

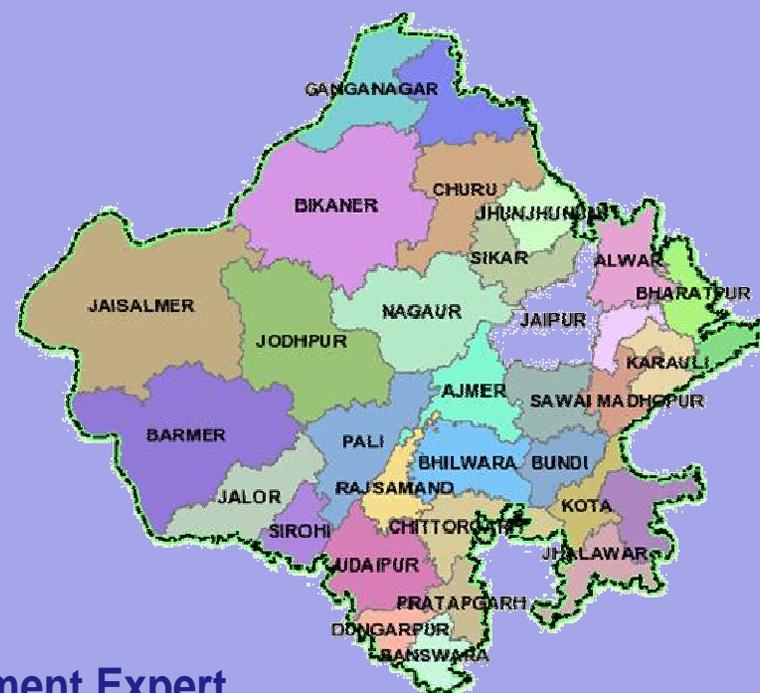


Ground Water Department,  
Rajasthan



European Union  
State Partnership Programme

# Web GIS for Ground Water Resource Assessment and End User Participation in its Management – Case Study from Rajasthan



M Mehta

Ground Water Management Expert  
EU SPP TA Team  
Former Commissioner (GW)  
Ministry of Water Resources, GoI

# Introduction

Geographical Area : 3,42,239 Sq  
km  
Population : 56,473,122  
No. of Districts : 33  
No. of Blocks : 249  
No. of Villages : 41,353  
No. of Towns : 222  
No. of Inhabited Villages: 39,753

No. of GMS(GWD) : 8057  
No. of GMS(CGWB) : 1570  
Average Annual Rainfall : 531 mm  
Stage of GW Development: 137%



# Rajasthan in the Context of India

Rajasthan is the largest state in India with over 10% of its area but only 1.4% of its water resources

	Rajasthan	India	Rajasthan as % of India
Population (2001) (Million)	56.5	1,050.0	5.40%
Utilizable water resources (BCM)	32.9	2,300.0	1.40%
b. Ground water (BCM)	11.2	431.0	2.50%
Irrigated area (Mha)	7.7	105.0	7.30%

# Vulnerability of Water Resources in Rajasthan

Source	Availability	Utilization
Internal	16.05	11.55
<b>Total</b>	<b>33.94</b>	<b>24.21(70%)</b>
<b>Grand Total</b>	<b>45.09</b>	<b>39.78 (88%)</b>

Note: (i) as of year 2008  
(ii) units in billion cubic meters unless mentioned otherwise  
(iii) Evapo-transpiration: 1500 -2500 mm p.a.

*Water levels falling at alarming rate in most of the state*

*Water quality problems due to geological reasons, municipal and industrial pollution*

# Ground Water Development over the Years

Year	Annual Ground Water Resources			Stage of Development (%)	Number of over exploited blocks / Total Blocks
	Recharge (mcm)	Draft (mcm)	Balance (mcm)		
1984	13,790	4,927	+ 8,863	36	12/237
1990	10,801	5,821	+ 4,981	56	44/237
1995	11,028	6,494	+ 4,535	59	60/237
1998	12,602	8,708	+ 3,894	69	41/237
2001	11,159	11,635	- 476	104	86/237
2004	10,383	12,991	- 2,609	125	140/237
2009	10,563	14,570	- 4,007	134	166/239
2011	10,829	14,843	- 4,014	137	172/243

*Notified Blocks as on today : 34. Saline Blocks – 2*

# EU SPP Rajasthan- An Overview

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## Objectives

- State wide water sector reforms leading to sustainable and integrated water resources management
- Support PRIs in 11 districts for:
  - Equitable access to safe, adequate, affordable, sustainable drinking water
  - Conservation and replenishment of surface and ground water

## Sector budget support of €80 mn from EU

- €73.5 mn for the government of Rajasthan implementation from 2007 till December 2013
- Remaining €6.5 mn – Technical Assistance, Monitoring/Evaluation, Audits (EU contracted)

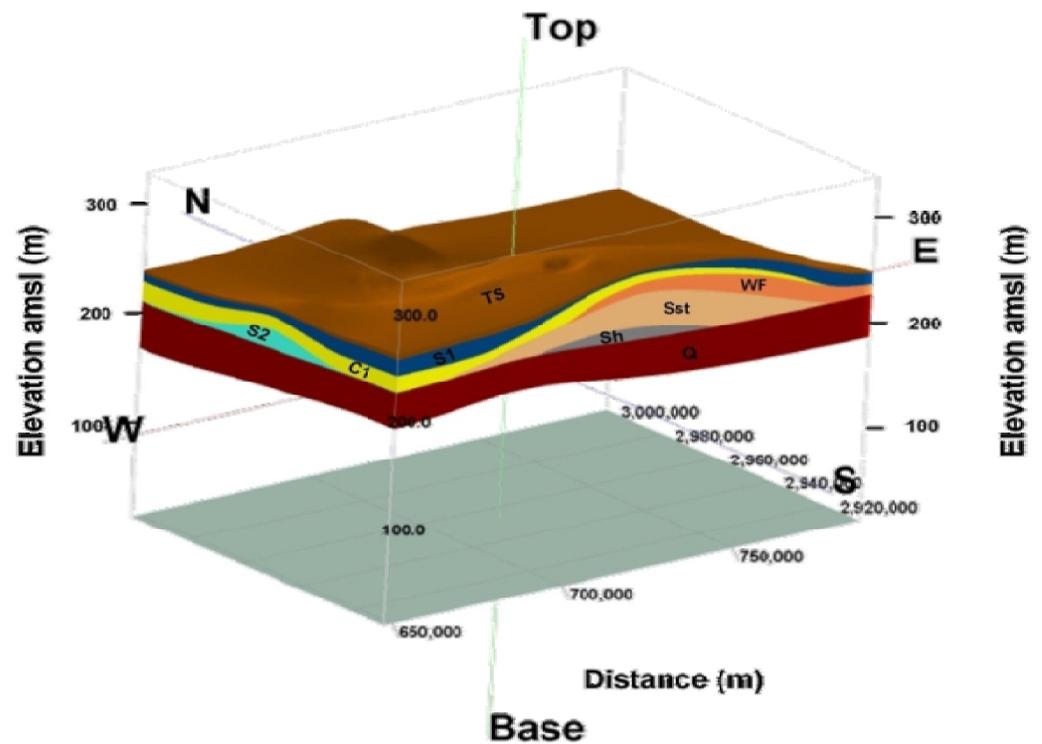
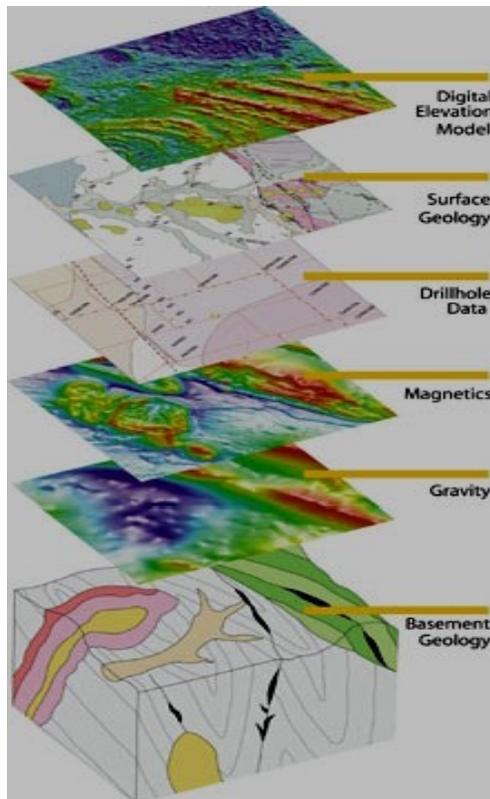
**Time period 2007 – 2013** ( extended up to Dec. 2015)

# Problems in Ground Water Management

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- Not aquifer based
- Fragmentation of management at Central/ State level
- Poor coordination between water supply and water quality management programs
- Inadequate recognition of GW/ SW connections
- Rules/ regulations not aimed at preventing aquifer mining
- Decline in resources and emphasis on GW protection, especially monitoring programs
- GW departments are Dying-Organisational aspects
- Overlapping tasks GWD/ Water supply

