84	7	385	5.8	23
27.	Khekda	**Sabanpur**	28.8455	77.3910	HP (M-II)	29.06.23	8.16	2125	634	142			320	370	64	50	335	4.5	23
28.	Khekda	**Fakarpur**	28.8434	77.2975	HP (M-II)	30.06.23	8.13	881	488	14	0.38		23	280	64	29	78	5.2	26
29.	Khekda	**Noorpur**	28.8439	77.2452	HP (M-II)	30.06.23	8.16	1980	378	206	0.19		380	540	124	55	225	4.5	27
30.	Khekda	**Bhagot**	28.8073	77.3599	HP (M-II)	29.06.23	8.23	1095	500	64	0.48		40	200	64	10	160	6.1	28
31.	Khekra	**Bhagout**	28.8056	77.3599	SBTW	22.07.23	7.40	1900	476	298	0.29	30	80	420	60	82	200	5.5	34

(A) Basic Chemical Analysis Results of Ground Water Samples collected during Pre-Monsoon

Sl. NO	BLOCK	KEY WELL LOCA-TION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	pH	EC µS/cm 25°C	H-CO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	Si-O_2
32.	Khekra	**Bhagout**	28.8055	77.3599	SBTW	22.07.23	7.46	2330	464	425	0.19	36	105	610	60	110	240	17	33
33.	Khekra	**Bhagout**	28.8055	77.3601	HP(STW)	22.07.23	8.01	1200	500	64	0.52	32	39	250	44	34	156	4.6	32
34.	Khekra	**NaglaBadi**	28.8217	77.3227	DcB TW	22.07.23	7.77	1070	549	7	0.53	11	70	250	40	36	135	6	24
35.	Khekra	**NaglaBadi**	28.8221	77.3300	SBTW	22.07.23	7.88	650	354	7	0.94	6	29	230	32	36	48	4.7	25
36.	Khekra	**Badagaon**	28.8695	77.3219	SBTW	22.07.23	7.95	820	451	7	1.06	7	37	170	32	22	120	4.3	25
37.	Khekra	**Firojpur**	28.8409	77.3073	SBTW	22.07.23	8.16	920	500	21	0.89		24	90	16	12	180	2.4	21
38.	Pilana	**Doula**	28.9564	77.3394	HP (M-II)	28.06.23	8.27	1183	537	64	3.50		48	290	44	43	140	4.4	21
39.	Pilana	**Murkand -pur**	28.9131	77.3887	HP(M-II)	29.06.23	8.23	1597	647	106	0.56	16	52	200	44	22	260	5.1	23
40.	Pilana	**Ogati Muk -randpur**	28.9118	77.3865	SBTW	22.07.23	8.04	1470	671	71	0.92	8	64	180	32	24	256	3.9	26
41.	Pilana	**Pilana**	28.9367	77.3705	SBTW	22.07.23	7.94	1604	561	106	0.46	33	115	330	28	62	195	20	27
42.	Pilana	**Shobhapur**	28.9899	77.3632	HP(STW)	21.07.23	7.94	1860	805	142	0.32	10	76	600	104	82	165	7.6	35
43.	Pilana	**Shobhapur**	28.9896	77.3636	HP(STW)	21.07.23	8.04	1685	744	78	0.46	11	86	400	44	70	205	6.5	28
44.	Pilana	**Shobhapur**	28.9897	77.3637	SBTW	21.07.23	8.04	1410	647	64	0.39	21	64	410	44	72	140	6.4	27
45.	Pilana	**Pura Mahadev**	28.9981	77.4503	HP (M-II)	29.06.23	8.13	1402	708	42	0.89	20	43	250	52	29	220	5.6	31
46.	Pilana	**Aminna-gar Sarai**	28.9862	77.3989	HP (M-II)	28.06.23	8.07	1216	573	78	0.66		49	330	68	38	145	6.4	29
47.	Pilana	**Baleni**	28.9540	77.4549	HP (M-II)	28.06.23	8.10	725	354	14	0.54	6.8	58	220	40	29	74	4.5	24
48.	Pilana	**Baleni**	28.9588	77.4711	HP(STW)	22.07.23	7.88	594	354	7	0.23			220	44	26	37	6.3	28
49.	Pilana	**Singha-wali Ahir**	28.9570	77.4027	HPSTW)	22.07.23	8.09	990	512	21	0.53	34	28	320	36	55	87	5.4	26
50.	Binauli	**Faulad-nagar**	29.1853	77.4371	SBTW	27.06.23	8.06	880	390	50	0.72		47	240	44	31	97	5.2	27
51.	Binauli	**Binauli**	29.0931	77.4005	HP (M-II)	27.06.23	8.18	820	390	28	0.38		56	180	68	2	110	5	25
52.	Binauli	**Tikri**	29.2298	77.3620	HP (M-II)	27.06.23	8.02	634	317	21	0.84		38	220	44	26	51	6.3	20
53.	Binauli	**Tikri**	29.2323	77.3541	SBTW	24.07.23	8.19	710	329	21	0.56		56	150	28	19	100	3.4	24
54.	Binauli	**Kambala**	29.0483	77.4031	HP (M-II)	28.06.23	8.15	926	439	28	0.68		23	260	48	34	77	6.8	28
55.	Binauli	**Mangroli**	29.1906	77.4707	HP(STW)	24.07.23	7.82	790	451	21	0.64		10	280	64	29	64	4.4	24
56.	Binauli	**Edrishpur School**	29.1728	77.3572	HP(STW)	24.07.23	7.65	1000	573	14	0.51		18	280	76	22	110	5.8	28
57.	Binauli	**Barawad**	29.0685	77.3226	HP(STW)	24.07.23	7.85	1120	610	14	0.70	8	48	480	64	77	46	6.7	24
58.	Binauli	**Tabel-garhi**	29.1970	77.4594	HP (M-II)	27.06.23	7.98	1190	622	28	0.43	7.4	43	430	92	48	80	6.3	32
59.	Binauli	**Nirpura**	29.2333	77.3943	HP(STW)	24.07.23	7.92	897	415	42	0.30		20	260	84	12	73	6.1	23
60.	Binauli	**Bamnauli**	29.1433	77.3478	HP(M-II)	27.06.23	8.2	790	342	14	0.43		90	100	28	7	140	3.2	21
61.	Binauli	**Khaprana**	29.1906	77.4707	HP(STW)	24.07.23	7.9	700	378	21	0.83		16	230	60	19	62	4.6	21

(B) Basic Chemical Analysis Results of Surface Water Samples collected during Pre-Monsoon

Sl. NO	BLOCK	KEY WELL LOCATION/ VILLAGE	LATITUDE	LONGITUDE	WELL TYPE	DATE OF COLLECTION	pH	EC µS/cm 25°C	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2
1.	Chhaprauli	**Chhaprauli**	29.2067	77.1685	SW	23.07.23	7.52	1004	305	92	0.59		74	210	40	26	81	70	21
2.	Chhaprauli	**Boddha**	29.2801	77.1641	SW	23.07.23	7.42	907	342	64	1.05	12	48	200	52	17	60	90	27
3.	Chhaprauli	**Ramala**	29.2263	77.2707	SW	23.07.23	7.49	768	293	57	0.70	7	60	170	36	19	73	60	17
4.	Baraut	**Malakpur**	29.1059	77.2523	SW (Nahar)	23.07.23	7.35	269	110	14			16	90	32	2	18	2.9	12
5.	Baraut	**Shadatpur Jounmana**	29.0915	77.2174	SW	23.07.23	8.14	945	488	21	0.60		48	180	28	26	145	5.6	18
6.	Baghpat	**Tatiri**	28.9473	77.2676	SW	25.07.23	7.55	1223	561	113	0.73		62	250	48	31	190	35	20
7.	Baghpat	**Gauripur**	28.9884	77.2028	SW (Yamuna)	25.07.23	7.61	348	159	14	0.32	7.6	10	140	52	2	12	3.7	11
8.	Baghpat	**Osikka**	29.0461	77.2828	SW	25.07.23	7.18	696	268	57	0.81	5.2	48	190	48	17	53	45	10
9.	Baghpat	**Faizulapur**	29.0214	77.2052	SW	25.07.23	7.95	735	268	57	0.77	9	64	160	32	19	81	35	12
10.	Khekra	**Firojpur**	28.8409	77.3073	SW (Pond)	22.07.23	7.14	410	159	28	0.42		28	100	24	10	28	35	15
11.	Khekra	**Rataul**	28.8299	77.3374	SW	22.07.23	7.12	340	122	7	0.42	16	27	100	24	10	12	25	10
12.	Khekda	**Lalyana**	28.8612	77.4098	SW (Hindon)	30.06.23	7.33	449	183	28	0.34	23	35	180	58	10	23	19	14
13.	Pilana	**Shobhapur**	28.9899	77.3632	SW (Pond)	21.07.23	7.56	1418	622	78	1.60	31	58	210	40	26	180	90	33
14.	Pilana	**Pura Mahadev**	29.0010	77.4609	SW (Hindon)	29.06.23	7.25	696	268	50	0.72	23	40	230	72	12	47	25	21
15.	Pilana	**Aminagar Sarai**	28.9195	77.3962	SW (Pond)	21.07.23	7.45	1210	512	85	1.20	22	37	240	48	34	155	35	34
16.	Pilana	**Baleni**	28.9588	77.4711	SW (Hindon)	22.07.23	7.31	280	122	7	0.25	5.7	17	110	32	7	9	7.1	13
17.	Pilana	**Basand**	28.9843	77.3263	SW (Pond)	21.07.23	7.65	1199	439	92	1.14	31	43	220	36	31	150	22	16
18.	Binauli	**Tabela Gadi**	29.1906	77.4707	SW (Hindon)	24.07.23	7.48	518	244	35	0.44		20	200	64	10	31	10	17
19.	Binauli	**Nirpura**	29.2328	77.3932	SW (Pond)	24.07.23	7.49	717	268	71	0.46	7	24	200	52	17	38	57	20
20.	Binauli	**Bamnauli**	29.1451	77.3551	SW (Hindon)	24.07.23	6.95	463	220	28	0.52		28	180	56	10	20	25	17
21.	Binauli	**Barnawa Bridge**	29.1143	77.4398	SW (Hindon)	28.06.23	7.45	710	268	64	0.55	10	41	230	68	14	55	20	22

(C) Heavy Metals Analysis Results of Ground Water Samples collected during Pre-Monsoon

Sl. NO	BLOCK	KEY WELL LOCATION /VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
1.	Chhaprauli	**Tanda**	29.2703	77.1560	HP (M-II)	23.06.23	BDL	0.214	BDL	BDL	0.243	BDL	BDL	0.024
2.	Chhaprauli	**Lumb**	29.2603	77.2132	HP (M-II)	23.06.23	BDL	0.178	0.057	BDL	0.495	BDL	BDL	0.021
3.	Chhaprauli	**Asara**	29.2488	77.3031	HP (M-II)	23.06.23	BDL	5.753	0.139	BDL	0.532	BDL	0.001	0.006
4.	Chhaprauli	**Soop**	29.2014	77.2644	HP (M-II)	23.06.23	BDL	0.325	0.076	BDL	1.937	BDL	0.002	0.052
5.	Chhaprauli	**Badarkha**	29.1891	77.1576	HP (M-II)	23.06.23	BDL	0.512	0.054	BDL	0.345	BDL	0.001	0.023
6.	Chhaprauli	**Chandan Hedi**	29.1691	77.1955	HP (STW)	23.07.23	BDL	0.143	BDL	BDL	3.904	BDL	0.001	0.057
7.	Chhaprauli	**Mukandpur**	29.2043	77.2285	SBTW	23.07.23	BDL	BDL	BDL	BDL	BDL	0.001	BDL	0.025
8.	Baraut	**Luhari**	29.0806	77.1914	HP (M-II)	24.06.23	BDL	10.125	0.118	BDL	0.275	BDL	BDL	0.007
9.	Baraut	**Luhari**	29.0996	77.1852	HP (M-II)	24.06.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.019
10.	Baraut	**Luhari**	29.0798	77.1920	DTW(JN)	23.07.23	BDL	BDL	0.063	BDL	0.085	BDL	0.002	0.020
11.	Baraut	**Shabga**	29.1494	77.1692	HP (M-II)	24.06.23	BDL	0.143	BDL	BDL	1.232	BDL	BDL	0.012
12.	Baraut	**Kotana**	29.1027	77.1669	HP (M-II)	24.06.23	BDL	0.111	0.06	BDL	0.358	BDL	0.001	0.038
13.	Baraut	**Malakpur**	29.1059	77.2523	HP(STW)	23.07.23	BDL	3.369	BDL	BDL	BDL	BDL	BDL	0.010
14.	Baraut	**Baoli**	29.1547	77.2730	HP(STW)	23.07.23	BDL	BDL	BDL	BDL	0.471	BDL	BDL	0.004
15.	Baraut	**Bijrol**	29.1219	77.3185	HP (M-II)	24.06.23	BDL	0.407	0.059	BDL	0.871	BDL	BDL	0.014
16.	Baraut	**Angadpur**	29.1015	77.3317	HP (M-II)	24.06.23	BDL	0.22	0.16	BDL	0.18	BDL	0.002	0.026
17.	Baraut	**Saroorpur Kala**	29.0341	77.2315	DcB TW	23.07.23	BDL	BDL	BDL	BDL	BDL	0.002	BDL	0.024
18.	Baraut	**Biharipur**	29.0373	77.2066	HP(STW)	25.07.23	BDL	BDL	BDL	BDL	0.095	BDL	0.003	0.043
19.	Baghpat	**Pawla Begmabad**	28.9308	77.2946	HP (M-II)	25.06.23	BDL	0.379	0.065	BDL	1.795	BDL	0.002	0.041
20.	Baghpat	**Khera Hatana**	29.0452	77.1907	HP (M-II)	25.06.23	BDL	0.181	0.136	BDL	3.507	BDL	BDL	0.021
21.	Baghpat	**Tyothi**	29.0534	77.2426	HP (M-II)	25.06.23	BDL	0.228	BDL	BDL	0.069	BDL	BDL	0.008
22.	Baghpat	**Budhera**	29.0312	77.3081	HP (M-II)	25.06.23	BDL	0.115	0.114	BDL	0.94	BDL	BDL	0.023
23.	Baghpat	**Norozpur Gurjar**	28.9973	77.2498	HP (M-II)	25.06.23	BDL	0.085	BDL	BDL	1.652	BDL	0.001	0.016
24.	Baghpat	**Tatiri**	28.9502	77.2666	HP(STW)	25.07.23	0.005	1.513	BDL	BDL	1.611	BDL	0.013	0.029
25.	Baghpat	**Osikka**	29.0461	77.2824	HP(STW)	25.07.23	BDL	BDL	BDL	BDL	0.093	BDL	0.001	0.014
26.	Baghpat	**Faizullapur**	29.0213	77.2052	HP(STW)	25.07.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.005
27.	Khekda	**Shabanpur**	28.8455	77.3910	HP (M-II)	29.06.23	BDL	0.20	0.083	BDL	1.162	BDL	BDL	0.027
28.	Khekda	**Fakharpur**	28.8434	77.2975	HP (M-II)	30.06.23	BDL	2.195	0.108	BDL	2.54	BDL	0.001	0.012
29.	Khekda	**Noorpur Khalsa**	28.8439	77.2452	HP (M-II)	30.06.23	0.002	0.306	0.12	BDL	1.012	BDL	BDL	0.013
30.	Khekda	**Bhagot**	28.8073	77.3599	HP (M-II)	29.06.23	BDL	0.573	0.069	BDL	1.34	BDL	BDL	0.013

(C) Heavy Metals Analysis Results of Ground Water Samples collected during Pre-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
31.	Khekra	**Bhagout**	28.8056	77.3599	SBTW	22.07.23	BDL	BDL	0.125	BDL	BDL	BDL	BDL	0.011
32.	Khekra	**Bhagout**	28.8055	77.3599	SBTW	22.07.23	BDL	BDL	0.081	BDL	BDL	BDL	BDL	0.016
33.	Khekra	**Bhagout**	28.8055	77.3601	HP(STW)	22.07.23	BDL	0.177	0.063	BDL	BDL	BDL	0.003	0.011
34.	Khekra	**Nagla Badi**	28.8217	77.3227	DcB TW	22.07.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.026
35.	Khekra	**Nagla Badi**	28.8221	77.3300	SBTW	22.07.23	BDL	BDL	BDL	BDL	BDL	BDL	0.001	0.011
36.	Khekra	**Badagaon**	28.8695	77.3219	SBTW	22.07.23	BDL	BDL	BDL	BDL	BDL	BDL	0.011	0.015
37.	Khekra	**Firojpur**	28.8409	77.3073	SBTW	22.07.23	BDL	BDL	BDL	BDL	BDL	0.001	BDL	0.009
38.	Pilana	**Doula**	28.9564	77.3394	HP(M-II)	28.06.23	BDL	2.135	0.223	BDL	1.613	BDL	0.001	0.015
39.	Pilana	**Murkandpur**	28.9131	77.3887	HP(M-II)	29.06.23	BDL	BDL	0.056	BDL	0.135	BDL	BDL	0.019
40.	Pilana	**Ogati Mukrandpur**	28.9118	77.3865	SBTW	22.07.23	BDL	BDL	BDL	BDL	BDL	0.001	BDL	0.026
41.	Pilana	**Pilana**	28.9367	77.3705	SBTW	22.07.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.018
42.	Pilana	**Shobhapur**	28.9899	77.3632	HP(STW)	21.07.23	BDL	0.079	0.207	BDL	0.693	BDL	0.001	0.035
43.	Pilana	**Shobhapur**	28.9896	77.3636	HP(STW)	21.07.23	BDL	0.303	0.053	BDL	0.613	BDL	0.001	0.033
44.	Pilana	**Shobhapur**	28.9897	77.3637	SBTW	21.07.23	BDL	BDL	BDL	BDL	BDL	0.002	BDL	0.022
45.	Pilana	**Pura Mahadev**	28.9981	77.4503	HP(M-II)	29.06.23	BDL	0.013	BDL	BDL	1.374	BDL	BDL	0.050
46.	Pilana	**Aminnagar Sarai**	28.9862	77.3989	HP(M-II)	28.06.23	BDL	0.134	BDL	BDL	3.803	BDL	0.001	0.019
47.	Pilana	**Baleni**	28.9540	77.4549	HP(M-II)	28.06.23	BDL	0.052	BDL	BDL	1.064	BDL	0.001	0.016
48.	Pilana	**Baleni**	28.9588	77.4711	HP(STW)	22.07.23	BDL	0.728	0.47	BDL	0.301	0.0108	BDL	0.004
49.	Pilana	**Singhawali Ahir**	28.9570	77.4027	HP(STW)	22.07.23	BDL	2.080	0.104	BDL	0.843	BDL	BDL	0.016
50.	Binauli	**Fauladnagar**	29.1853	77.4371	SBTW	27.06.23	BDL	0.476	0.077	BDL	BDL	0.001	0.001	0.014
51.	Binauli	**Binauli**	29.0931	77.4005	HP(M-II)	27.06.23	BDL	0.078	0.034	BDL	1.095	BDL	BDL	0.010
52.	Binauli	**Tikri**	29.2298	77.3620	HP(M-II)	27.06.23	BDL	3.242	0.057	BDL	0.184	BDL	BDL	0.005
53.	Binauli	**Tikri**	29.2323	77.3541	SBTW	24.07.23	BDL	BDL	BDL	BDL	BDL	0.002	0.001	0.007
54.	Binauli	**Kambala**	29.0483	77.4031	HP(M-II)	28.06.23	BDL	0.279	0.068	BDL	0.321	BDL	0.001	0.020
55.	Binauli	**Mangroli**	29.1906	77.4707	HP(STW)	24.07.23	BDL	7.857	0.062	BDL	0.387	BDL	0.002	0.004
56.	Binauli	**Edrishpur**	29.1728	77.3572	HP(STW)	24.07.23	BDL	5.519	0.105	BDL	0.43	BDL	0.001	0.013
57.	Binauli	**Barawad**	29.0685	77.3226	HP(STW)	24.07.23	BDL	0.07	BDL	BDL	1.829	BDL	0.001	0.052
58.	Binauli	**Tabelgarhi**	29.1970	77.4594	HP(M-II)	27.06.23	BDL	0.081	BDL	BDL	1.862	BDL	BDL	0.044
59.	Binauli	**Nirpura**	29.2333	77.3943	HP(STW)	24.07.23	BDL	BDL	0.052	BDL	1.025	BDL	BDL	0.017
60.	Binauli	**Bamnauli**	29.1433	77.3478	HP(M-II)	27.06.23	BDL	0.834	BDL	BDL	BDL	0.002	0.001	0.011
61.	Binauli	**Khaprana**	29.1906	77.4707	HP(STW)	24.07.23	BDL	1.051	BDL	BDL	0.242	BDL	0.003	0.015

(D) Heavy Metals Analysis Results of Surface Water Samples collected during Pre-Monsoon

Sl. NO	BLOCK	KEY WELL LOCATION /VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE -CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
1.	Chhaprauli	**Chhaprauli**	29.2067	77.1685	SW	23.07.23	BDL	BDL	0.06	BDL	BDL	0.005	0.001	BDL
2.	Chhaprauli	**Boddha**	29.2801	77.1641	SW	23.07.23	BDL	BDL	0.203	BDL	BDL	0.006	0.003	BDL
3.	Chhaprauli	**Ramala**	29.2263	77.2707	SW	23.07.23	BDL	BDL	BDL	BDL	BDL	0.004	0.005	0.006
4.	Baraut	**Malakpur**	29.1059	77.2523	SW (Nahar)	23.07.23	BDL	BDL	BDL	BDL	BDL	0.007	0.022	BDL
5.	Baraut	**Shadatpur Jounmana**	29.0915	77.2174	SW	23.07.23	BDL	BDL	BDL	BDL	BDL	0.010	BDL	0.037
6.	Baghpat	**Tatiri**	28.9473	77.2676	SW	25.07.23	BDL	BDL	BDL	BDL	BDL	0.003	0.002	0.009
7.	Baghpat	**Gauripur**	28.9884	77.2028	SW (Yamuna)	25.07.23	BDL	BDL	BDL	BDL	BDL	0.001	0.002	BDL
8.	Baghpat	**Osikka**	29.0461	77.2828	SW	25.07.23	BDL	BDL	BDL	BDL	BDL	0.003	0.001	0.004
9.	Baghpat	**Faizullapur**	29.0214	77.2052	SW	25.07.23	BDL	BDL	BDL	BDL	BDL	0.004	BDL	0.003
10.	Khekra	**Firojpur**	28.8409	77.3073	SW (Pond)	22.07.23	BDL	BDL	0.137	BDL	BDL	0.010	BDL	BDL
11.	Khekra	**Rataul**	28.8299	77.3374	SW	22.07.23	BDL	BDL	BDL	BDL	BDL	0.006	BDL	BDL
12.	Khekda	**Lalyana**	28.8612	77.4098	SW (Hindon)	30.06.23	BDL	0.06	0.314	BDL	BDL	0.006	0.001	BDL
13.	Pilana	**Shobhapur**	28.9899	77.3632	SW (Pond)	21.07.23	BDL	BDL	0.083	BDL	BDL	0.005	0.001	0.004
14.	Pilana	**Pura Mahadev**	29.0010	77.4609	SW (Hindon)	29.06.23	BDL	0.066	0.542	BDL	BDL	0.003	BDL	BDL
15.	Pilana	**Aminagar Sarai**	28.9195	77.3962	SW (Pond)	21.07.23	BDL	BDL	BDL	BDL	BDL	0.002	0.002	BDL
16.	Pilana	**Baleni**	28.9588	77.4711	SW (Hindon)	22.07.23	BDL	BDL	BDL	BDL	BDL	0.007	0.032	BDL
17.	Pilana	**Basand**	28.9843	77.3263	SW (Pond)	21.07.23	BDL	BDL	BDL	BDL	BDL	0.008	0.001	BDL
18.	Binauli	**Tabela Gadi**	29.1906	77.4707	SW (Hindon)	24.07.23	BDL	0.052	0.276	BDL	BDL	0.009	0.002	0.004
19.	Binauli	**Nirpura**	29.2328	77.3932	SW (Pond)	24.07.23	BDL	0.08	0.085	BDL	BDL	0.006	BDL	BDL
20.	Binauli	**Bamnauli**	29.1451	77.3551	SW (Hindon)	24.07.23	BDL	0.156	0.11	BDL	BDL	0.008	0.006	BDL
21.	Binauli	**Barnawa Bridge**	29.1143	77.4398	SW (Hindon)	28.06.23	BDL	BDL	0.897	BDL	BDL	0.001	0.001	BDL

(E) Basic Chemical Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO	BLOCK	KEY WELL LOCATION/ VILLAGE	LATITUDE	LONGITUDE	WELL TYPE	DATE OF COLLECTION	pH	EC µS/cm 25°C	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2
1.	Chhap-rauli	**Tanda**	29.2703	77.1560	HP(M-II)	29.11-13.12.23	7.59	985	390	50	0.90	13	100	290	68	29	100	6.6	30
2.	Chhap-rauli	**Lumb**	29.2603	77.2132	HP(M-II)	29.11-13.12.23	7.56	1152	488	99	0.78	0	62	460	96	53	70	6.3	32
3.	Chhap-rauli	**Asara**	29.2488	77.3031	HP(M-II)	29.11-13.12.23	7.76	705	390	7	1.19	0	40	290	64	32	42	4.2	22
4.	Chhap-rauli	**Soop**	29.2014	77.2644	HP(M-II)	29.11-13.12.23	7.75	1500	683	21	0.73	7	62	290	52	39	225	6.2	29
5.	Chhap-rauli	**Soop**	29.1946	77.2613	HP(M-II)	29.11-13.12.23	7.84	1136	549	7	1.18	14	68	250	52	29	88	9.0	24
6.	Chhap-rauli	**Kishanpur**	29.1922	77.2803	HP(M-II)	29.11-13.12.23	7.86	392	183	7	3.15	0	14	150	36	15	15	3.3	18
7.	Chhap-rauli	**Rajpur**	29.1994	77.2531	HP(M-II)	29.11-13.12.23	7.86	1030	512	31	0.81	0	58	300	52	41	109	7.3	24
8.	Chhap-rauli	**Badarkha**	29.1891	77.1576	HP(M-II)	29.11-13.12.23	7.87	1052	451	35	0.79	6	64	330	52	48	97	5.0	28
9.	Chhap rauli	**Chandan Hedi**	29.1747	77.1986	HP(M-II)	29.11-13.12.23	7.64	979	451	50	0.47	21	50	380	68	51	62	6.7	31
10.	Chhap-rauli	**Chandan Hedi**	29.1691	77.1955	HP (STW)	29.11-13.12.23	8.02	1701	720	99	0.69	0	125	410	80	51	215	6.2	34
11.	Chhap-rauli	**Khwaja Nagla**	29.1638	77.1982	HP(M-II)	29.11-13.12.23	7.66	1060	586	14	0.36	0	35	360	88	34	87	6.6	26
12.	Chhap-rauli	**Bachhor**	29.1693	77.1779	HP(M-II)	29.11-13.12.23	7.96	1131	525	28	2.05	15	84	100	20	12	225	7.5	9
13.	Chhap-rauli	**Halalpur Nahar**	29.1820	77.1888	HP(M-II)	29.11-13.12.23	7.92	805	439	21	0.63	0	34	230	32	36	95	5.7	25
14.	Chhap-rauli	**Mukandp ur**	29.2043	77.2285	SBTW	29.11-13.12.23	8.11	864	464	21	0.68	10	21	250	32	41	89	6.0	25
15.	Baraut	**Luhari**	29.0806	77.1914	HP(M-II)	29.11-13.12.23	7.96	1364	573	35	0.68	0	115	340	56	48	150	6.5	22
16.	Baraut	**Luhari**	29.0996	77.1852	HP(M-II)	29.11-13.12.23	7.67	1117	525	28	0.75	8	51	390	92	39	68	5.6	30
17.	Baraut	**Luhari**	29.0798	77.1920	DTW (JN)	29.11-13.12.23	8.01	1298	427	57	0.83	10	165	260	48	34	170	5.3	28
18.	Baraut	**Shabga**	29.1494	77.1692	HP(M-II)	29.11-13.12.23	7.89	860	378	35	0.97	0	43	270	48	36	73	7.4	25
19.	Baraut	**Kotana**	29.1027	77.1669	HP(M-II)	29.11-13.12.23	7.98	1611	647	57	0.76	0	150	210	40	27	265	5.0	20
20.	Baraut	**Kotana road**	29.1042	77.1609	HP(M-II)	29.11-13.12.23	8.24	698	317	14	1.07	0	39	200	32	29	65	3.5	24
21.	Baraut	**Kotana**	29.1076	77.1627	HP(M-II)	29.11-13.12.23	7.73	712	293	35	1.04	0	33	250	56	27	45	3.8	26
22.	Baraut	**Kotana**	29.0937	77.1592	HP (STW)	29.11-13.12.23	8.00	838	354	35	1.16	10	55	240	60	22	80	6.3	27
23.	Baraut	**Malakpur**	29.1059	77.2523	HP (STW)	29.11-13.12.23	8.04	702	354	28	4.00	0	45	170	28	24	100	4.5	23
24.	Baraut	**Baoli**	29.1547	77.2731	HP (STW)	29.11-13.12.23	7.95	330	146	14	4.70	0	22	150	20	24	10	3.6	18
25.	Baraut	**Baoli**	29.1420	77.2700	HP (STW)	29.11-13.12.23	8.05	790	415	21	0.90	0	32	260	32	44	71	6.3	23
26.	Baraut	**Bijrol**	29.1219	77.3185	HP(M-II)	29.11-13.12.23	7.77	871	415	14	1.18	0	28	220	44	27	80	20	26
27.	Baraut	**Angadpur**	29.1015	77.3317	HP(M-II)	29.11-13.12.23	7.76	986	354	57	0.96	0	80	310	64	36	73	6.4	27