# Conceptualization of Rajasthan Ground Water Project

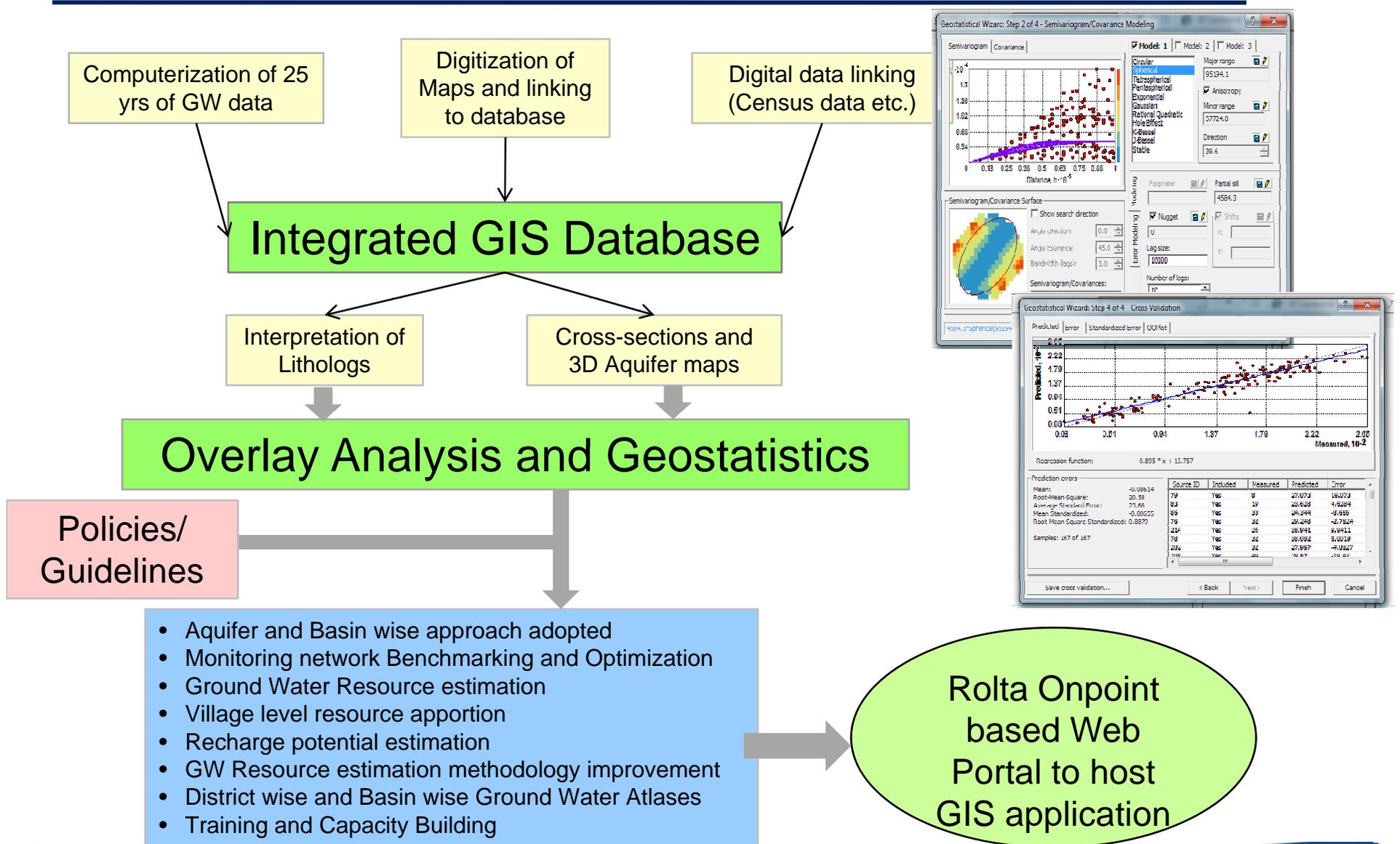


# Project Objectives

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- Computerization of historic ground water data,
- Interpretation of data and demarcation of the aquifer system in three dimensions
- Estimation of the aquifer wise groundwater resources and apportion to the level of village,
- Benchmarking of GW Monitoring network and recommendations for its optimization,
- DGPS Survey of monitoring wells for accurate position and RL establishment,
- Development of Web enabled GIS Application for the assessment and management of Ground water,
- Empowering the community to asses periodical ground water availability
- To equip ground water users / stakeholders with the necessary data, skills and knowledge to manage groundwater resources available in a sustainable manner.

# Solution



- Aquifer and Basin wise approach adopted
- Monitoring network Benchmarking and Optimization
- Ground Water Resource estimation
- Village level resource apportion
- Recharge potential estimation
- GW Resource estimation methodology improvement
- District wise and Basin wise Ground Water Atlases
- Training and Capacity Building

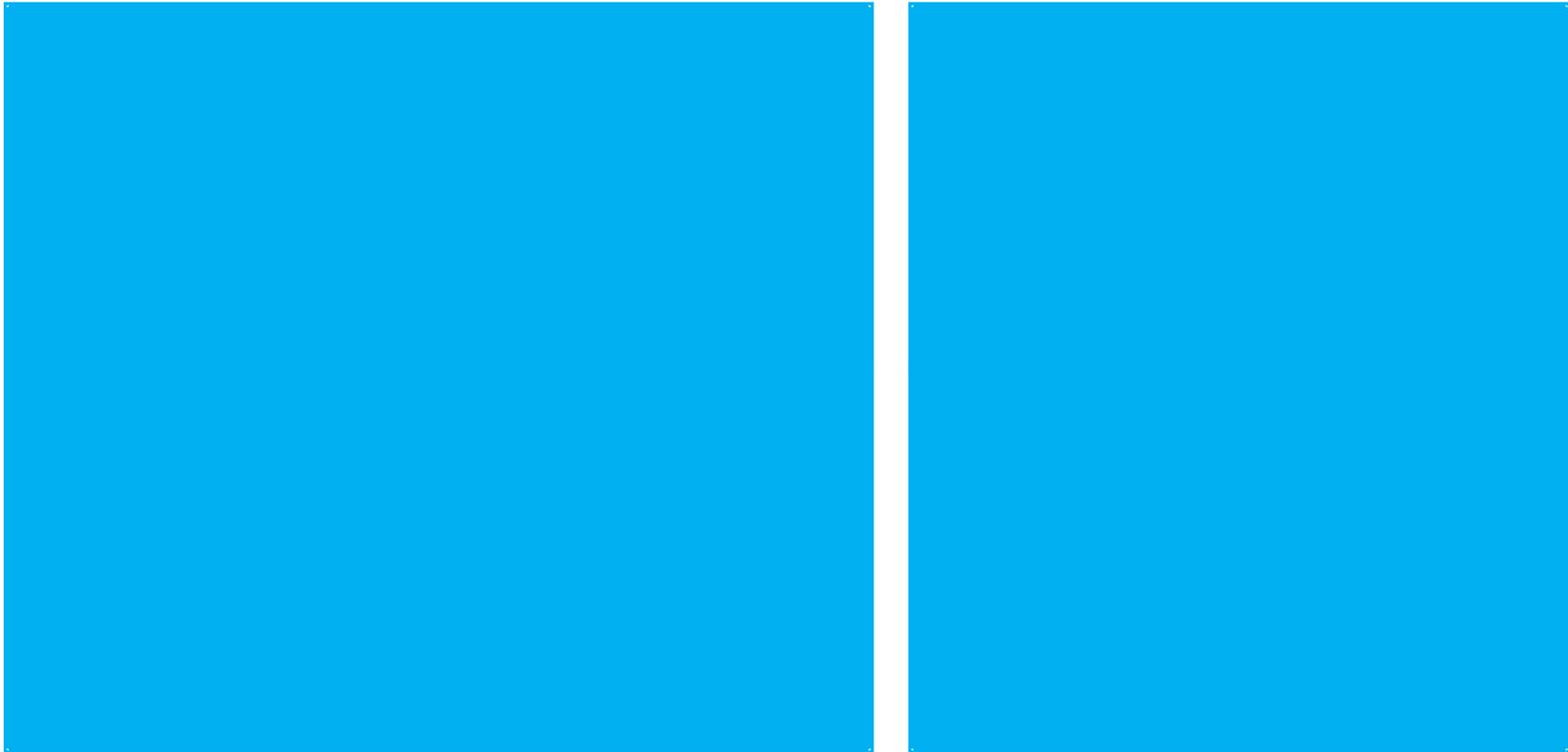
Rolta Onpoint  
based Web  
Portal to host  
GIS application

# Inputs Used

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- Geographical locations of all existing ground water monitoring Wells with their RL values,
- Time series Water Level and Water Quality (1984 – 2011) Data of both GWD and CGWB,
- Exploratory well lithologs of both GWD and CGWB,
- Geophysical Survey Data – Electrical Resistivity data, Interpreted Lithologs, Geophysical well logging data,
- Metrological Data (Rainfall only),
- Aquifer Parameters of both GWD and CGWB,
- Updated Administrative Boundary (state, district, block and village) and Demographic data as per Census of India and State,
- District wise Geological, Geomorphology and Ground Water Potential Zone Maps etc.,
- Guidelines of GEC and Published Annual Assessment Reports of the State Ground Water Department.

# Data Entry, Validation & Evaluation



A Snap shot of Key well (WL) / Geophysical Data Entry Form

- For each type of input data, specific forms and formats were designed,
- Quality checks were adopted to ensure error free data entry into database