(E) Basic Chemical Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO	BLOCK	KEY WELL LOCA-TION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	pH	EC µS/ cm 25°C	H-CO3	Cl	F	NO3	SO4	TH	Ca	Mg	Na	K	Si-O2
28.	Baraut	**Kishanpur Baral**	29.1647	77.2758	HP (STW)	29.11-13.12.23	8.10	621	354	14	0.51	0	30	330	48	51	10	4.2	19
29.	Baraut	**Saroorpur Kala**	29.0341	77.2315	DcBTW	29.11-13.12.23	7.72	1142	549	57	0.62	10	42	270	56	32	150	6	27
30.	Baraut	**Biharipur**	29.0373	77.2066	HP (STW)	29.11-13.12.23	8.07	1896	891	57	3.50	20	125	210	48	22	360	5.4	30
31.	Baraut	**Biharipur**	29.0441	77.2085	HP (STW)	29.11-13.12.23	8.13	1380	610	14	1.12	0	175	310	40	51	200	6.2	31
32.	Baraut	**Faizpur Ninana**	29.0289	77.2044	HP (STW)	29.11-13.12.23	8.24	1798	726	64	5.00	10	150	140	36	12	355	4.2	27
33.	Baraut	**Kishanpur Baral**	29.1913	77.2814	SBTW	29.11-13.12.23	7.85	651	378	7	0.30	0	29	290	72	27	29	4.1	27
34.	Baraut	**Chhachar pur**	29.1463	77.2841	HP (STW)	29.11-13.12.23	7.90	610	329	7	1.32	7	30	240	44	32	41	5.0	25
35.	Baraut	**Chhachar pur**	29.1483	77.2851	SBTW	29.11-13.12.23	8.08	704	427	7	4.00	6	25	240	40	34	75	5.5	28
36.	Baraut	**Barwala**	29.1598	77.2525	HP (STW)	29.11-13.12.23	7.81	1120	549	28	0.68	14	64	310	56	41	120	5.9	28
37.	Baraut	**Barwala**	29.1600	77.2523	SBTW	29.11-13.12.23	7.79	2250	1086	50	1.22	11	135	580	56	107	180	140	30
38.	Baghpat	**Pawla Begmabad**	28.9308	77.2946	HP (M-II)	29.11-13.12.23	7.71	1103	561	28	0.92	0	49	330	56	46	107	7.5	26
39.	Baghpat	**Pawla Begmabad**	28.9382	77.2875	HP (M-II)	29.11-13.12.23	7.69	976	451	21	0.80	8	45	320	64	39	70	6.1	28
40.	Baghpat	**Pawla Begmabad**	28.9263	77.2976	HP (M-II)	29.11-13.12.23	7.69	993	500	43	0.76	13	39	330	44	53	93	8.0	23
41.	Baghpat	**Pabla**	28.9215	77.3060	HP (M-II)	29.11-13.12.23	7.86	1010	525	35.0	0.46	0	26	340	88	29	87	5.3	27
42.	Baghpat	**Basatikri**	28.9370	77.3105	HP (M-II)	29.11-13.12.23	7.79	1261	647	28	1.04	14	54	410	68	53	96	20	28
43.	Baghpat	**Khera Hatana**	29.0452	77.1907	HP (M-II)	29.11-13.12.23	7.81	1827	671	113	0.81	9	90	340	72	39	255	6.2	28
44.	Baghpat	**Tyothi**	29.0534	77.2426	HP (M-II)	29.11-13.12.23	7.94	592	256	7	1.00	0	43	260	60	27	9	3.7	28
45.	Baghpat	**Budhera**	29.0312	77.3081	HP (M-II)	29.11-13.12.23	8.00	914	500	7	1.02	6	33	280	56	34	87	6.5	24
46.	Baghpat	**Norozpur Gurjar**	28.9973	77.2498	HP (M-II)	29.11-13.12.23	7.91	907	439	14	0.74	5	47	270	56	32	80	6.0	24
47.	Baghpat	**Kheriki**	29.0388	77.2375	SBTW	29.11-13.12.23	8.11	2209	805	121	4.10	140	170	390	44	68	345	6.7	26
48.	Baghpat	**Kheratana**	29.0431	77.1956	SBTW	29.11-13.12.23	7.83	1471	683	35	1.06	7	105	300	52	41	210	6.7	30
49.	Baghpat	**Tatiri**	28.9502	77.2666	HP(STW)	29.11-13.12.23	7.81	1160	586	28	0.80	12	68	420	60	65	90	15	29
50.	Baghpat	**Goripur Gate**	28.9858	77.2211	SBTW	29.11-13.12.23	7.94	1725	732	78	1.50	16	140	410	60	60	225	5.9	30
51.	Baghpat	**Osikka**	29.0461	77.2824	HP(STW)	29.11-13.12.23	7.93	549	281	7	1.08	5	48	280	64	29	10	4.6	25
52.	Baghpat	**Faizulla-pur**	29.0213	77.2052	HP(STW)	29.11-13.12.23	8.11	2113	464	206	0.59	26	380	490	72	75	290	6.4	28
53.	Khekra	**Shabban-pur**	28.8455	77.3910	HP (M-II)	29.11-13.12.23	7.79	2055	610	121	0.07	0	340	310	64	36	350	4.7	22
54.	Khekra	**Fakhar-pur**	28.8434	77.2975	HP (M-II)	29.11-13.12.23	7.73	903	439	21	0.50	19	43	330	76	34	60	5.9	30

(E) Basic Chemical Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO	BLOCK	KEY WELL LOCA-TION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	pH	EC µS/ cm 25°C	H-CO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	Si-O_2
55.	Khekra	**Noorpur Khalsa**	28.8439	77.2452	HP (M-II)	29.11-13.12.23	7.79	2131	378	227	0.20	12	400	610	148	58	225	5.1	28
56.	Khekra	**Bhagout**	28.8073	77.3599	HP (M-II)	29.11-13.12.23	8.07	1143	512	57	0.50	5	41	280	68	27	130	5.9	30
57.	Khekra	**Bhagout**	28.8056	77.3599	SBTW	29.11-13.12.23	7.23	2102	525	340	0.63	58	70	700	232	29	150	7.1	35
58.	Khekra	**Bhagout**	28.8055	77.3599	SBTW	29.11-13.12.23	7.69	1301	525	113	0.62	11	30	390	96	36	119	6.5	34
59.	Khekra	**Bhagout**	28.8055	77.3601	HP (STW)	29.11-13.12.23	7.93	1163	464	99	0.61	11	34	370	84	39	103	6.0	32
60.	Khekra	**Nagla Badi**	28.8217	77.3227	DcBTW	29.11-13.12.23	7.88	696	378	7	0.75	0	36	320	64	39	23	6.0	26
61.	Khekra	**Nagla Badi**	28.8221	77.3300	SBTW	29.11-13.12.23	7.66	689	342	14	1.05	7	30	300	68	32	24	5.2	28
62.	Khekra	**Nagla Badi**	28.8205	77.3248	SBTW	29.11-13.12.23	7.73	1100	598	7	1.13	18	47	380	68	51	96	6.5	32
63.	Khekra	**Badagaon**	28.8695	77.3219	SBTW	29.11-13.12.23	7.72	850	427	14	1.39	17	45	250	48	32	90	5.2	27
64.	Khekra	**Firojpur**	28.8409	77.3073	SBTW	29.11-13.12.23	7.79	630	305	7	0.97	0	37	190	44	19	56	4.1	27
65.	Pilana	**Daula**	28.9564	77.3394	HP (M-II)	29.11-13.12.23	7.93	1203	525	71	0.70	0	60	430	56	70	85	4.6	25
66.	Pilana	**Doula**	28.9524	77.3319	HP (M-II)	29.11-13.12.23	8.04	1239	478	21	0.60	20	70	280	44	41	160	4.4	27
67.	Pilana	**Ahamadshahpur Padra**	28.9576	77.3218	HP (M-II)	29.11-13.12.23	7.99	1034	488	21	0.45	11	64	350	56	51	77	5.6	27
68.	Pilana	**Aadarsh IntCollege**	28.9562	77.3433	HP (M-II)	29.11-13.12.23	8.20	1019	476	21	3.00	13	53	180	28	27	150	3.2	24
69.	Pilana	**Rampur Khurd**	28.9724	77.3232	HP (M-II)	29.11-13.12.23	7.87	348	207	14	1.00	0	5	190	24	19	5	3.7	19
70.	Pilana	**Murka-ndpur**	28.9131	77.3887	HP (M-II)	29.11-13.12.23	8.23	1289	549	85	0.70	0	48	210	40	27	200	4.6	18
71.	Pilana	**Budhsaini**	28.9961	77.4299	HP (M-II)	29.11-13.12.23	7.73	2076	549	234	0.50	95	145	770	144	99	44	25	31
72.	Pilana	**Mavi Khurd**	29.0111	77.4465	HP (M-II)	29.11-13.12.23	7.75	796	354	28	0.57	16	45	250	52	29.0	73	5.0	28
73.	Pilana	**Ogati Mu-krandpur**	28.9118	77.3865	SBTW	29.11-13.12.23	7.85	1260	634	35	1.414	13	56	220	40	29	205	4.5	27
74.	Pilana	**Pilana**	28.9367	77.3705	SBTW	29.11-13.12.23	7.79	1439	561	92	0.96	57	100	270	64	27	210	17	29
75.	Pilana	**Sidhauli**	28.9570	77.4027	HP(STW)	29.11-13.12.23	7.91	804	488	7	0.78	0	9	250	64	22	80	6.5	23
76.	Pilana	**Sidhauli**	28.9570	77.4027	HP(STW)	29.11-13.12.23	7.69	950	500	14	0.56	19	41	370	80	41	70	60	32
77.	Pilana	**Khindora**	29.0060	77.3689	HP(STW)	29.11-13.12.23	7.80	1151	525	64	0.10	0	35	450	100	48	56	6.2	30
78.	Pilana	**Fatehpur**	28.9979	77.3583	HP(STW)	29.11-13.12.23	7.76	1821	915	57	1.10	24	62	320	44	51	280	6.2	28
79.	Pilana	**Gouspur**	28.9801	77.3445	HP(STW)	29.11-13.12.23	7.59	1184	573	35	0.90	17	60	340	56	48	123	5.3	28
80.	Pilana	**Hisawada**	28.9728	77.3643	HP(STW)	29.11-13.12.23	8.21	795	439	21	1.00	0	13	170	12	34	115	4.3	15
81.	Pilana	**Shobha-pur**	28.9899	77.3632	HP(STW)	29.11-13.12.23	7.90	1700	708	106	0.80	27	70	500	76	75	165	7.8	31

(E) Basic Chemical Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATITUDE	LONGITUDE	WELL TYPE	DATE OF COLLECTION	pH	EC µS/cm 25°C	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2
82.	Pilana	**Shobhapur**	28.9896	77.3636	HP(STW)	29.11-13.12.23	7.42	1846	781	149	0.70	7	70	720	116	104	105	8.6	35
83.	Pilana	**Shobhapur**	28.9897	77.3637	SBTW	29.11-13.12.23	7.92	1621	744	85.0	0.27	15	56	530	64	90	135	7.0	31
84.	Pilana	**Pura Mahadev**	28.9986	77.4559	HP(M-II)	29.11-13.12.23	7.81	884	378	28	0.72	23	30	240	52	27	81	5.3	27
85.	Pilana	**Pura Mahadev**	28.9922	77.4552	HP(M-II)	29.11-13.12.23	7.78	788	415	35	0.48	0	18	300	56	39	56	5.3	25
86.	Pilana	**Pura Mahadev**	28.9980	77.4506	HP(M-II)	29.11-13.12.23	7.95	648	354	21	0.40	0	13	230	40	32	57	3.8	23
87.	Pilana	**Aminnagar Sarai**	28.9862	77.3989	HP(M-II)	29.11-13.12.23	7.61	1180	537	64	0.60	17	53	370	76	44	118	6.2	29
88.	Pilana	**Baleni**	28.9540	77.4549	HP(M-II)	29.11-13.12.23	8.17	736	342	21	0.60	0	31	210	40	27	66	4.2	24
89.	Pilana	**Baleni**	28.9588	77.4711	HP(STW)	29.11-13.12.23	7.58	698	366	28	0.39	7	0	300	64	34	23	5.8	30
90.	Binauli	**Fauladnagar**	29.1853	77.4371	SBTW	29.11-13.12.23	7.75	1268	500	85	0.64	31	57	460	76	65	86	6.5	32
91.	Binauli	**Binauli**	29.0931	77.4005	HP(M-II)	29.11-13.12.23	7.89	1084	378	71	0.65	45	51	370	84	39	73	5.3	31
92.	Binauli	**Tikri**	29.2298	77.3620	HP(M-II)	29.11-13.12.23	7.93	640	317	14	1.05	0	30	230	52	24	46	4.7	28
93.	Binauli	**Tikri**	29.2323	77.3541	SBTW	29.11-13.12.23	8.13	616	268	14	0.35	0	45	60	20	2	112	2.4	26
94.	Binauli	**Kambala**	29.0483	77.4031	HP(M-II)	29.11-13.12.23	7.87	966	488	28	0.35	9	27	390	72	51	50	6.3	30
95.	Binauli	**Mangroli**	29.1906	77.4707	HP (STW)	29.11-13.12.23	7.69	1140	525	85	0.88	0	28	400	84	46	95	6.9	31
96.	Binauli	**Edrishpur School**	29.1728	77.3572	HP (STW)	29.11-13.12.23	7.98	613	329	21	0.84	0	38	200	40	24	73	4.5	23
97.	Binauli	**Edrishpur School**	29.1726	77.3568	SBTW	29.11-13.12.23	7.96	1070	561	28	0.83	23	25	350	80	36	101	6.8	35
98.	Binauli	**Bari Nangla**	29.0647	77.3311	HP (STW)	29.11-13.12.23	7.93	1477	781	14	0.66	18	49	240	48	29	235	6.4	31
99.	Binauli	**Barawad**	29.0685	77.3226	HP (STW)	29.11-13.12.23	7.96	1240	671	14	0.87	16	41	410	60	63	107	7.6	26
100.	Binauli	**Barawad**	29.0759	77.3262	HP (STW)	29.11-13.12.23	7.80	1234	647	14	0.78	19	56	400	68	56	109	16	30
101.	Binauli	**Barawad**	29.0725	77.3243	SBTW	29.11-13.12.23	8.02	1282	683	14	1.16	15	42	290	60	34	175	6.8	30
102.	Binauli	**Gurana**	29.0740	77.3110	HP (STW)	29.11-13.12.23	8.25	671	366	14	1.14	6	25	290	56	36	35	5.9	25
103.	Binauli	**Tabelgarhi**	29.1970	77.4594	HP(M-II)	29.11-13.12.23	7.79	1178	598	21	0.49	26	48	440	100	46	81	6.0	35
104.	Binauli	**Tabelgarhi**	29.1981	77.4567	HP(M-II)	29.11-13.12.23	8.24	1147	573	28	0.47	0	38	270	72	22	135	5.9	32
105.	Binauli	**Tabelgarhi**	29.1963	77.4629	DTW (JN)	29.11-13.12.23	7.79	1410	622	57	0.50	6	63	310	72	29	170	5.9	28
106.	Binauli	**Tabelgarhi**	29.2028	77.4583	HP(M-II)	29.11-13.12.23	8.13	1098	537	14	0.70	15	37	290	72	39	108	3.9	26
107.	Binauli	**Nirpura**	29.2333	77.3943	HP (STW)	29.11-13.12.23	7.55	883	366	71	0.86	33	35	420	108	36	26	6.2	35
108.	Binauli	**Bamnauli**	29.1433	77.3478	HP(M-II)	29.11-13.12.23	8.15	760	317	21	0.76	0	50	140	20	22	99	2.9	22

(F) Basic Chemical Analysis Results of Surface Water Samples collected during Post-Monsoon

Sl. NO	BLOCK	KEY WELL LOCATION/ VILLAGE	LATITUDE	LONGITUDE	WELL TYPE	DATE OF COLLECTION	pH	EC µS/cm 25°C	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2	PO_4
1.	Chhaprauli	**Chhaprauli**	29.2067	77.1685	SW	29.11-13.12.23	7.33	1536	561	149	1.06	22	48	380	68	51	120	86	36	0
2.	Chhaprauli	**Boddha**	29.2801	77.1641	SW	29.11-13.12.23	7.34	1400	525	92	1.95	51	44	310	64	36	125	55	41	0
3.	Chhaprauli	**Ramala**	29.2263	77.2707	SW	29.11-13.12.23	7.50	978	354	64	0.84	18	48	220	44	27	84	45	23	3.8
4.	Baraut	**Shadatpur Jounmana**	29.0915	77.2175	SW	29.11-13.12.23	7.71	1102	549	43	0.60	12	45	200	16	39	175	6.3	28	0
5.	Baghpat	**Tatiri**	28.9473	77.2676	SW	29.11-13.12.23	7.35	1840	610	128	2.00	52	200	370	68	48	260	35	31	19
6.	Baghpat	**Gauripur**	28.9885	77.2028	SW (Yamuna)	29.11-13.12.23	7.78	567	183	35	0.60	16	58	220	72	10	30	5.9	14	1.5
7.	Baghpat	**Osikka**	29.0461	77.2828	SW	29.11-13.12.23	7.45	832	281	71	0.94	22	52	210	44	24	58	80	35	0
8.	Baghpat	**Faizulapur**	29.0214	77.2052	SW	29.11-13.12.23	7.48	1985	769	135	2.30	37	54	400	64	58	240	45	37	0
9.	Khekra	**Firojpur**	28.8409	77.3073	SW (Pond)	29.11-13.12.23	7.29	700	293	50	0.95	37	10	200	52	17	60	30	15	5.2
10.	Khekra	**Rataul**	28.8299	77.3374	SW	29.11-13.12.23	6.75	371	146	7	0.71	19	25	150	44	10	6	20	16	1.5
11.	Khekra	**Lalyana**	28.8612	77.4098	SW (Hindon)	29.11-13.12.23	7.30	467	171	21	0.19	9	30	180	44	17	16	5.4	10	2.6
12.	Pilana	**Shobhapur**	28.9899	77.3632	SW (Pond)	29.11-13.12.23	7.70	2300	1086	135	2.85	26	43	400	80	48	290	100	57	16
13.	Pilana	**Pura Mahadev**	29.0010	77.4609	SW (Hindon)	29.11-13.12.23	7.32	1182	512	71	0.93	21	48	430	96	46	77	20	30	4.6
14.	Pilana	**Aminagar Sarai**	28.9195	77.3962	SW (Pond)	29.11-13.12.23	7.47	1803	732	135	1.17	15	60	360	60	51	210	70	39	12
15.	Pilana	**Baleni**	28.9588	77.4711	SW (Hindon)	29.11-13.12.23	7.28	491	183	21	0.35	23	37	200	56	15	24	6.5	16	2
16.	Pilana	**Basand**	28.9843	77.3263	SW (Pond)	29.11-13.12.23	7.61	1304	500	92	1.48	28	44	300	68	32	101	100	22	14
17.	Binauli	**Tabela Garhi**	29.1906	77.4707	SW (Hindon)	29.11-13.12.23	7.48	1190	525	92	0.98	11	41	420	128	24	89	16	31	0
18.	Binauli	**Nirpura**	29.2329	77.3932	SW (Pond)	29.11-13.12.23	7.36	1800	720	156	0.79	22	46	480	88	63	140	88	35	2.9
19.	Binauli	**Bamnauli**	29.1451	77.3551	SW (Hindon)	29.11-13.12.23	7.21	1093	451	64	1.27	52	46	310	80	27	88	45	32	0
20.	Binauli	**Barnawa Bridge**	29.1143	77.4398	SW (Hindon)	29.11-13.12.23	7.33	1290	464	92	0.64	10	74	420	104	39	80	17	27	2.5

(G) Heavy Metals Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
1.	Chhap-rauli	**Tanda**	29.2703	77.1560	HP (M-II)	29.11-13.12.23	BDL	BDL	0.054	BDL	BDL	BDL	BDL	0.022
2.	Chhap-rauli	**Lumb**	29.2603	77.2132	HP (M-II)	29.11-13.12.23	BDL	0.061	BDL	BDL	0.695	BDL	BDL	0.025
3.	Chhap-rauli	**Asara**	29.2488	77.3031	HP (M-II)	29.11-13.12.23	BDL	6.803	0.119	BDL	0.178	BDL	BDL	0.004
4.	Chha-prauli	**Soop**	29.2014	77.2644	HP (M-II)	29.11-13.12.23	BDL	BDL	0.062	BDL	2.602	BDL	BDL	0.046
5.	Chha-prauli	**Soop**	29.1946	77.2613	HP (M-II)	29.11-13.12.23	BDL	BDL	0.065	BDL	0.331	BDL	BDL	0.031
6.	Chhap-rauli	**Kishanpur**	29.1922	77.2803	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003
7.	Chhap-rauli	**Rajpur**	29.1994	77.2531	HP (M-II)	29.11-13.12.23	BDL	BDL	0.081	BDL	2.184	BDL	BDL	0.024
8.	Chhap-rauli	**Badarkha**	29.1891	77.1576	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.153	BDL	BDL	0.020
9.	Chhap-rauli	**Chandan Hedi**	29.1747	77.1986	HP (M-II)	29.11-13.12.23	BDL	0.208	BDL	BDL	0.073	BDL	BDL	0.018
10.	Chhapra uli	**Chandan Hedi**	29.1691	77.1955	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	3.257	BDL	BDL	0.061
11.	Chhap-rauli	**Khwaja Nagla**	29.1638	77.1982	HP (M-II)	29.11-13.12.23	BDL	0.518	0.080	BDL	0.346	BDL	BDL	0.013
12.	Chhap-rauli	**Bachhor**	29.1693	77.1779	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.001	BDL	0.038
13.	Chhap-rauli	**Halalpur Nahar**	29.1820	77.1888	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.309	BDL	BDL	0.022
14.	Chhap-rauli	**Mukandpur**	29.2043	77.2285	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.023
15.	Baraut	**Luhari**	29.0806	77.1914	HP (M-II)	29.11-13.12.23	BDL	4.211	0.098	BDL	0.460	BDL	BDL	0.010
16.	Baraut	**Luhari**	29.0996	77.1852	HP (M-II)	29.11-13.12.23	BDL	0.394	0.120	BDL	0.240	BDL	0.002	0.029
17.	Baraut	**Luhari**	29.0798	77.1920	DTW (JN)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.014
18.	Baraut	**Shabga**	29.1494	77.1692	HP (M-II)	29.11-13.12.23	BDL	0.103	BDL	BDL	1.749	BDL	BDL	0.014
19.	Baraut	**Kotana**	29.1027	77.1669	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.066	BDL	BDL	0.003
20.	Baraut	**Kotana road**	29.1042	77.1609	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.547	BDL	0.001	0.013
21.	Baraut	**Kotana**	29.1076	77.1627	HP (M-II)	29.11-13.12.23	BDL	0.187	0.057	BDL	3.457	BDL	BDL	0.005
22.	Baraut	**Kotana**	29.0937	77.1592	HP (STW)	29.11-13.12.23	BDL	4.434	0.101	BDL	0.475	BDL	BDL	0.009
23.	Baraut	**Malakpur**	29.1059	77.2523	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.010
24.	Baraut	**Baoli**	29.1547	77.2731	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.479	BDL	BDL	0.005
25.	Baraut	**Baoli**	29.1420	77.2700	HP (STW)	29.11-13.12.23	BDL	1.626	0.051	BDL	BDL	BDL	BDL	0.012
26.	Baraut	**Bijrol**	29.1219	77.3185	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.903	BDL	BDL	0.016

(G) Heavy Metals Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE -CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
27.	Baraut	**Angadpur**	29.1015	77.3317	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.120	BDL	BDL	0.017
28.	Baraut	**Kishanpur Baral**	29.1647	77.2758	HP (STW)	29.11-13.12.23	BDL	0.764	0.065	BDL	0.774	BDL	BDL	0.014
29.	Baraut	**Saroorpur Kala**	29.0341	77.2315	DcB TW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.001	BDL	0.021
30.	Baraut	**Biharipur**	29.0373	77.2066	HP (STW)	29.11-13.12.23	0.003	BDL	BDL	BDL	BDL	BDL	BDL	0.028
31.	Baraut	**Biharipur**	29.0441	77.2085	HP (STW)	29.11-13.12.23	BDL	1.914	0.061	BDL	0.290	BDL	0.003	0.018
32.	Baraut	**Faizpur Ninana**	29.0289	77.2044	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.116	BDL	BDL	0.080
33.	Baraut	**Kishanpur Baral**	29.1913	77.2814	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	0.088	BDL	BDL	0.004
34.	Baraut	**Chhachar-pur**	29.1463	77.2841	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.389	BDL	BDL	0.010
35.	Baraut	**Chhachar-pur**	29.1483	77.2851	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.014
36.	Baraut	**Barwala**	29.1598	77.2525	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.051
37.	Baraut	**Barwala**	29.1600	77.2523	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	0.174	BDL	BDL	0.023
38.	Baghpat	**Pawla Begmabad**	28.9308	77.2946	HP (M-II)	29.11-13.12.23	0.001	BDL	BDL	BDL	0.539	BDL	BDL	0.030
39.	Baghpat	**Pawla Begmabad**	28.9382	77.2875	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.533	BDL	0.001	0.036
40.	Baghpat	**Pawla Begmabad**	28.9263	77.2976	HP (M-II)	29.11-13.12.23	BDL	BDL	0.066	BDL	2.744	BDL	BDL	0.020
41.	Baghpat	**Pabla**	28.9215	77.3060	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.155	BDL	BDL	BDL
42.	Baghpat	**Basatikri**	28.9370	77.3105	HP (M-II)	29.11-13.12.23	BDL	0.063	0.052	BDL	0.172	BDL	BDL	0.025
43.	Baghpat	**Khera Hatana**	29.0452	77.1907	HP (M-II)	29.11-13.12.23	BDL	BDL	0.137	BDL	2.906	BDL	BDL	0.020
44.	Baghpat	**Tyothi**	29.0534	77.2426	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.008
45.	Baghpat	**Budhera**	29.0312	77.3081	HP (M-II)	29.11-13.12.23	BDL	BDL	0.086	BDL	1.613	BDL	BDL	0.021
46.	Baghpat	**Norozpur Gurjar**	28.9973	77.2498	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.495	BDL	BDL	0.016
47.	Baghpat	**Kheriki**	29.0388	77.2375	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	0.229	BDL	BDL	0.037
48.	Baghpat	**Kheratana**	29.0431	77.1956	SBTW	29.11-13.12.23	BDL	0.806	0.060	BDL	0.101	BDL	BDL	0.020
49.	Baghpat	**Tatiri**	28.9502	77.2666	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.026	BDL	BDL	0.022
50.	Baghpat	**Goripur Gate**	28.9858	77.2211	SBTW	29.11-13.12.23	0.001	BDL	BDL	BDL	0.086	BDL	BDL	0.007
51.	Baghpat	**Osikka**	29.0461	77.2824	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.167	BDL	BDL	0.012