# Basin Wise Thematic Maps

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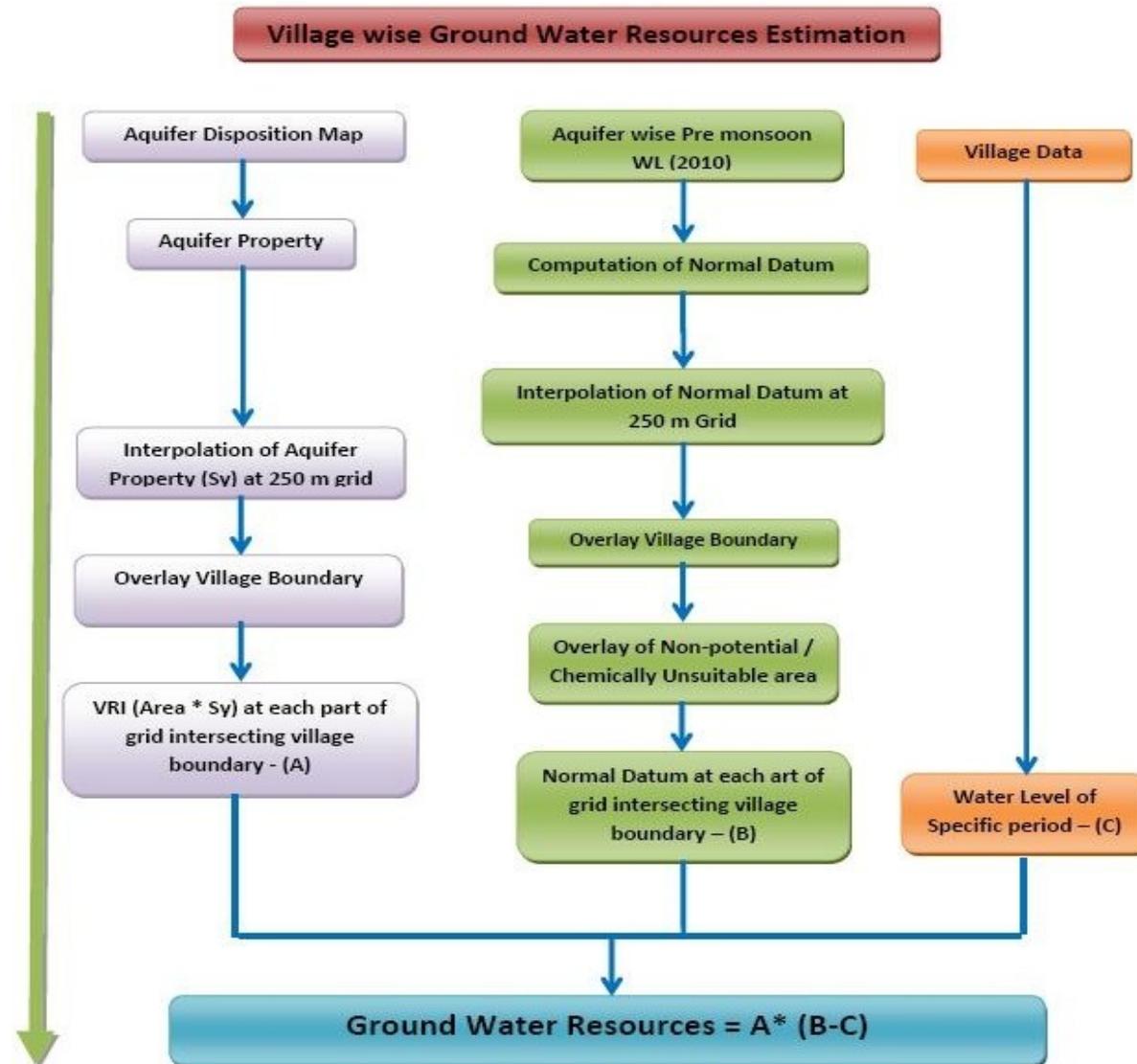
- Digital maps on following themes were prepared for systematic assessment of aquifers in a basin:
  - Geological , geomorphological, ground water potential maps,
  - Well (GMS and Exploratory) location maps,
  - Depth to water level, Water table elevation and fluctuation maps
  - Water quality maps (EC, Chloride, Fluoride, Nitrate) distribution maps
  - Depth to bedrock maps
  - Isopach maps for Unconfined and Confined aquifers (if present)
  - Multiple Vertical cross sections across the basin
  - 3D maps for panel diagram

# Approach to GW Resource Assessment

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- Appraisal of current methodology of RGWD carried out and suitable refinements suggested,
- All the ground water recharge and discharge data linked to corresponding spatial features,
- Overlay analyses carried for isopach, GWP and other thematic maps for computation of basin wise, aquifer wise and village wise ground water resources,
- Both static and dynamic ground water resources were computed at 250m grid cells that can be summarized to any boundary,
- Quickly replicable and standardized methodology finalized for computation of resources annually.

# Approach to GW Resource Assessment



# Approach to GW Resource Assessment

Limitations faced	Solution
All draft and recharge values were available at Block boundary level,	Actual location of wells preferred
Keeping in view the size of the state, no. of specific yield values was less and quite old (often >20 years),	Values need to be revisited as aquifers might have changed
Agriculture draft can be improved by using crop type distribution	Remote Sensing studies can help in crop mapping
Agriculture draft should be applied to agriculture field areas only and so be the domestic draft,	LULC map be used
Many new canals have come up resulting into rise of water table	Revised command area map be used
Some unusually high –ve fluctuation areas	Either more frequent or stabilized water level readings be taken

# Static and Dynamic GW Resources- Rajasthan

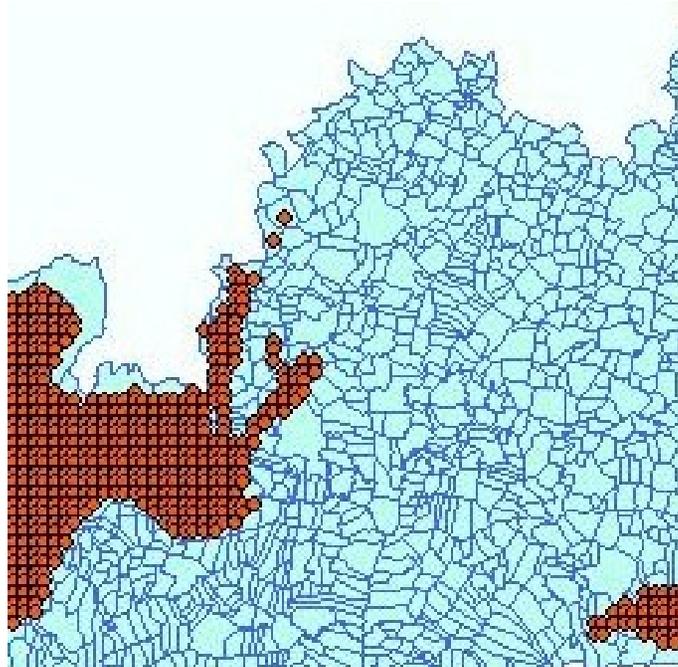
(Aquifer wise)

Aquifer Name	Dynamic Resources *	Static Resources *
	(mcm)	(mcm)
Basalt	207.21	629.95
BGC	270.01	2,226.93
Bilara Limestone	279.87	3,361.23
Gneiss	469.08	2,353.74
Granite	218.2	2,165.74
Granite Jalore	53.05	512.09
Limestone	246.39	1,064.26
Nagaur & Jodhpur Sandstone	291.48	4,453.79
Older Alluvium	5,712.20	199,826.99
Parewar Sandstone	47.71	1,150.22
Phyllite	461.29	3,231.78
Quartzite	170.14	999.36
Rhyolite	117.05	950.22
Sandstone	873.9	11,423.80
Schist	641.7	4,506.50
Shale	120.74	224.07
Tertiary Sandstone	534.61	17,965.53
Ultra Basic	2.06	18.96
Younger Alluvium	3,309.13	154,029.76
<b>Total</b>	<b>14,025.82</b>	<b>411,094.93</b>

# Achievements

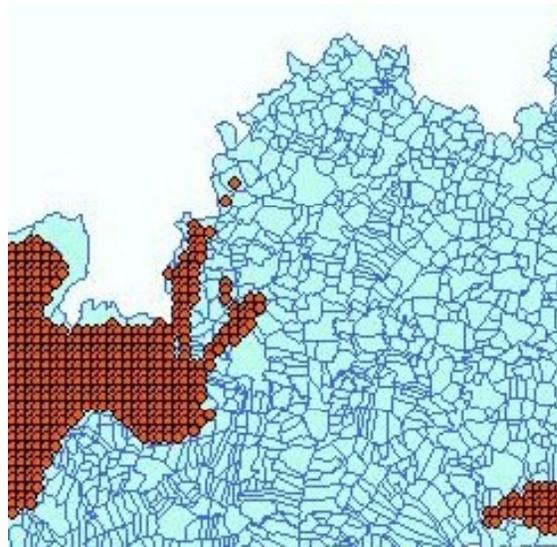
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- All the relevant historic ground water related data possessed by Department is digitally available for scientists,
- The Department now has large number of GIS software licenses and those for ground water study (like: Rolta Geomatica, Surfer, Aquachem, RockWorks, Visual Modflow) for quickly derive analytical results,



# Achievements

- CGWB and GWD data integrated through implementation of GEMS at GWD,
- Training on all the softwares has been imparted to GWD scientists for carrying out GIS based mapping and analysis,
- GW resource can now be computed very quickly, accurately and annually,
- All the data and maps are in public domain,
- Village user groups and stakeholders can compute the available GW resources as on date by just inserting the water levels and also get to know the balance and its sufficiency for different purposes till next monsoon. This will help them in better planning the scarce ground water that is available in hand.





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**Final outcome of the project implementation**