(G) Heavy Metals Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE -CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
52.	Baghpat	**Faizullapur**	29.0213	77.2052	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.143	BDL	BDL	0.015
53.	Khekra	**Shabbanpur**	28.8455	77.3910	HP (M-II)	29.11-13.12.23	BDL	BDL	0.065	BDL	0.967	BDL	BDL	0.024
54.	Khekra	**Fakharpur**	28.8434	77.2975	HP (M-II)	29.11-13.12.23	BDL	BDL	0.058	BDL	0.301	BDL	BDL	0.019
55.	Khekra	**Noorpur Khalsa**	28.8439	77.2452	HP (M-II)	29.11-13.12.23	BDL	BDL	0.083	BDL	0.642	BDL	BDL	0.017
56.	Khekra	**Bhagout**	28.8073	77.3599	HP (M-II)	29.11-13.12.23	BDL	0.154	BDL	BDL	1.074	BDL	BDL	0.017
57.	Khekra	**Bhagout**	28.8056	77.3599	SBTW	29.11-13.12.23	BDL	BDL	0.083	BDL	BDL	BDL	BDL	0.012
58.	Khekra	**Bhagout**	28.8055	77.3599	SBTW	29.11-13.12.23	BDL	BDL	0.064	BDL	BDL	BDL	BDL	0.016
59.	Khekra	**Bhagout**	28.8055	77.3601	HP (STW)	29.11-13.12.23	BDL	0.165	0.061	BDL	0.103	BDL	BDL	0.013
60.	Khekra	**Nagla Badi**	28.8217	77.3227	DcB TW	29.11-13.12.23	BDL	6.301	0.118	BDL	0.604	BDL	BDL	0.007
61.	Khekra	**Nagla Badi**	28.8221	77.3300	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.012
62.	Khekra	**Nagla Badi**	28.8205	77.3248	SBTW	29.11-13.12.23	BDL	BDL	0.086	BDL	0.621	BDL	BDL	0.023
63.	Khekra	**Badagaon**	28.8695	77.3219	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.017
64.	Khekra	**Firojpur**	28.8409	77.3073	SBTW	29.11-13.12.23	BDL	0.361	BDL	BDL	0.176	BDL	BDL	0.010
65.	Pilana	**Daula**	28.9564	77.3394	HP (M-II)	29.11-13.12.23	BDL	1.734	0.254	BDL	2.521	BDL	0.001	0.008
66.	Pilana	**Doula**	28.9524	77.3319	HP (M-II)	29.11-13.12.23	BDL	0.065	BDL	BDL	0.111	BDL	BDL	0.033
67.	Pilana	**Ahamadshahpur Padra**	28.9576	77.3218	HP (M-II)	29.11-13.12.23	BDL	BDL	0.055	BDL	2.313	BDL	BDL	0.021
68.	Pilana	**Aadarsh Int. College**	28.9562	77.3433	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.372	BDL	0.002	0.026
69.	Pilana	**Rampur Khurd**	28.9724	77.3232	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.516	BDL	0.001	0.005
70.	Pilana	**Murkandpur**	28.9131	77.3887	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.433	BDL	BDL	0.025
71.	Pilana	**Budhsaini**	28.9961	77.4299	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.879	BDL	BDL	0.008
72.	Pilana	**Mavi Khurd**	29.0111	77.4465	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.068	BDL	BDL	0.025
73.	Pilana	**OgatiMukrandpur**	28.9118	77.3865	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.001	BDL	0.021
74.	Pilana	**Pilana**	28.9367	77.3705	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.016
75.	Pilana	**Sidhauli**	28.9570	77.4027	HP (STW)	29.11-13.12.23	BDL	1.725	0.091	BDL	0.275	BDL	BDL	0.009
76.	Pilana	**Sidhauli**	28.9570	77.4027	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.018

(G) Heavy Metals Analysis Results of Ground Water Samples collected during Post-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
77.	Pilana	**Khindora**	29.0060	77.3689	HP (STW)	29.11-13.12.23	BDL	3.843	BDL	BDL	0.119	BDL	BDL	0.017
78.	Pilana	**Fatehpur**	28.9979	77.3583	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.059	BDL	BDL	0.022
79.	Pilana	**Gouspur**	28.9801	77.3445	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.430	BDL	BDL	0.031
80.	Pilana	**Hisawada**	28.9728	77.3643	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.055	BDL	BDL	0.007
81.	Pilana	**Shobhapur**	28.9899	77.3632	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.541	BDL	BDL	0.034
82.	Pilana	**Shobhapur**	28.9896	77.3636	HP (STW)	29.11-13.12.23	BDL	0.199	0.169	BDL	0.674	BDL	BDL	0.029
83.	Pilana	**Shobhapur**	28.9897	77.3637	SBTW	29.11-13.12.23	BDL	BDL	0.067	BDL	BDL	BDL	BDL	0.037
84.	Pilana	**Pura Mahadev**	28.9986	77.4559	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.299	BDL	BDL	0.017
85.	Pilana	**Pura Mahadev**	28.9922	77.4552	HP (M-II)	29.11-13.12.23	BDL	2.743	0.052	BDL	BDL	BDL	BDL	0.021
86.	Pilana	**Pura Mahadev**	28.9980	77.4506	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.252	BDL	BDL	0.012
87.	Pilana	**Aminnagar Sarai**	28.9862	77.3989	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	3.514	BDL	BDL	0.019
88.	Pilana	**Baleni**	28.9540	77.4549	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.090	BDL	BDL	0.018
89.	Pilana	**Baleni**	28.9588	77.4711	HP (STW)	29.11-13.12.23	BDL	0.265	0.498	BDL	1.450	0.032	BDL	0.005
90.	Binauli	**Fauladnagar**	29.1853	77.4371	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.026
91.	Binauli	**Binauli**	29.0931	77.4005	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.350	BDL	BDL	0.009
92.	Binauli	**Tikri**	29.2298	77.3620	HP (M-II)	29.11-13.12.23	BDL	1.763	BDL	BDL	0.492	BDL	BDL	0.008
93.	Binauli	**Tikri**	29.2323	77.3541	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.003	BDL	0.008
94.	Binauli	**Kambala**	29.0483	77.4031	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.352	BDL	BDL	0.018
95.	Binauli	**Mangroli**	29.1906	77.4707	HP (STW)	29.11-13.12.23	BDL	3.972	0.128	BDL	0.358	BDL	BDL	0.018
96.	Binauli	**Edrishpur School**	29.1728	77.3572	HP (STW)	29.11-13.12.23	BDL	1.108	BDL	BDL	BDL	BDL	BDL	BDL
97.	Binauli	**Edrishpur School**	29.1726	77.3568	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.016
98.	Binauli	**Bari Nangla**	29.0647	77.3311	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.963	BDL	BDL	0.045
99.	Binauli	**Barawad**	29.0685	77.3226	HP (STW)	29.11-13.12.23	0.002	BDL	BDL	BDL	0.861	BDL	BDL	0.033
100.	Binauli	**Barawad**	29.0759	77.3262	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.787	BDL	BDL	0.004
101.	Binauli	**Barawad**	29.0725	77.3243	SBTW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.039

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Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	DATE OF COLLE-CTION	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
102.	Binauli	**Gurana**	29.0740	77.3110	HP (STW)	29.11-13.12.23	BDL	BDL	0.058	BDL	0.359	BDL	0.003	0.029
103.	Binauli	**Tabelgarhi**	29.1970	77.4594	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.186	BDL	BDL	0.036
104.	Binauli	**Tabelgarhi**	29.1981	77.4567	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.817	BDL	BDL	0.030
105.	Binauli	**Tabelgarhi**	29.1963	77.4629	DTW (JN)	29.11-13.12.23	BDL	BDL	BDL	BDL	1.668	BDL	BDL	BDL
106.	Binauli	**Tabelgarhi**	29.2028	77.4583	HP (M-II)	29.11-13.12.23	BDL	BDL	BDL	0.049	3.746	BDL	0.003	0.014
107.	Binauli	**Nirpura**	29.2333	77.3943	HP (STW)	29.11-13.12.23	BDL	BDL	BDL	BDL	0.066	BDL	BDL	0.041
108.	Binauli	**Bamnauli**	29.1433	77.3478	HP (M-II)	29.11-13.12.23	BDL	0.086	BDL	BDL	0.051	0.001	BDL	0.010

(H) Heavy Metals Analysis Results of Surface Water Samples collected during Post-Monsoon

Sl. NO.	BLOCK	KEY WELL LOCATION/ VILLAGE	LATI-TUDE	LONGI-TUDE	WELL TYPE	COLLE-CTION DATE	Cr (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)	As (mg/l)	Pb (mg/l)	U (mg/l)
1.	Chhap-rauli	**Chhaprauli**	29.2067	77.1685	SW	29.11-13.12.23	BDL	BDL	0.094	BDL	BDL	0.004	BDL	BDL
2.	Chhap-rauli	**Boddha**	29.2801	77.1641	SW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.003	BDL	BDL
3.	Chhap-rauli	**Ramala**	29.2263	77.2707	SW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.004	BDL	0.006
4.	Baraut	**ShadatpurJou nmana**	29.0915	77.2175	SW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.005	BDL	0.045
5.	Baghpat	**Tatiri**	28.9473	77.2676	SW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.002	BDL	0.006
6.	Baghpat	**Gauripur**	28.9885	77.2028	SW (Yamuna)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.004	0.002	BDL
7.	Baghpat	**Osikka**	29.0461	77.2828	SW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.003	BDL	0.005
8.	Baghpat	**Faizullapur**	29.0214	77.2052	SW	29.11-13.12.23	BDL	BDL	0.073	BDL	BDL	0.004	BDL	0.008
9.	Khekra	**Firojpur**	28.8409	77.3073	SW (Pond)	29.11-13.12.23	BDL	BDL	0.053	BDL	BDL	0.021	0.002	BDL
10.	Khekra	**Rataul**	28.8299	77.3374	SW	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.006	BDL	BDL
11.	Khekra	**Lalyana**	28.8612	77.4098	SW (Hindon)	29.11-13.12.23	BDL	BDL	0.142	BDL	BDL	0.004	BDL	0.004
12.	Pilana	**Shobhapur**	28.9899	77.3632	SW (Pond)	29.11-13.12.23	BDL	BDL	0.137	BDL	BDL	0.004	BDL	0.007
13.	Pilana	**Pura Mahadev**	29.0010	77.4609	SW (Hindon)	29.11-13.12.23	BDL	BDL	0.392	BDL	BDL	0.002	BDL	0.005
14.	Pilana	**Aminagar Sarai**	28.9195	77.3962	SW (Pond)	29.11-13.12.23	BDL	BDL	0.097	BDL	BDL	0.002	BDL	0.004
15.	Pilana	**Baleni**	28.9588	77.4711	SW (Hindon)	29.11-13.12.23	BDL	BDL	0.136	BDL	BDL	0.004	BDL	BDL
16.	Pilana	**Basand**	28.9843	77.3263	SW (Pond)	29.11-13.12.23	BDL	BDL	BDL	BDL	BDL	0.006	BDL	BDL
17.	Binauli	**Tabela Gadi**	29.1906	77.4707	SW (Hindon)	29.11-13.12.23	BDL	BDL	0.445	BDL	BDL	0.002	BDL	0.004
18.	Binauli	**Nirpura**	29.2329	77.3932	SW (Pond)	29.11-13.12.23	BDL	BDL	0.143	BDL	BDL	0.005	BDL	0.006
19.	Binauli	**Bamnauli**	29.1451	77.3551	SW(Hind on)	29.11-13.12.23	BDL	BDL	0.177	BDL	BDL	0.005	BDL	0.004
20.	Binauli	**Barnawa Bridge**	29.1143	77.4398	SW (Hindon)	29.11-13.12.23	BDL	BDL	0.299	BDL	BDL	0.002	BDL	0.008

Annexure -III

Farmer Feedback Form

		Photograph
Name	Brijendra Kumar	
Village	Titronda	
Block	Binauli	
District	Baghpat.	
Address	Titronda, Baghpat.	
Mobile Number (optional)	+91 (6398175244).	
Type and number of structures		
Type	Tubewell	
Number	1	
(coordinates of the structures are to be obtained by the field officer)	29.034750° 77.383337°	
Drill time discharge (lps)	NA	
Depth of installation of pump	120 foot	
Casing depth (Bore wells) HR	200 foot	
Fracture encountered depth-HR	NA	
Slotted pipe depths (TW) SR	NA	
Average water levels – pre-monsoon		
Average water levels – post-monsoon		
The well is used for	irrigation	
Is water available throughout the year	yes	
If not for how many months water is available	NA	

Pumping Duration			
	Number of days pump is operated (days) of each well	What is the average pumping duration (in hours) of each well	Instantaneous Discharge Measurement (to be carried out by the field officer) in lps
Rabi (no of months to be specified) wheat	50 days	1hr / 1bigha	600 LPM

23

Water Market*	- Do you share the pumped water with other farmers No - If yes - For how many days do you share pumped water in Kharif - For how many days do you share pumped water in Rabi Period - On an average how much do you charge per annum (in Rs)
	- Do you receive additional water from boreholes of nearby farmers NO - If yes - For how many days do you receive pumped water in Kharif - For how many days do you receive pumped water in Rabi Period - On an average how much do you pay per annum (in Rs)
Other issues/Remarks	e.g. common problems in drilling of wells, common health issues in the area etc NIL
- Feedback of the local users will form an important input for problem identification and characterization. Feedbacks are to be obtained in case of Urban areas, Industrial clusters also. Feedbacks on drinking water availability, dependence on ground water etc are also to be obtained. The above feedback form can be customized to the type of priority area and objective of the study.	

[illegible] - 07.10.2023

Annexure -III

Farmer Feedback Form

			Photograph
Name	Richpal Gujjar		
Village	Rewari Rewara (Garhi Kalanjari).		
Block	Khekra		
District	Baghpat		
Address	near Hindon Bridge.		
Mobile Number (optional)	6396927428		
Type and number of structures			
Type	Shallow irrigation Tubewell (cavity well)		
Number	1 no.		
(coordinates of the structures are to be obtained by the field officer)	28.785177° 77.394006°		
Drill time discharge (lps)	NA		
Depth of installation of pump	Pumping through water Pump set, due to shallow TW.		
Casing depth (Bore wells) HR	125 foot		
Fracture encountered depth-HR	NA		
Slotted pipe depths (TW) SR	NA		
Average water levels – pre-monsoon	4 to 5 mtre.		
Average water levels – post-monsoon	2 to 3 mtr.		
The well is used for	irrigation		
Is water available throughout the year	Yes		
If not for how many months water is available	NA		
Pumping Duration			
	Number of days pump is operated (days) of each well	What is the average pumping duration (in hours) of each well	Instantaneous Discharge Measurement (to be carried out by the field officer) in lps
Rabi (no of months to be specified) Wheat	50 days (Nov. to March.)	10 hrs	300 LPM

23

Water Market*	Do you share the pumped water with other farmers – No If yes For how many days do you share pumped water in Kharif For how many days do you share pumped water in Rabi Period On an average how much do you charge per annum (in Rs)
	Do you receive additional water from boreholes of nearby farmers NO If yes For how many days do you receive pumped water in Kharif For how many days do you receive pumped water in Rabi Period On an average how much do you pay per annum (in Rs)
Other issues/Remarks	e.g. common problems in drilling of wells, common health issues in the area etc NIL

- Feedback of the local users will form an important input for problem identification and characterization. Feedbacks are to be obtained in case of Urban areas, Industrial clusters also. Feedbacks on drinking water availability, dependence on ground water etc are also to be obtained. The above feedback form can be customized to the type of priority area and objective of the study.

निरवाना सिंह 11-1-2024

25

Annexure -III

Farmer Feedback Form

		Photograph
Name	- Sanjay Kumar	
Village	- Shobhapur (G.P. Hiswada)	
Block	- Pilana	
District	- Baghpat	
Address	- Shobhapur, Baghpat	
Mobile Number (optional)	- 9758843746.	
Type and number of structures		
Type	- Tubewell (210 foot)	
Number	- 1	
(coordinates of the structures are to be obtained by the field officer)	28.9897 77.363452	
Drill time discharge (lps)	- NA	
Depth of installation of pump	- 120 foot	
Casing depth (Bore wells) HR	- 210 foot.	
Fracture encountered depth-HR	- NA	
Slotted pipe depths (TW) SR	- NA	
Average water levels – pre-monsoon	- 90-95 foot	
Average water levels – post-monsoon	- 80 foot	
The well is used for	- irrigation well	
Is water available throughout the year	- yes.	
If not for how many months water is available	~	

Pumping Duration

	Number of days pump is operated (days) of each well	What is the average pumping duration (in hours) of each well	Instantaneous Discharge Measurement (to be carried out by the field officer) in lps
Rabi (no of months to be specified) wheat	45 days (Nov-April)	1hr / 1 bigha	300 LPM

NA

Water Market*	○ Do you share the pumped water with other farmers ○ If yes ○ For how many days do you share pumped water in Kharif ○ For how many days do you share pumped water in Rabi Period ○ On an average how much do you charge per annum (in Rs)
NA	○ Do you receive additional water from boreholes of nearby farmers ○ If yes ○ For how many days do you receive pumped water in Kharif ○ For how many days do you receive pumped water in Rabi Period ○ On an average how much do you pay per annum (in Rs)
Other issues/Remarks	e.g. common problems in drilling of wells, common health issues in the area etc

- Feedback of the local users will form an important input for problem identification and characterization. Feedbacks are to be obtained in case of Urban areas, Industrial clusters also. Feedbacks on drinking water availability, dependence on ground water etc are also to be obtained. The above feedback form can be customized to the type of priority area and objective of the study.

12-1-2024

Annexure -III

Farmer Feedback Form

			Photograph
Name	Sh. Satyam Kumar		
Village	- Kasimpur Khedi		
Block	- Baraut		
District	- Baghpat		
Address	- Kasimpur Khedi		
Mobile Number (optional)	7560880580		
Type and number of structures			
Type	Tubewell		
Number			
(coordinates of the structures are to be obtained by the field officer)	- 29.183997° 77.287918°		
Drill time discharge (lps)	- NA		
Depth of installation of pump	- 50 foot		
Casing depth (Bore wells) HR	- 220 foot (depth)		
Fracture encountered depth-HR	- NA		
Slotted pipe depths (TW) SR	- NA		
Average water levels – pre-monsoon	- 15-20 mtr		
Average water levels – post-monsoon	- 10-15 mtr.		
The well is used for	- Irrigation.		
Is water available throughout the year	- Yes		
If not for how many months water is available	-		
Pumping Duration			
	Number of days pump is operated (days) of each well	What is the average pumping duration (in hours) of each well	Instantaneous Discharge Measurement (to be carried out by the field officer) in lps
Rabi (no of months to be specified) Wheat	45 days. (Nov-April)	1 hrs / 1 bigha.	300 LPM

Water Market*	○ Do you share the pumped water with other farmers ○ If yes No ○ For how many days do you share pumped water in Kharif ○ For how many days do you share pumped water in Rabi Period ○ On an average how much do you charge per annum (in Rs)
	○ Do you receive additional water from boreholes of nearby farmers NO ○ If yes ○ For how many days do you receive pumped water in Kharif ○ For how many days do you receive pumped water in Rabi Period ○ On an average how much do you pay per annum (in Rs)
Other issues/Remarks	e.g. common problems in drilling of wells, common health issues in the area etc

- Feedback of the local users will form an important input for problem identification and characterization. Feedbacks are to be obtained in case of Urban areas, Industrial clusters also. Feedbacks on drinking water availability, dependence on ground water etc are also to be obtained. The above feedback form can be customized to the type of priority area and objective of the study.

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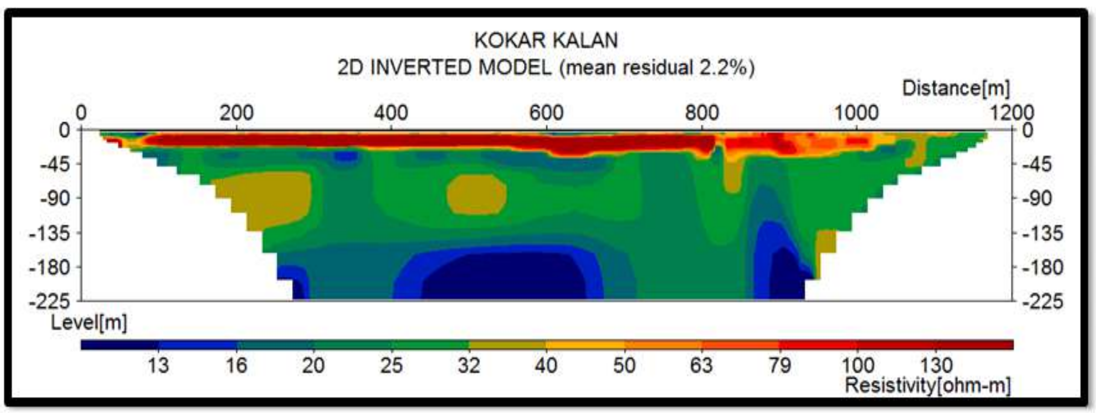
Interpretation of Electrical Resistivity Tomography Data under NAQUIM 2.0 in 2023-24

(A) ERT-1 at Kokar Kalan

East-west oriented ERT No.-1 was carried out with a spread length of 1200 m, giving insight into 225.0 m of sub-surface disposition. Resistivity values were obtained in the range of 1 Ωm to 50 Ωm. The topsoil is clay and has an extension in the depth ranges from 0 to 5 km stretching from 0 – 50m. Sand deposition is inferred from 1 to 35m. Two distinct resistivity zones were identified:

(i) A high resistivity zone, colored brown and orange, was encountered at the top—values of resistivity range from 55 to 130 Ωm. The freshwater zone extends from 1 to 30 m in depth. The values have been inferred to be topsoil and clay between depths of 0 to 5.0 m.

(ii) A low resistivity zone, colored blue, was encountered below the 1st zone. Values of resistivity were below 20 Ωm. There are some patches of clay rich groundwater bearing sandy clay zones have been inferred between depths of 190.00 to 225.00 m.



Model of the ERT Profile obtained at Kokar Kalan

Thickness	Depth (m)	Resistivity (Ωm)	Lithology
5	0-5	20-25	Clay
17	5-22	45-130	Sand
38	22-60	16-25	Clay mixed with silt
90	60-150	20-35	Sandy clay
75	150-225	10-20	Moderate quality Sandy clay

The results of the 2D section indicate the presence of topsoil mixed with silt down to a depth of 5 m. The colors added to the pseudo-section help demarcate fresh and moderate ground water interfaces at an average depth of 165.00 m.

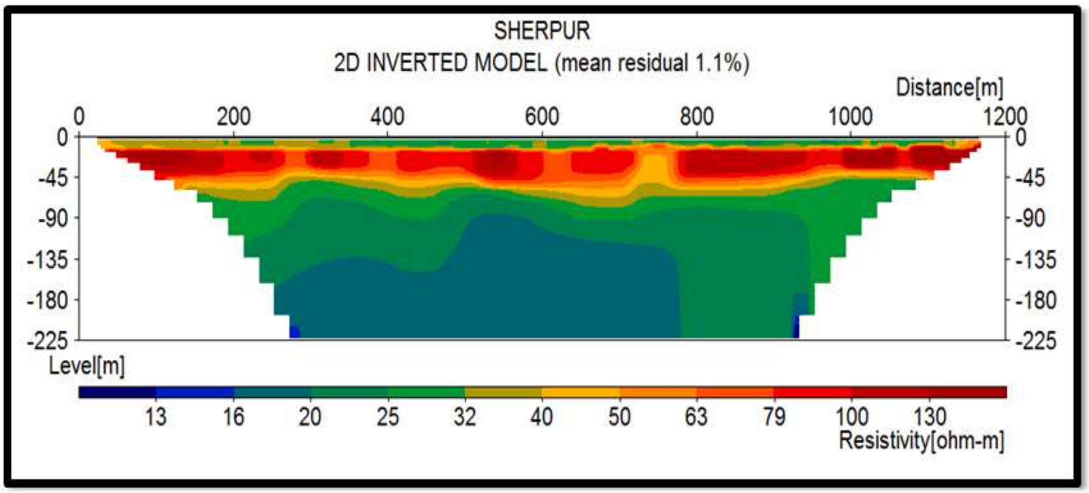
(B) ERT–2 at Sherpur

East-west oriented ERT No.-2 was carried out with a spread length of 1200 m, giving a coverage up to 225 m of sub-surface disposition. Resistivity values were in range of 10 to 150 Ωm.

Two distinct resistivity zones were identified based on resistivity values:

(i) A high resistivity zone, colored brown and red, was encountered at the top—values of resistivity range from 80 to 100 Ωm. The freshwater zone extends from 22 to 65 m in depth. The values have been inferred to be topsoil and clay between depths of 0 to 17.5.00 m.

(ii) A low resistivity zone, coloured sky blue and light blue, was encountered below 165m. Values of resistivity were below 16 Ωm. The values have been inferred to be moderate quality groundwater bearing granular zones between depths of 165.00 to 225.00 m.



Model of the ERT Profile obtained at Sherpur

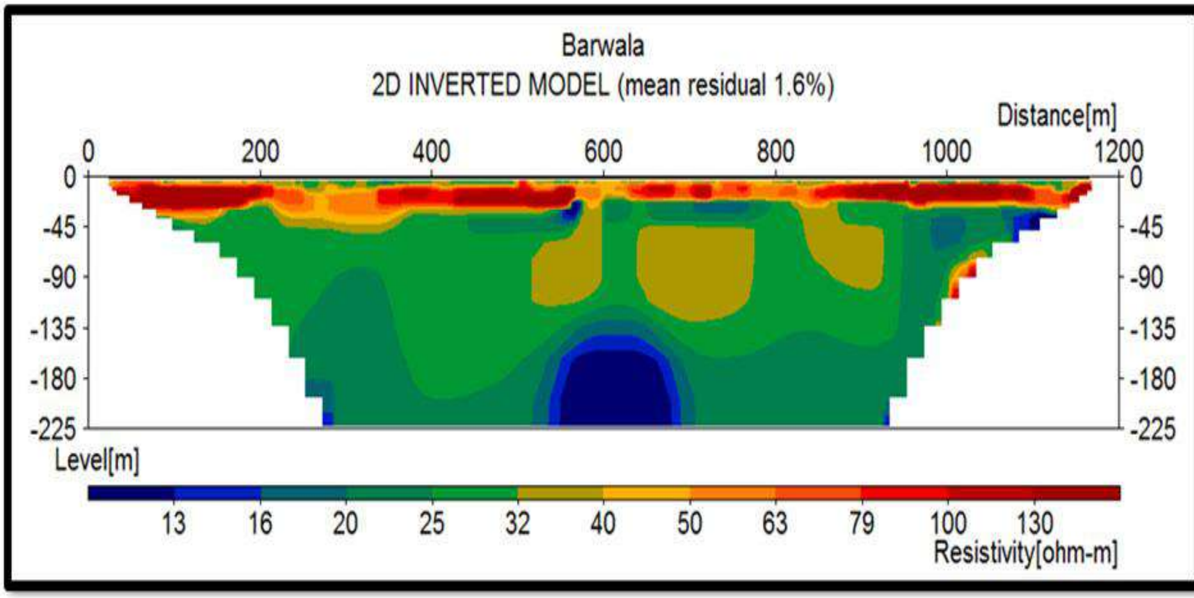
Thickness	Depth (m)	Resistivity (Ωm)	Lithology
22	0 - 22	20 - 30	Clay
43	22 - 65	50 - 100	Sand
10	65 - 75	40 - 50	Sandy clay
90	75 - 165	25 - 32	Clay mixed with sand
60	165 - 225	16 - 25	Moderate quality Sandy clay

(C) ERT–3 at Barwala

East-west oriented ERT -3 was carried out with a spread length of 1200 m, giving insight into 225.0 m of sub-surface disposition. Resistivity values were obtained in the range of 10 Ωm to 150 Ωm. The topsoil is thin extending from 0- 5m. Two distinct resistivity zones were identified:

(i) A high resistivity zone, colored brown and orange, was encountered at the top—values of resistivity range from 55-130 Ωm. The freshwater zone extends from 5 to 45 m in depth.