**–One Point based Web GIS Solution**

**Link:** <http://gwd.rajasthan.gov.in>

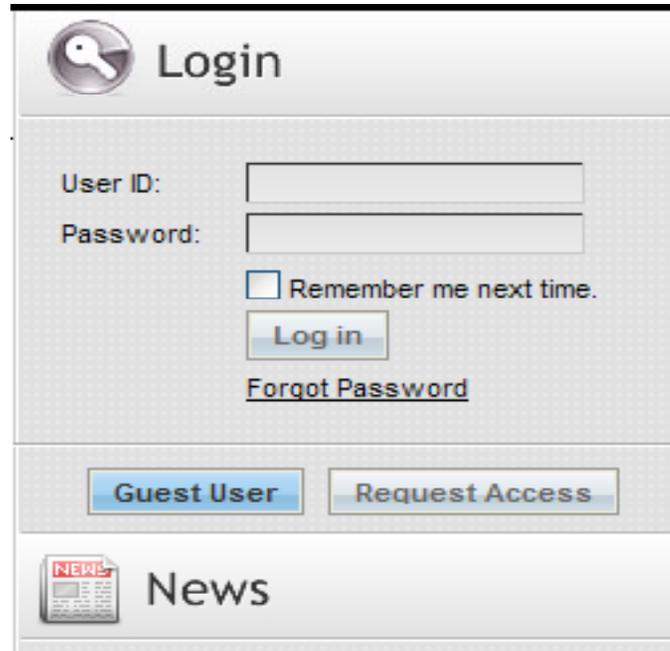


# Detailed navigation on the first page

1	2	3	4
<ul style="list-style-type: none"> <li>Know RGWD</li> </ul>	<ul style="list-style-type: none"> <li>Know RGWD</li> </ul>	<ul style="list-style-type: none"> <li>Know RGWD</li> </ul>	<ul style="list-style-type: none"> <li>Know RGWD</li> </ul>
<ul style="list-style-type: none"> <li>About RGWD</li> </ul>	<ul style="list-style-type: none"> <li>Publications/Reports</li> </ul>	<ul style="list-style-type: none"> <li>Publications/Reports</li> </ul>	<ul style="list-style-type: none"> <li>Publications/Reports</li> </ul>
<ul style="list-style-type: none"> <li>Organization</li> </ul>	<ul style="list-style-type: none"> <li>Machine Power/Man Power</li> </ul>	<ul style="list-style-type: none"> <li>Notices</li> </ul>	<ul style="list-style-type: none"> <li>Notices</li> </ul>
<ul style="list-style-type: none"> <li>Vision</li> </ul>	<ul style="list-style-type: none"> <li>Annual Reports</li> </ul>	<ul style="list-style-type: none"> <li>Tenders</li> </ul>	<ul style="list-style-type: none"> <li>MIS Reports</li> </ul>
<ul style="list-style-type: none"> <li>Objectives</li> </ul>	<ul style="list-style-type: none"> <li>Brochures/Reports</li> </ul>	<ul style="list-style-type: none"> <li>Circulars</li> </ul>	<ul style="list-style-type: none"> <li>Well Summary Report</li> </ul>
<ul style="list-style-type: none"> <li>Functions</li> </ul>	<ul style="list-style-type: none"> <li>Ground Water Standards</li> </ul>	<ul style="list-style-type: none"> <li>Forms</li> </ul>	<ul style="list-style-type: none"> <li>Block Wise Summary Report</li> </ul>
<ul style="list-style-type: none"> <li>Achievements</li> </ul>	<ul style="list-style-type: none"> <li>Notices</li> </ul>	<ul style="list-style-type: none"> <li>Guidelines and Policies</li> </ul>	<ul style="list-style-type: none"> <li>Basin Wise Hydro-geological Information</li> </ul>
<ul style="list-style-type: none"> <li>Projects</li> </ul>	<ul style="list-style-type: none"> <li>MIS Reports</li> </ul>	<ul style="list-style-type: none"> <li>MIS Reports</li> </ul>	<ul style="list-style-type: none"> <li>Water Quality Charts</li> </ul>
<ul style="list-style-type: none"> <li>RTI</li> </ul>			
<ul style="list-style-type: none"> <li>Contact Us</li> </ul>			
<ul style="list-style-type: none"> <li>Publications/Reports</li> </ul>			
<ul style="list-style-type: none"> <li>Notices</li> </ul>			
<ul style="list-style-type: none"> <li>MIS Reports</li> </ul>			

# Login Module

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The image shows a screenshot of a web application's login module. At the top left, there is a circular icon containing a key, followed by the text "Login". Below this, there are two input fields: "User ID:" and "Password:". To the right of the "Password:" field is a checkbox labeled "Remember me next time.". Below the checkbox is a "Log in" button. Underneath the "Log in" button is a link labeled "Forgot Password". At the bottom of the login section, there are two buttons: "Guest User" and "Request Access". Below the login section, there is a "News" section with a newspaper icon and the word "News".

 Login

User ID:

Password:

Remember me next time.

[Forgot Password](#)

 News

# GIS Layer Organization and Legends

The screenshot displays a GIS application interface with a central map of Rajasthan, India, showing district boundaries and names: Jaisalmer, Bikaner, Jodhpur, Nagaur, Jaipur, Alwar, Bharatpur, Dhaulpur, Sikar, Jhunjhunnur, Churu, Hanumangarh, and Ganganagar.

Three 'Map Content' panels are overlaid on the map:

- Left Panel:** Shows a legend for the '1st confined aquifer (m)' layer. It lists 17 geomorphological features with corresponding color swatches: Alluvial Fan, Alluvial Plain, Structural/Linear/Denudational, Burried Pediment, Alluvial Plain (Sardy), Desert Pavement, Dissected Plateau, Dissected Sandy Plain, Valley Fill, Ravine, Dune Complex, Dune Valley Complex, Salt Encrustation/Playa, Eolian Plain, and Flood Plain.
- Center Panel:** Shows a legend for the '1st confined aquifer (m)' layer. It lists 17 hydrogeological parameters: Electrical Conductivity (Pre-Monsoon-2009) ( $\mu\text{S}/\text{cm}$  at  $25^\circ\text{C}$ ), Chloride Isolines (Pre-Monsoon-2009) ( $\text{mg}/\text{l}$ ), Fluoride Isolines (Pre-Monsoon-2009) ( $\text{mg}/\text{l}$ ), Nitrate Isolines (Pre-Monsoon-2009) ( $\text{mg}/\text{l}$ ), Total Dissolved Solids (Pre-Monsoon-2009) ( $\text{mg}/\text{l}$ ), Water Logged Areas (Pre-Monsoon-2010), Water Level Fluctuation (2010) (m), Depth to Water Level (Pre-Monsoon-2010) (mbgl), Depth to Water Level (Post-Monsoon-2010) (mbgl), Water Table Elevation (Pre-Monsoon-2010) (mamsl), Depth to Bedrock (mbgl), Unconfined aquifer (m), 1st confined aquifer (m), and 2nd confined aquifer (m).
- Right Panel:** Shows a legend for the '1st confined aquifer (m)' layer. It lists 17 monitoring and survey locations: Ground Water Monitoring Stations, DGPS Based Ground Water Monitoring Stations, Exploratory wells (with a 'Check to include' button), Geophysical Survey Locations, RGWD WQ Monitoring Stations, Block Headquarters, District Headquarters, Raingauge Stations, Isohyets - Year 2010 (mm), Water Bodies, River Basins, Hydrogeology, Geology, and Transportation.

# Search Functionality – Menu Based

Locate Ground Water Monitoring Stations Based on Agency

District: Ajmer

Block: Arain

Agency: RGWD

Search Reset

1

Locate Ground Water Monitoring Stations Based on Well Type

District: Ajmer

Block: Arain

Well Type: D/W

Search Reset

2

- Searches
- Metadata
- Locate Ground Water Monitoring Stations Based on Agency 1
- Locate Ground Water Monitoring Stations Based on Well Type 2
- Locate Village/Town 3
- Locate Block Headquarters 4
- Locate Major Aquifers 5

Locate Village/Town

Distname: Ajmer

Blockname: Arain

Villagename: Auu

- Auu
- Adeda
- Ahera
- Ajaysar
- Ajba Ka Bariya
- Ajgara
- Ajgari
- Ajmer (M CI)
- Akhri
- Akrol
- Alambo
- Alipura
- Almas
- Aloli
- Amali
- Amali (Jooniyan)
- Amargarh
- Amarpura
- Amarpura (Akrol)
- Amarpura(Kali Kankar)
- Amarpura(Khera Kalan)
- Amarsingh Ka Badiya
- Amba Maseena
- Ambapura
- Anakar
- Andhi Deori
- Aokhriya

3

Locate Major Aquifers

Aquifer: Older Alluvium

Search Reset

5

Locate Block Headquarters

District: Bundi

Headquarter: Like

Search Reset

4

# Village Resource Tool – Scenario 2

Gallery FAQ Ground Water Facts Atlas Contact Us About Us

District:  Block:  Gram Panchayat:(Optional)  Village:

Pre-Monsoon Depth to water level (mbgl) :  (Please enter the depth to water level as on 15th June)

Post-Monsoon Depth to water level (mbgl) :  Date:

**Ground Water Quality:** Not Suitable for drinking purpose due to high fluoride content.

**Ground Water Resource:** 21000.00 cubic meter of dynamic ground water resource is indicated in your village as of 12-Aug-2013.

**Domestic Water Requirement as per available / current population (based on census-2001 and @ 40 lpcd ) till next monsoon (15th June 2014):** 22202.24 cubic meter will be required.

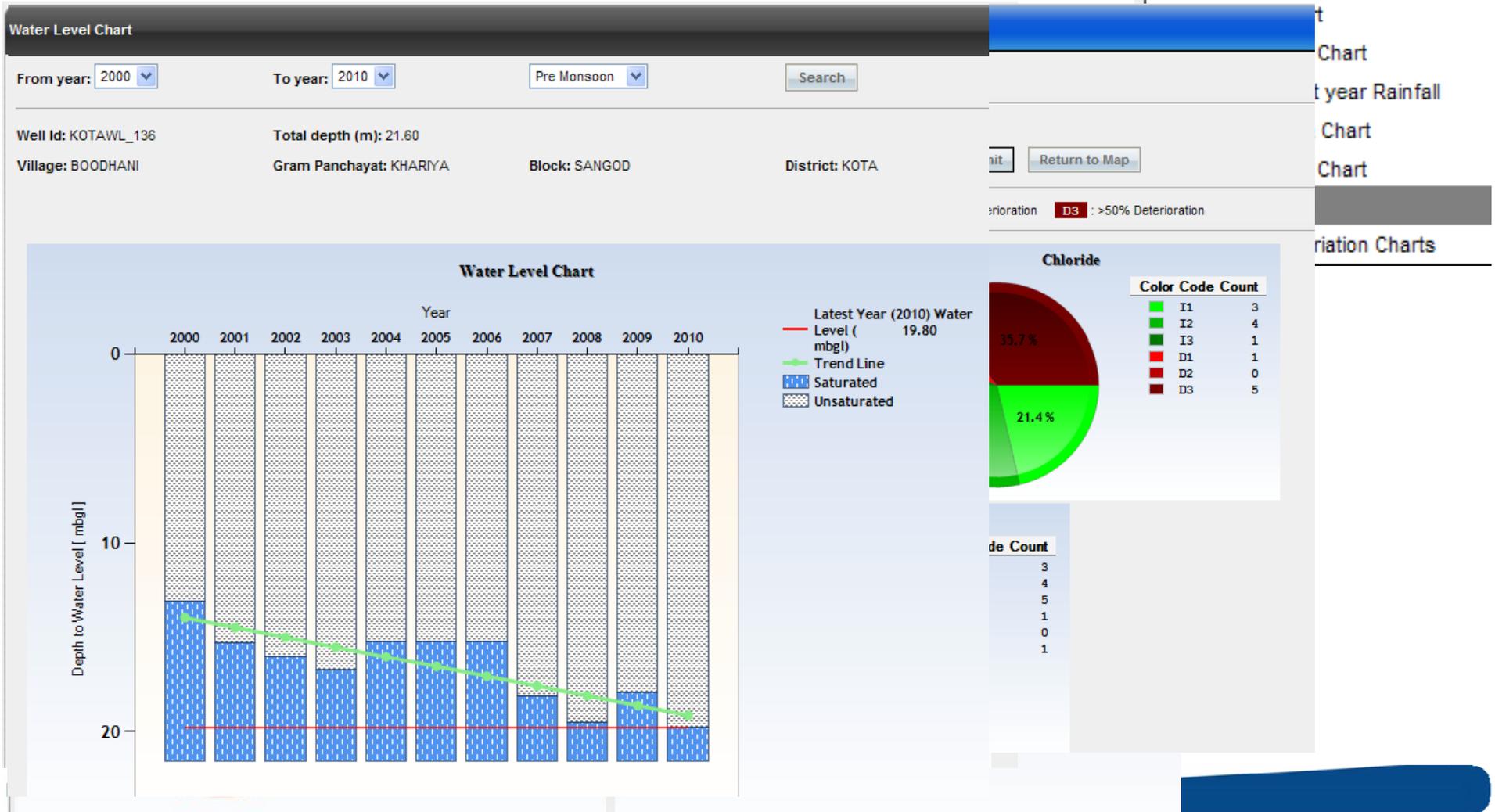
**Deficiency of Ground Water for Domestic Purpose as per current population (Census – 2001) @ 40 lpcd till next monsoon (15th June 2014):** 1202.24 cubic meter

You are going to withdraw static ground water resource. It is very-limited and it is very important to keep the reserve for Drought period. Thus ground water should not be utilized for other purposes.