(ii) A low resistivity zone, coloured green, was encountered below 135m Values of resistivity were below 25 Ωm. Some patches of moderate quality groundwater bearing granular zones between depths of 140 to 225 m at stretches in the range of 500 m to 700 m have been inferred.

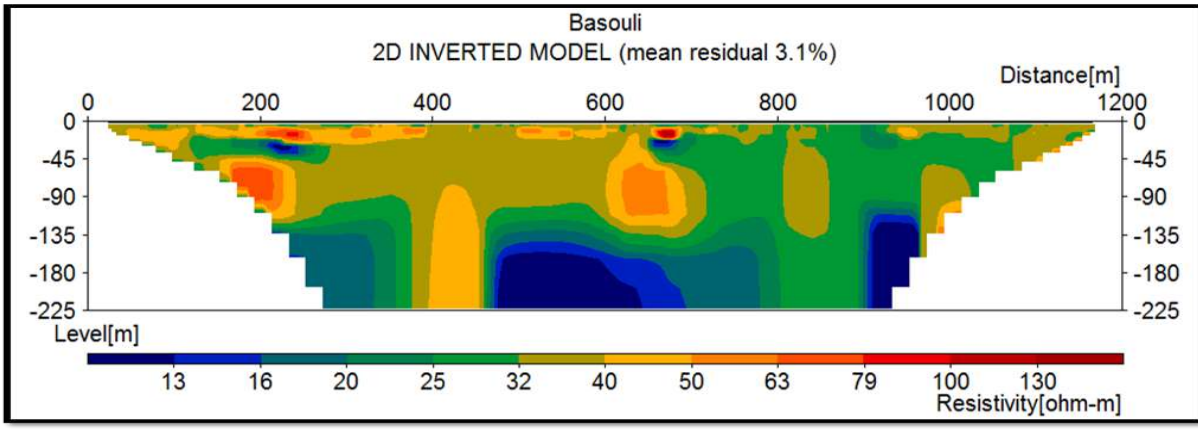


Model of the ERT Profile obtained at Barwala

Thickness	Depth (m)	Resistivity (Ωm)	Lithology
5	0-5	25-45	Clay
40	5-45	55-130	Silty Sand
90	45-135	20-40	Clay with patches of sand
90	135-225	10-25	Moderate quality Sandy clay

(D) ERT–4 at Basouli

East-west oriented ERT was done with a spread length of 1200 m for a 225.0 m of sub-surface disposition. Resistivity values were in the range of 10 to 150 Ωm and deposition is heterogeneous. The topsoil is thin and extends from 0-5.0 m, and stretches from 0-700m. The sand deposition is inferred at a depth from 1.0-25.0 m. Below that, clay is separated by sand having a resistivity range from 13-20 Ωm, extending from stretch 700-1200 m onward. The formation is sandy clay throughout. The colors added to the pseudo-section help demarcate saline ground water intrusion.



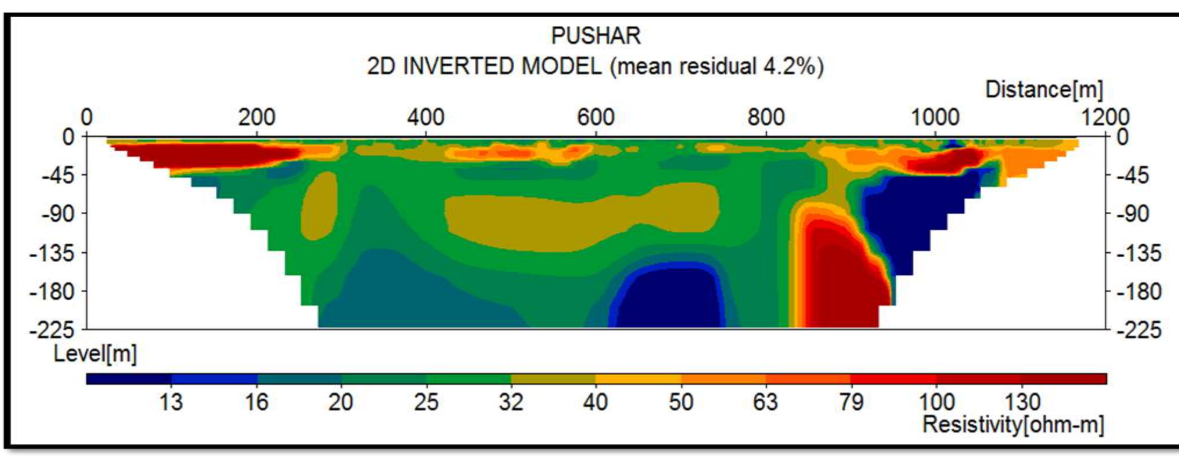
Model of the ERT Profile obtained at Basouli

(E) ERT–5 at Pushar

East-west oriented ERT No.- 5 was carried out with a spread length of 1200 m, giving insight into 225.00 m of sub-surface disposition. Resistivity values were in the range 1 to 50 Ωm.

(i) A high resistivity zone, colored red and yellow, was encountered at the top—values of resistivity range from 100 to 130 Ωm at a stretch of 0 to 280 m and a resistivity range of 80-120 Ωm at a depth range of 25-45 m stretches at 900-1200 m. The freshwater zone extends from 5 to 45 m in depth. The values have been inferred to be topsoil and clay between depths of 0 to 5.0 m, and clay mixed with silt is inferred throughout the deposition.

(ii) A low resistivity zone, colored sky blue and light blue, was encountered below 1st zone. Values of resistivity were below 13 Ωm. Values have been inferred to be moderate quality water bearing granular zones between 45 to 170 m around a stretch of 900-1000 m. Colors added to pseudo-section help demarcate fresh and moderate ground water interface at an average depth of 100 m.



Model of the ERT Profile obtained at Pushar

Thickness	Depth (m)	Resistivity (Ωm)	Lithology
5	0 - 5	25 - 32	Clay
40	5 - 45	35 - 120	Sand
47	45 - 92	20 - 35	Clay mixed with sand
43	92 - 135	22 - 55	Sandy Clay
90	135 - 225	10 - 18	Moderate quality Sandy clay

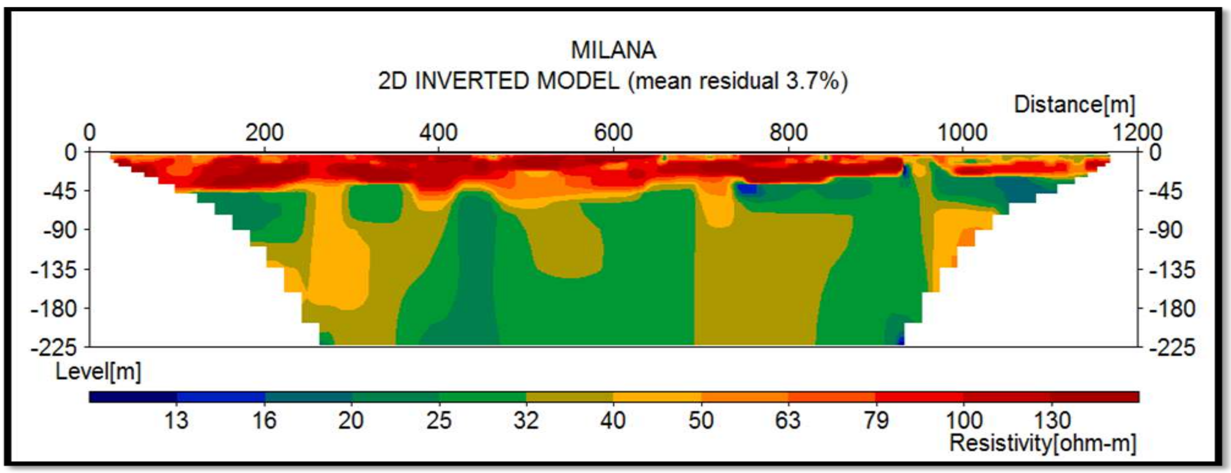
(F) ERT–6 at Milana

East-west oriented ERT - 6 was carried out with a spread length of 1200 m, giving insight into 225 m of sub-surface disposition. Resistivity values were obtained in the range of 10 to 150 Ωm. Two distinct resistivity zones were identified based on resistivity values:

(i) A high resistivity zone, colored red and yellow, was encountered at the top—values of resistivity range from 79 to 150.0 Ωm. The freshwater zone extends from 2 to 50 m in depth. The values have been inferred to be topsoil and clay between depths of 0 to 5.0 m.

(ii) A low resistivity zone, colored green and yellow, was encountered below 50m. Values of resistivity were below 40 Ωm.

Results of 2D section indicate presence of topsoil mixed with sand down to a depth of 2 m.



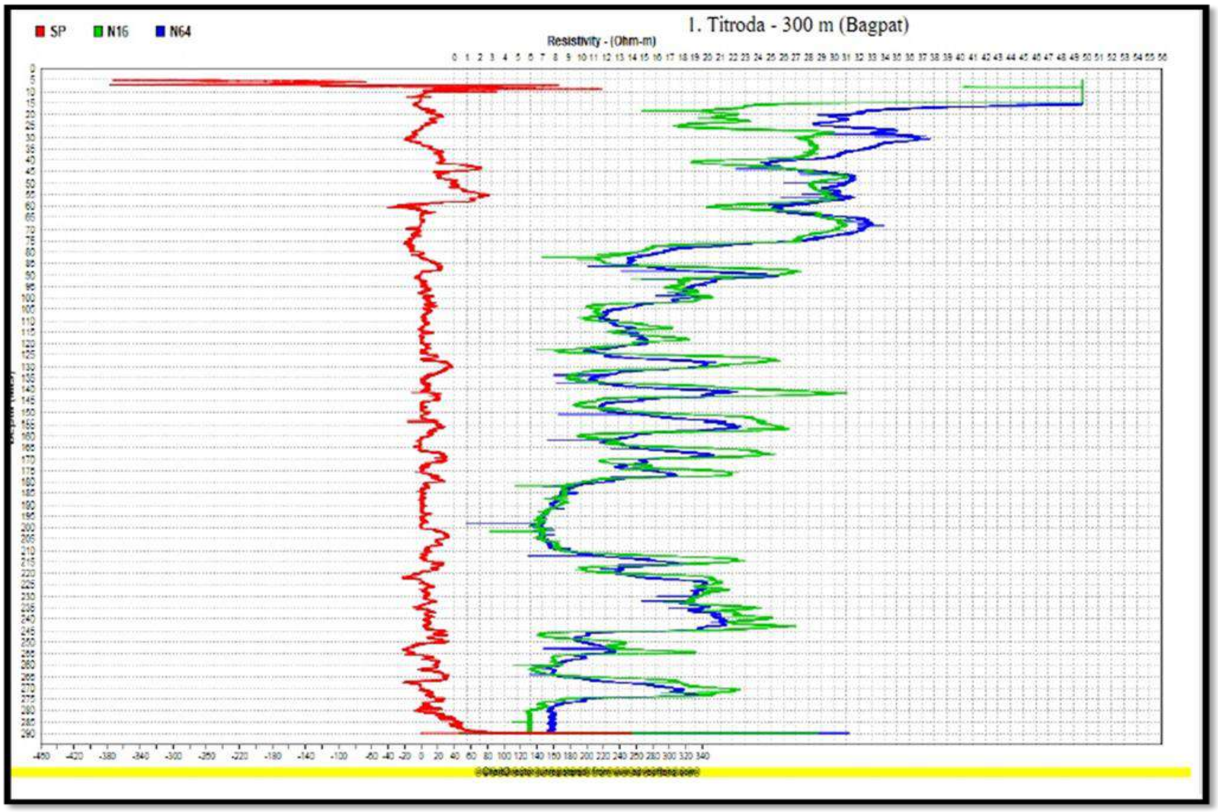
Model of the ERT Profile obtained at Milana

Thickness	Depth (m)	Resistivity (Ωm)	Lithology
2	0 - 2	40 - 50	Clay
48	2 - 50	79 - 150	Sand
45	50 - 95	20 - 45	Clay mixed with sand
130	95 - 225	20 - 40	Clay with silt

Interpretation of Borehole Logging Data under NAQUIM 2.0 work in 2023-24

(A) Titroda

The borehole drilled at Titroda, Block - Binoli, Baghpat (83.028432:26.638182), was logged down to 290 m bgl against the drilled depth of 300 m bgl on 25.08.23. Self-Potential, Short Normal (N-16”), Long Normal (N-64”) resistivity log and Gamma log were recorded using a digital logger. Based on electrical log, the following granular zones were identified for constructing the well.



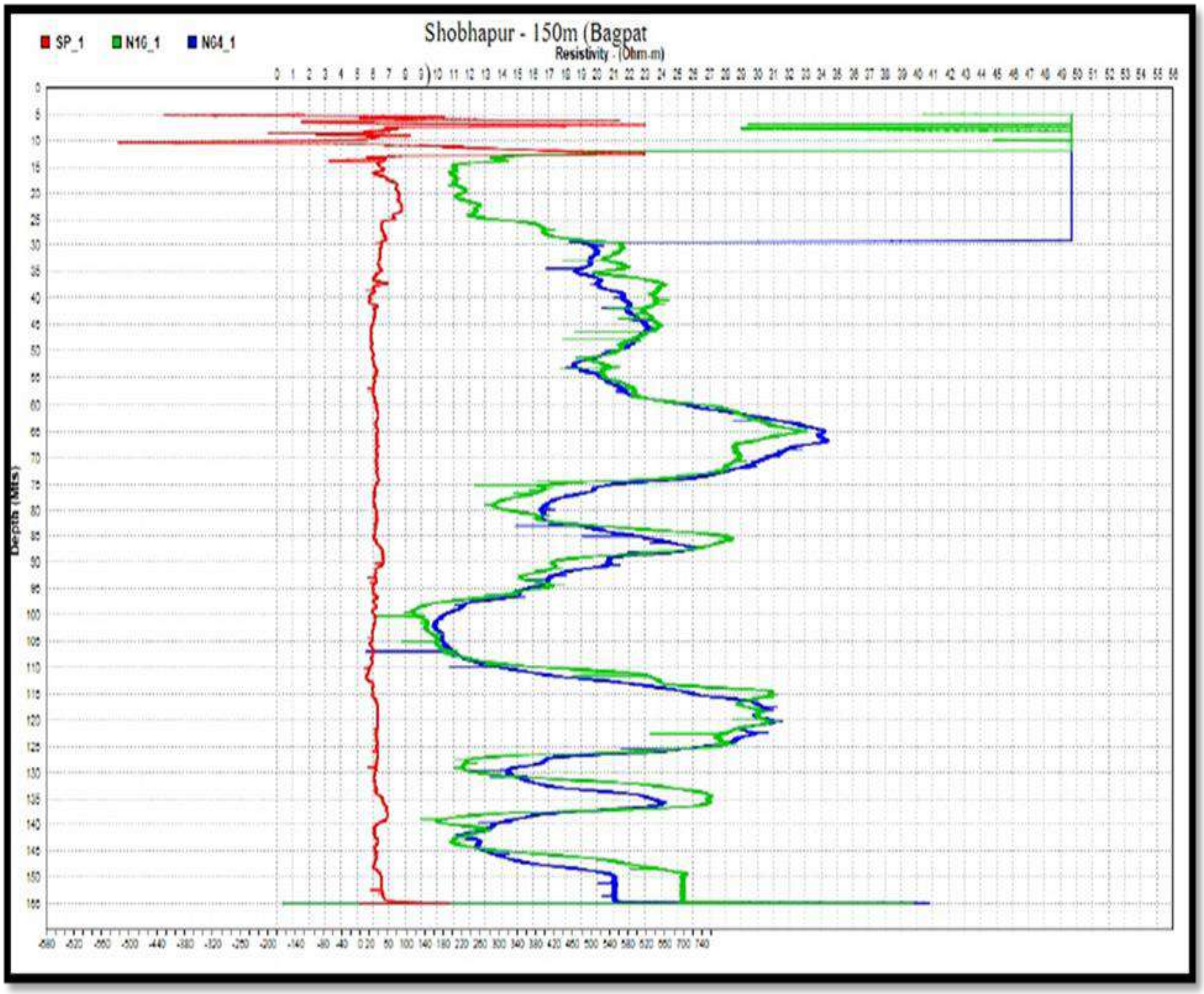
Borehole Log Chart of Titroda Exploration site

Interpretation : Granular zones are fine sand to moderate sand. Water quality is fresh up to 275 m bgl. Prominent clays mixed with silt are identified in depth range of 0-26, 39-45, 59-65, 75-86, 103- 111, 121-125, 131-137, 145-151, 158-165, 169-175, 217-221, 244-251, 257-266 and 275-290 m bgl.

Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality	Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality
1.	26-39	13	35	Good	8.	151-158	7	26	Good
2.	45-59	14	32	Good	9.	165-169	4	27	Good
3.	65-75	10	32	Good	10.	175-179	4	25	Good
4.	86-102	16	23	Good	11.	213-217	4	22	Good
5.	111-121	10	16	Good	12.	221-244	23	27	Good
6.	125-131	6	23	Good	13.	251-257	6	14	Good
7.	137-145	8	28	Good	14.	266-275	9	21	Good

(B) Shobhapur

The borehole drilled at Shobhapur, Block-Pilana, Bagpat (28.9903530, 77.3632230) was logged down to 150 mbgl against drilled depth of 155 mbgl on 24.08.23. Self-potential, Short Normal (N-16”), Long Normal (N-64”) resistivity log and Gamma log were recorded.



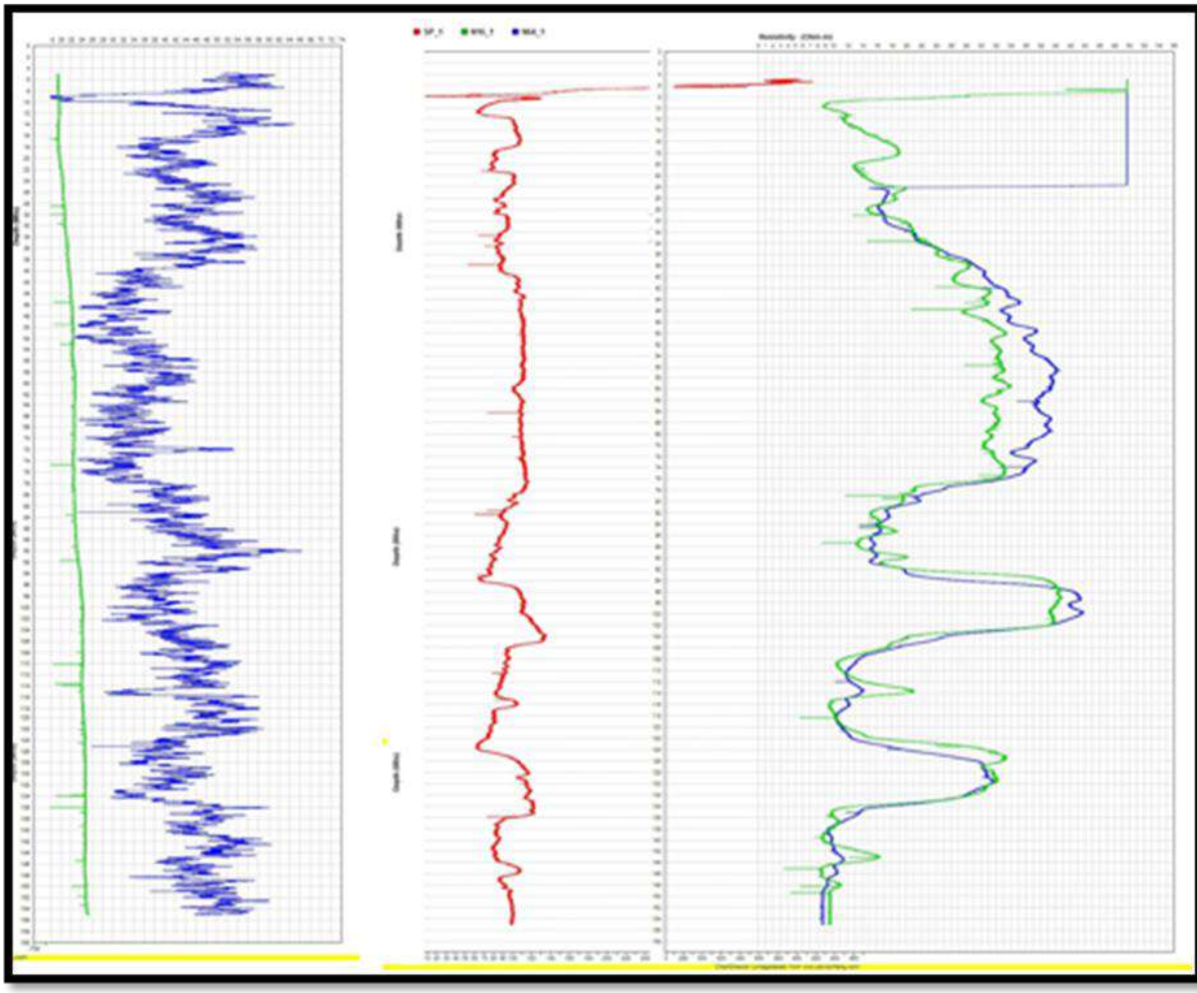
Borehole Log Chart of Shobhapur Exploration site

Interpretation: Granular zones are fine sand to moderate sand. Water quality is fresh up to 150 m bgl. Prominent clays mixed with silt are inferred in the depth range of 0-30, 50-59, 75-83, 88-110, 126-132 and 137-146 m bgl.

Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality	Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality
1.	30-50	20	23	Good	4.	110-126	16	28	Good
2.	59-75	16	31	Good	5.	132-137	5	25	Good
3.	83-88	5	25	Good	6.	146-150	4	24	Good

(C) Shahpur-Banpur Ganga

Borehole drilled at Shahpur, Banganga Block-Binauli**,** Bagpat (29.138251:77.447524) was logged down to 150 m bgl against the drilled depth of 152 mbgl on 28.12.23. Self-potential, Short normal (N-16"), long normal (N-64") resistivity log and Gamma log was recorded.



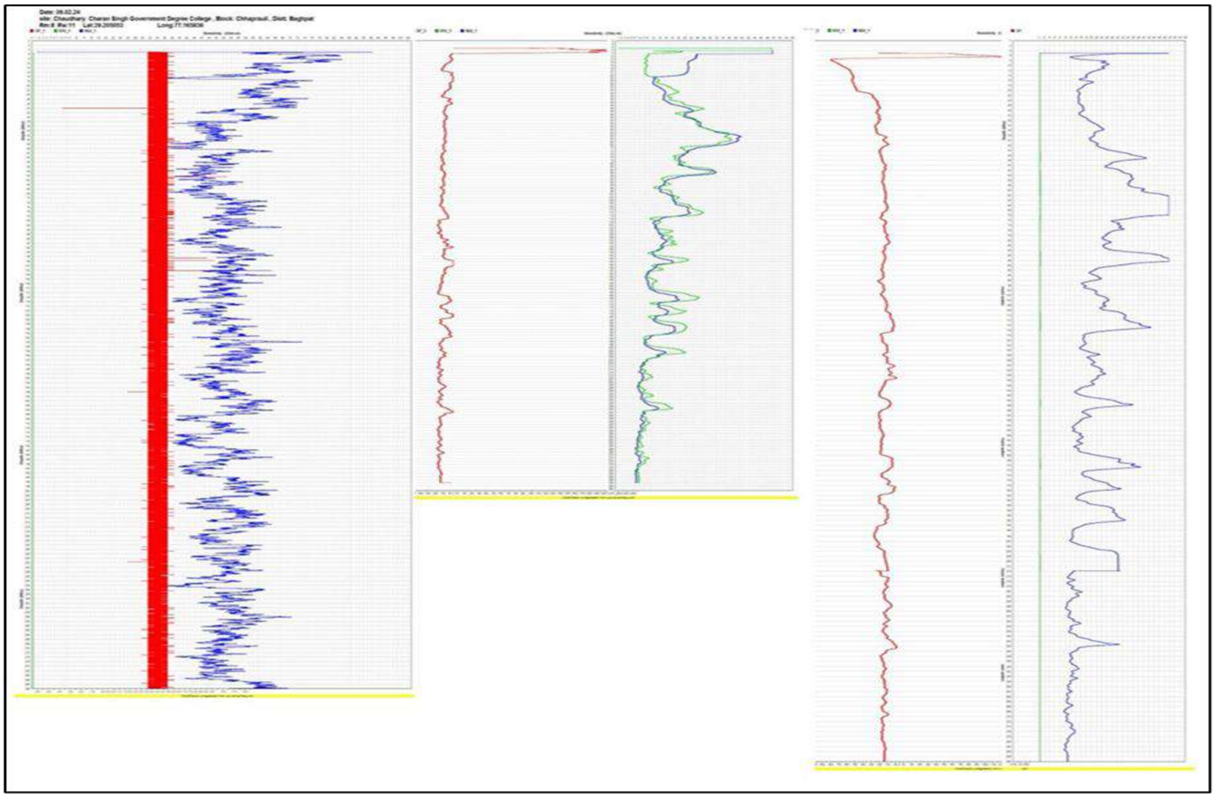
Borehole Log Chart of Shahpur BanGanga Exploration site

Interpretation: The granular zones are moderate to coarser sand mixed with thin kankar upto 76 m bgl. The water quality is fresh upto 150 m bgl. Prominent clays mixed with silt are inferred in the depth range of 32-36, 56-60, 86-92, 104-122 and 141-144 m bgl.

Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality	Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality
1.	16 - 20	4		Good	5.	92 - 104	12		Good
2.	22 - 25	3		Good	6.	122 - 134	12		Good
3.	36 - 56	20		Good	7.	144 - 150	6		Good
4.	60 - 78	16		Good					

(D) Chhaprauli

The borehole drilled at Chaudhary Charan Singh Government Degree College, Chhaprauli, Baghpat (77.165836, 29.205053) was logged down to 286 mbgl against the reported drilled depth of 300 mbgl on 06.02.24. Self-potential, Short Normal (N-16”), and Long Normal (N-64”) resistivity and Gamma Log was recorded using digital logger. Based on an electrical log, the following granular zones are recommended for construction of exploratory well.



Borehole Log Chart of Chhaprauli Exploration site

Interpretation: The granular zones have medium to coarse grain sand. The water quality is fresh up to 206 m bgl then it is of moderate quality up to 242 m bgl. Prominent clays mixed with silt are inferred in the depth range of 69-82, 88-102, 114-128, 146- 162, 192-200, and 206-236 m bgl.

Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality	Sl. No.	Depth Range(m)	Thick-ness(m)	Resistivity of Zone (ohm.m)	Water Quality
1.	38 - 46	8		Good	7.	162 - 170	8		Good
2.	48 - 69	21		Good	8.	174 - 180	6		Good
3.	82 - 88	6		Good	9.	184 - 192	8		Good
4.	102 - 114	12		Good	10.	200 - 206	6		Good
5.	128 - 134	6		Good	11.	236 - 242	6		Good
6.	141 - 146	5		Good					

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