Please encourage rain water harvesting in your village by making use of Tanka's etc.

**Ground Water Balance Available for other uses till next monsoon (15th June 2014):** Not Available

# Charts



# Accessing Atlas Library



Includes Atlas reports of state,district and basin.

- [-] Hydrogeological Atlas of Rajasthan
  - [-]
    - Rajasthan State Ground Water Atlas 2013.pdf
  - [+]
  - [-]
    - BANAS
      - [-] BANGANGA
        - Basinwise Atlas - Banganga River basin.pdf
      - [+] CHAMBAL
      - [+] GAMBHIR
      - [+] GHAGGAR
      - [+] KANTLI
      - [+] LUNI
      - [+] MAHI
      - [+] OTHER NALLAHS
      - [+] OUTSIDE BASIN
      - [+] PARBATI
      - [+] RUPARAIL
      - [+] SABARMATI
      - [+] SABI
      - [+] SHEKHAWATI
      - [+] SUKLI
      - [+] WEST BANAS

# Published Reports



<u>Technical Report(1)</u>	:	Review and Evaluation of Existing Data and Information.
<u>Technical Report(2, A)</u>	:	Strategy for GIS creation and Recommendation for SW/HW /DB / GIS and RASA Tools.
<u>Technical Report (2, B)</u>	:	Hard copy of GIS Maps – District Wise (Base, Geomorphology and Ground Water Potential Zone Maps).
<u>Technical Report (3, A – Part 1)</u>	:	Review of the Existing Methodology, Practices and Status of Ground Water Resources Assessment.
<u>Technical Report(3, A – Part 2)</u>	:	Hydrological unit wise 3D demarcation of aquifers and Preparation of aquifer wise isopach maps.
<u>Technical Report (3, B)</u>	:	Onetime Assessment of Groundwater Resources, Draft and Balance.
<u>Technical Report (4, A)</u>	:	Aquifer Wise Apportion Of Groundwater Resources at Village Level.
<u>Technical Report (4, B)</u>	:	Training Modules for various level of Ground Water Professionals.
<u>Technical Report(4, C)</u>	:	Mechanism for Collection of Requisite Data and Parameters at Community Level for Seasonal Assessment of Ground Water Resources.
<u>Technical Report (4, D)</u>	:	Appropriate Strategies and Action Plan for Strengthening Local Institutions and End Users for Ground Water Management.
<u>Draft Final Report</u>	:	Draft Final Report
<u>Final Report</u>	:	Final Report

## Benchmarking

<u>Technical Report (1)</u>	:	Review and Evaluation of Existing Ground Water Monitoring Networks for water level and water quality.
<u>Technical Report (2)</u>	:	Optimization of Ground Water Monitoring Network for water level and water quality.
<u>Technical Report (3)</u>	:	Mechanism for Integration of GWD and CGWB Data.
<u>Technical Report (4)</u>	:	Training Modules for various levels of Ground Water Professionals.
<u>Draft Final Report</u>	:	Draft Final Report
<u>Final Report</u>	:	Final Report

# Road Ahead

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- Computerization of all the district offices,
- Improving the distribution and accuracy of parameters for GW assessment,
- Synergy and interaction with other water related departments within State and Centre
- Continuous learning and enhance of skills
- Involvement of village level stakeholders through awareness raising campaigns

THANK YOU.....



"Not only the thirsty sobs water..... the water as well sobs thirsty" —Bumi..

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Additional slides  
(if required)



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**A typical basin approach walk through  
– Banganga basin**



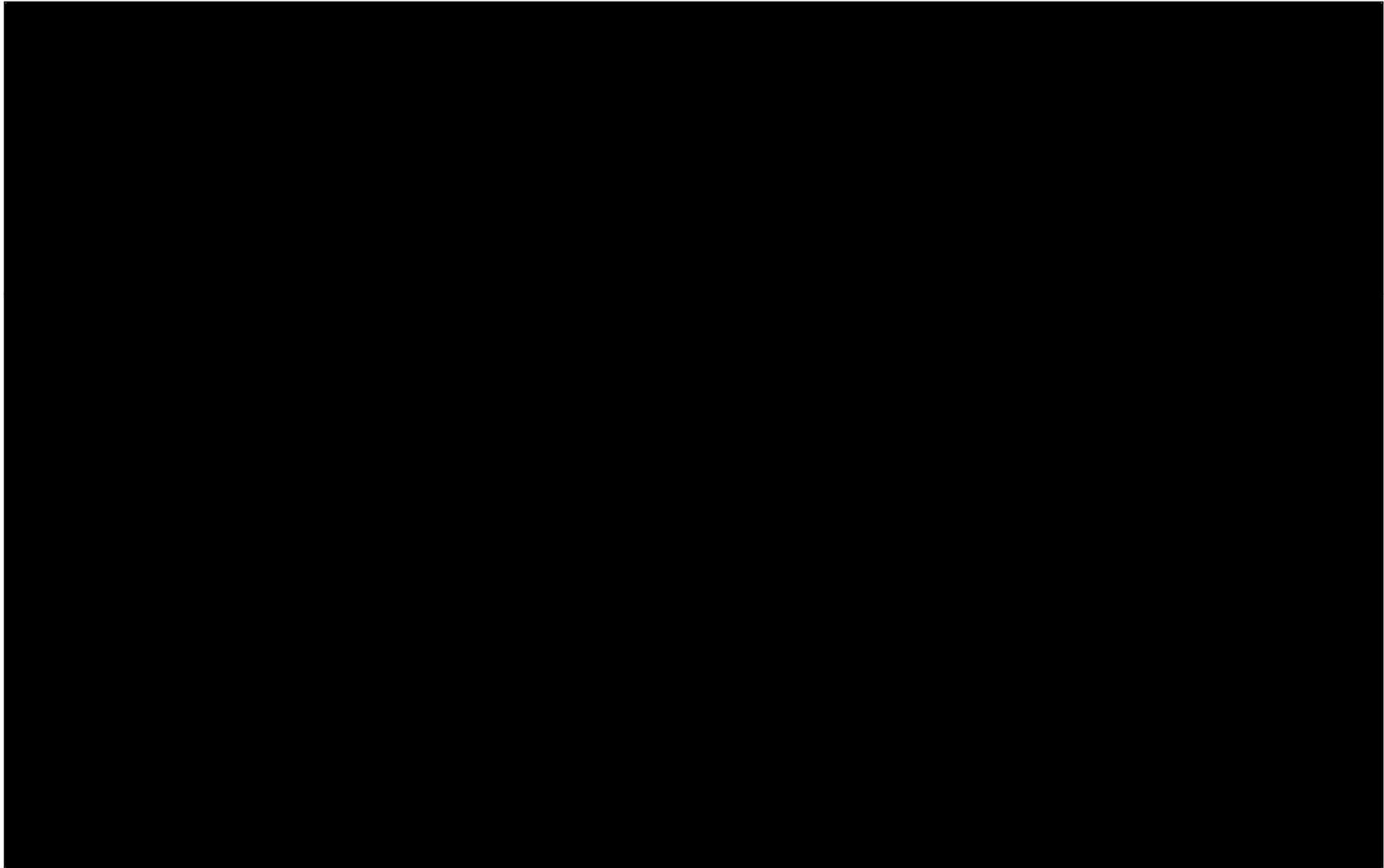
# BANGANGA RIVER BASIN - Topography

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# BANGANGA RIVER BASIN - Aquifer Distribution

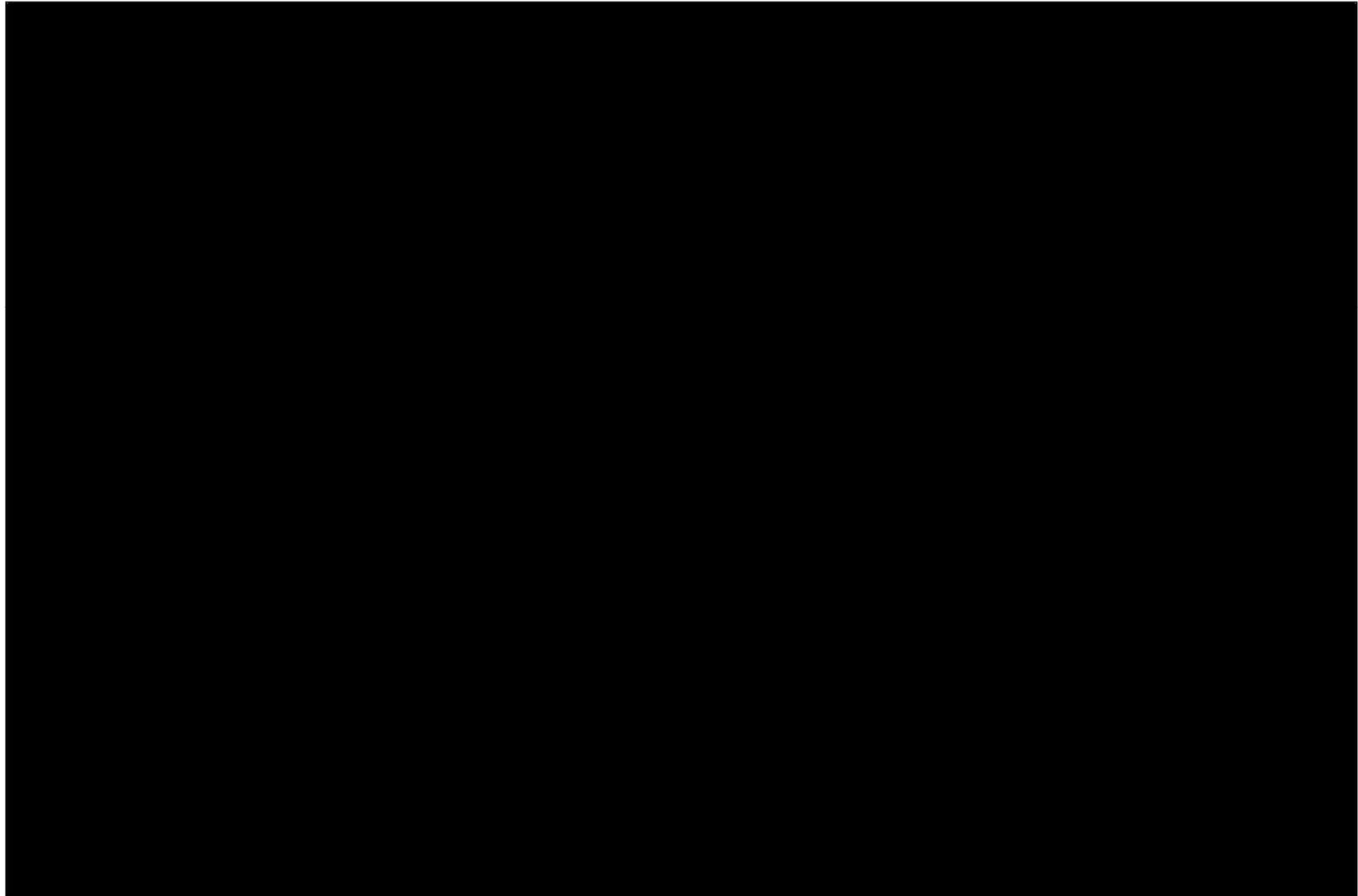
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# BANGANGA RIVER BASIN –

Pre-Monsoon Depth to Water level (2000-09)

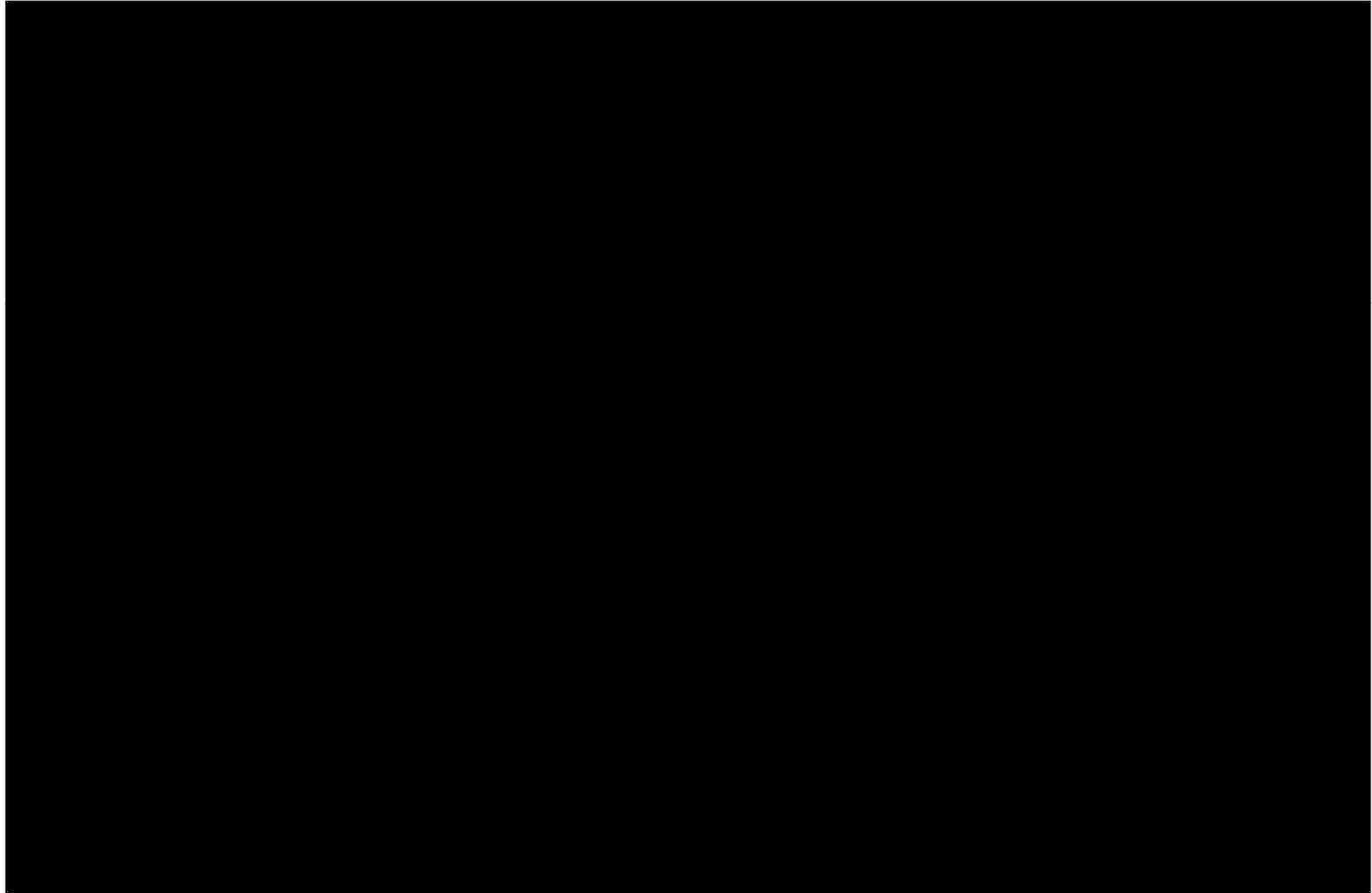
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# BANGANGA RIVER BASIN –

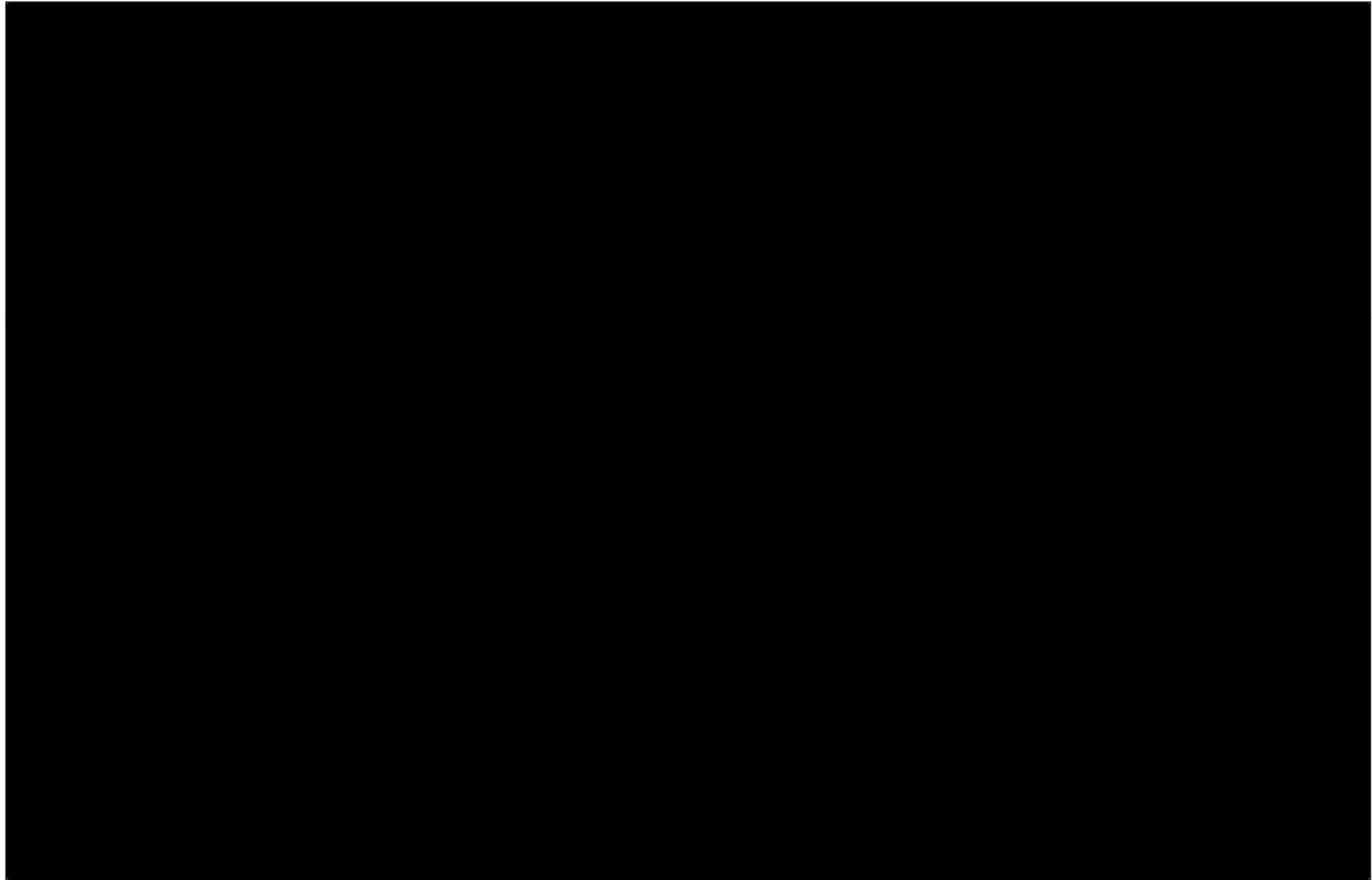
Water level fluctuation (Pre-Post Monsoon, 2010)

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# BANGANGA RIVER BASIN –

Average Ground Water EC (Pre-Monsoon 2005-09)



# BANGANGA RIVER BASIN –

## Thickness of Unconfined Aquifer

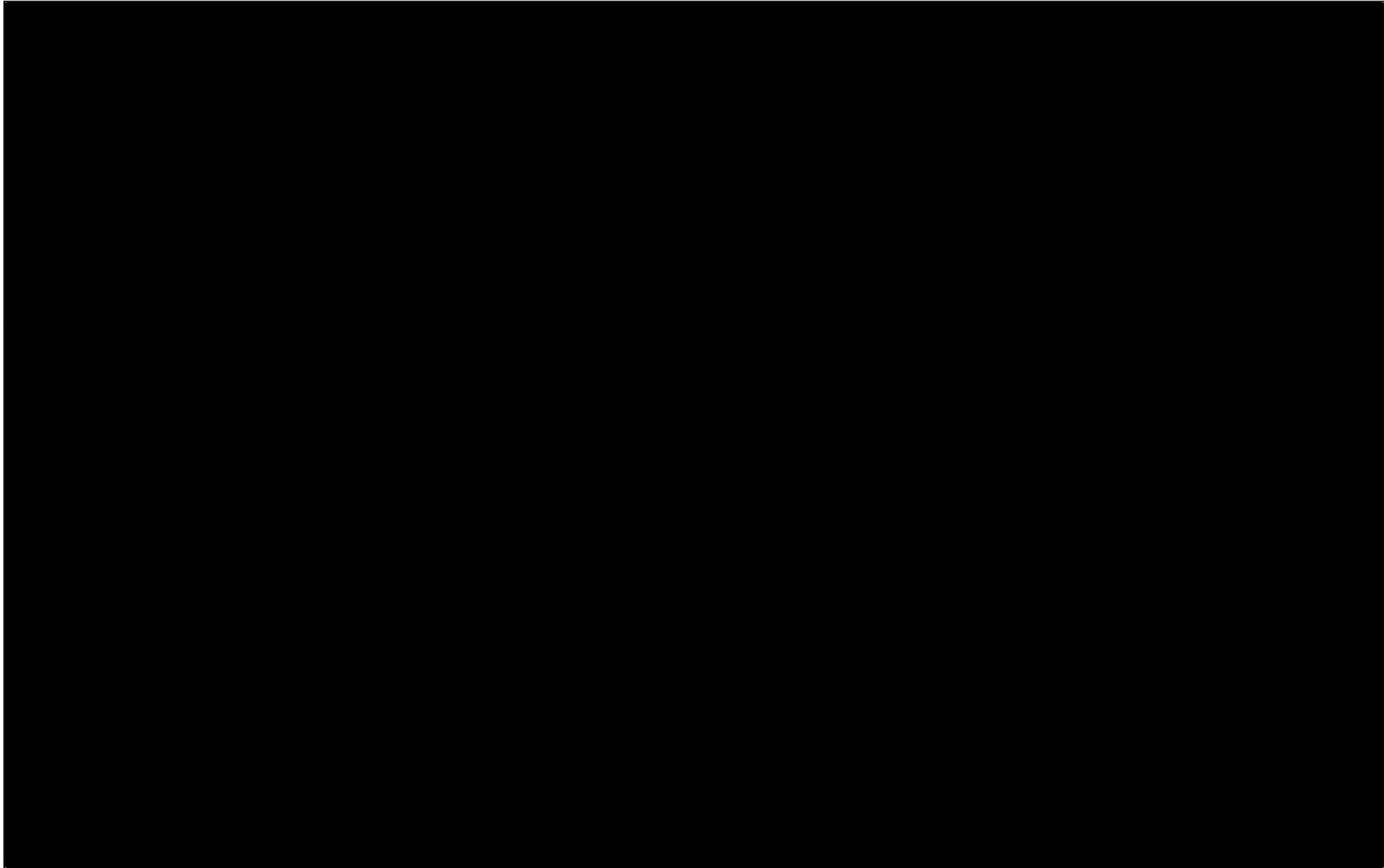
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# BANGANGA RIVER BASIN –

## Thickness of First Confined Aquifer

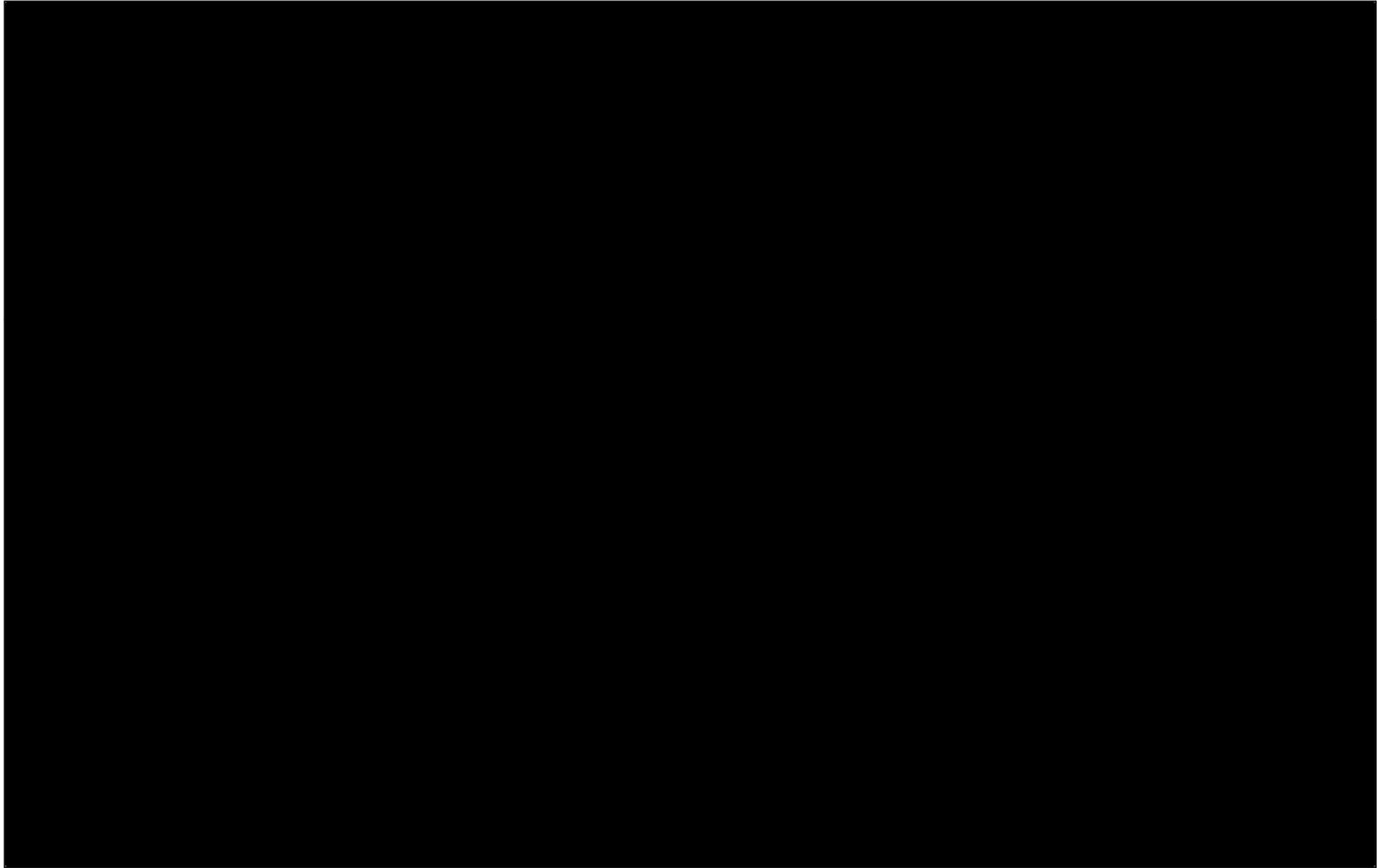
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# BANGANGA RIVER BASIN –

## Thickness of Second Confined Aquifer

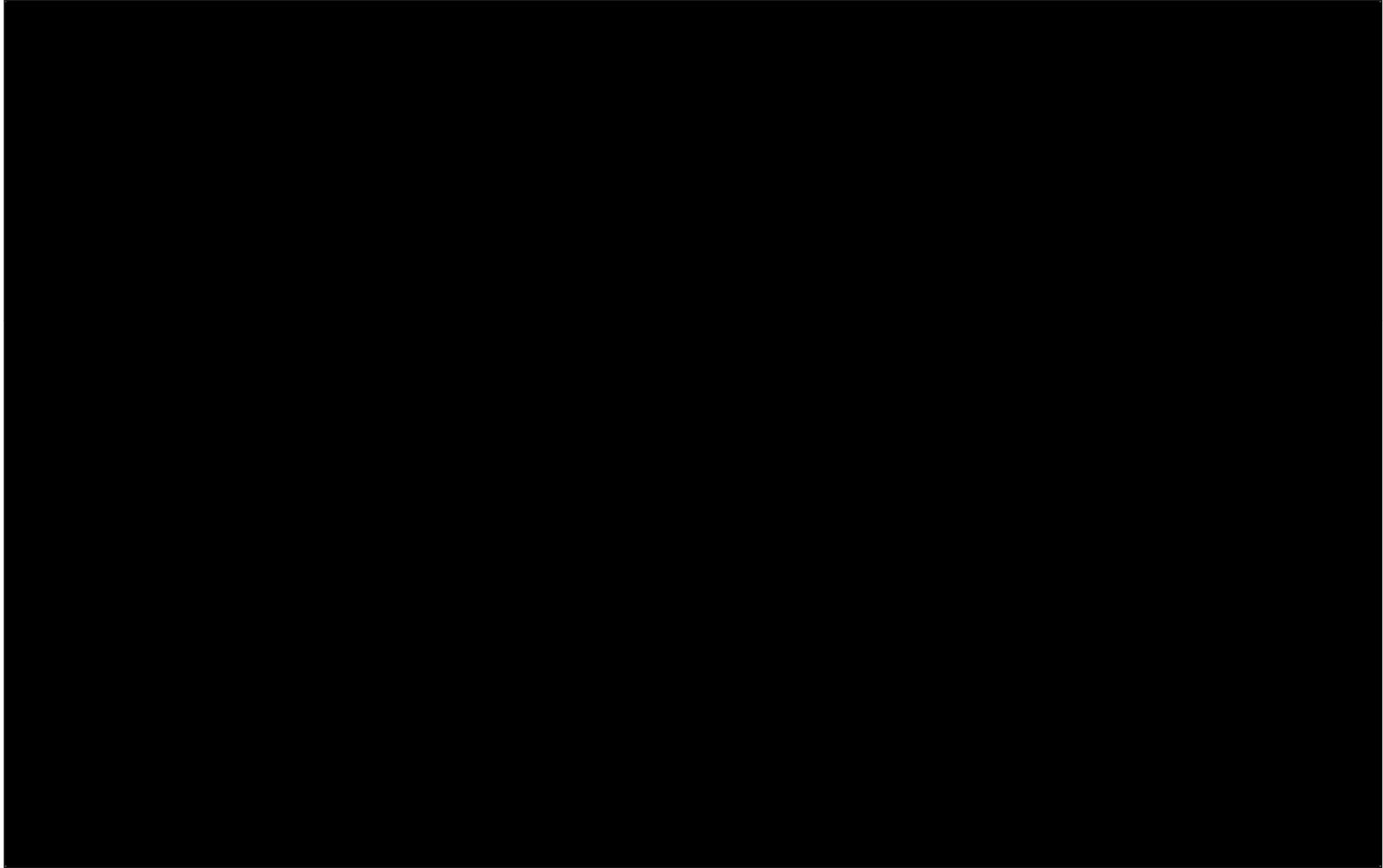
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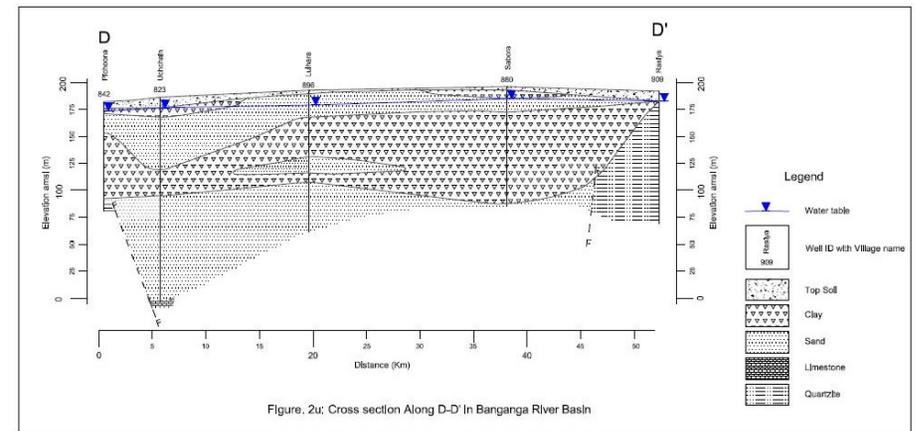
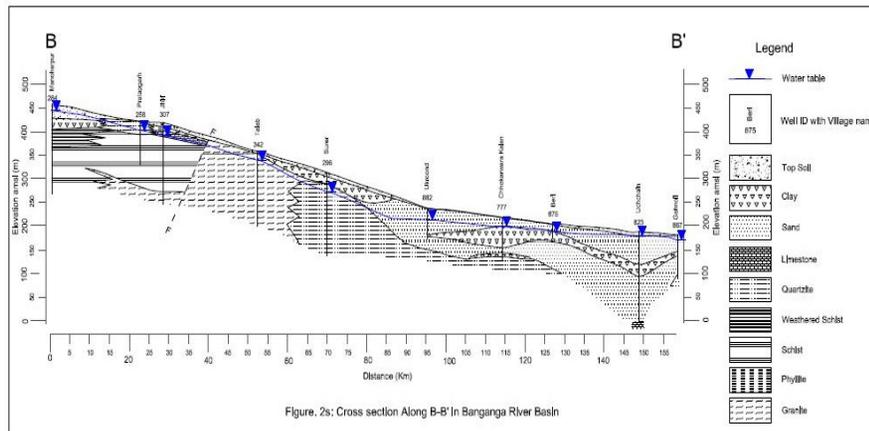
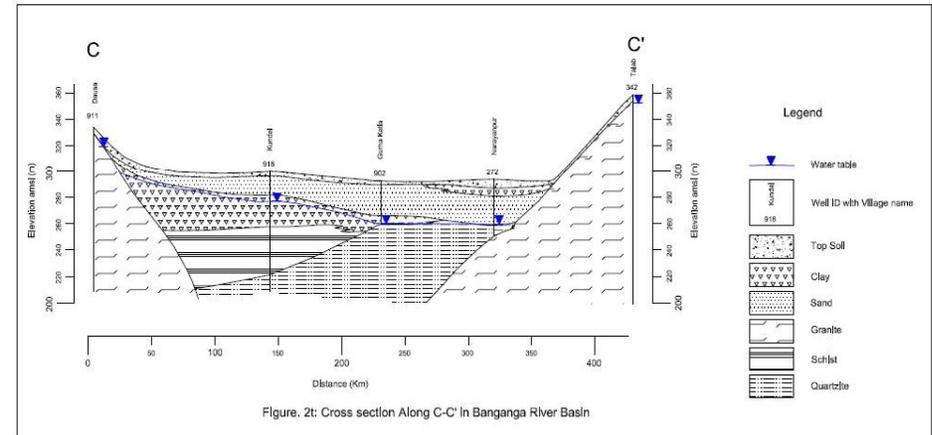
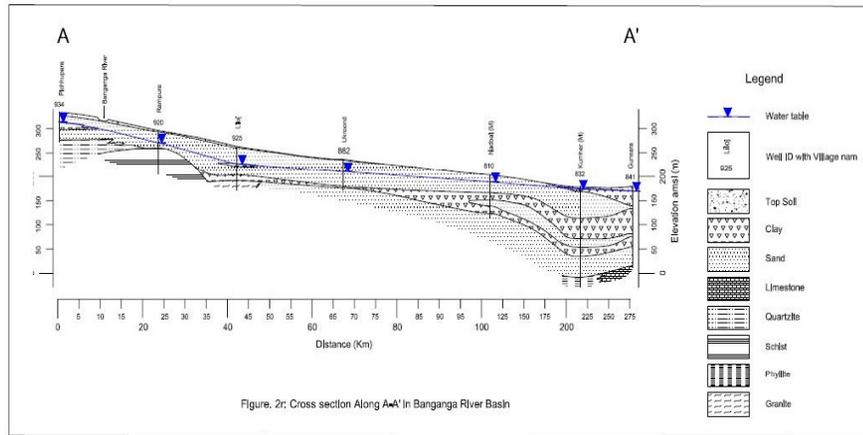
# BANGANGA RIVER BASIN –

Depth to Bedrock

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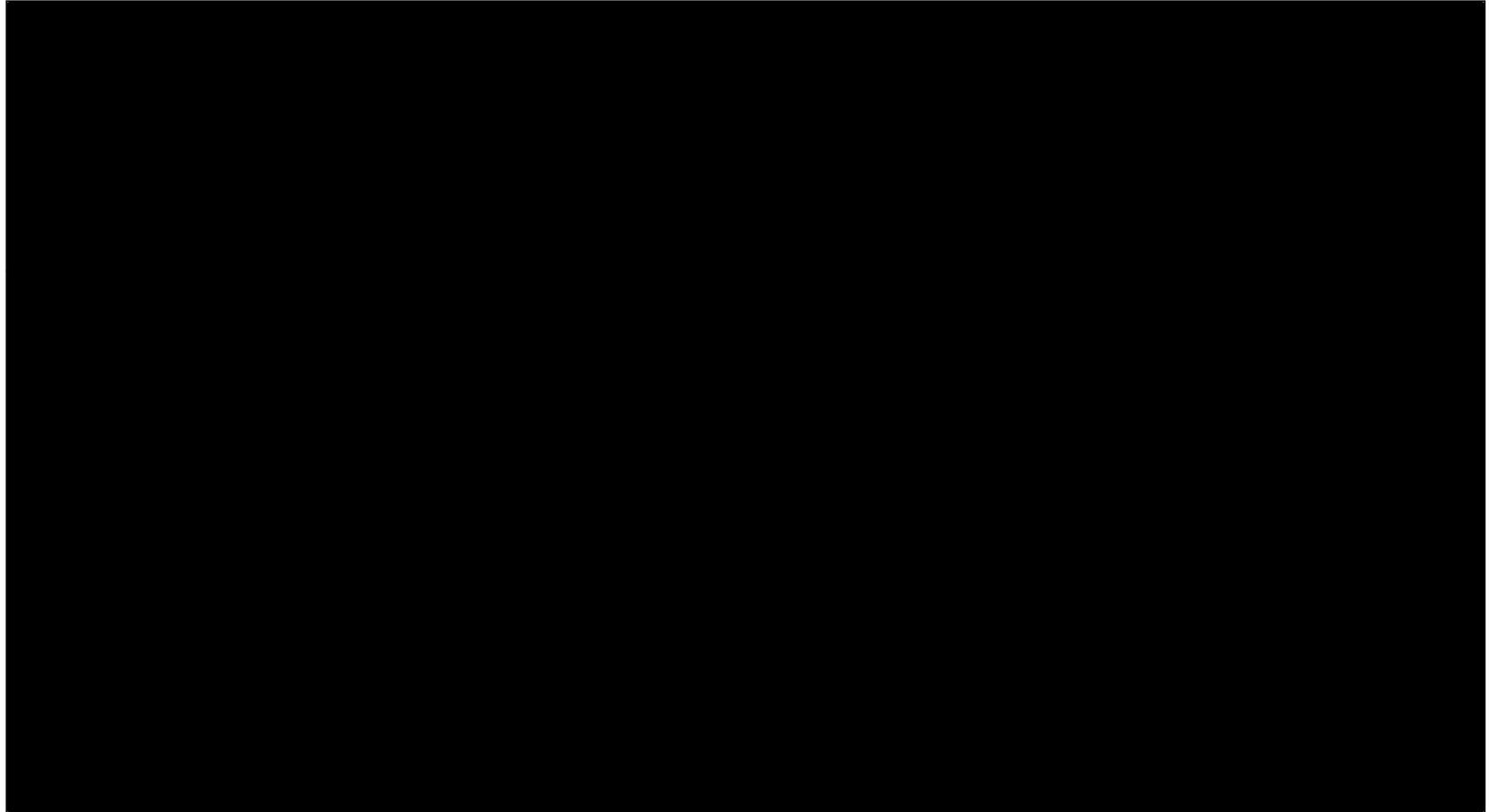
# BANGANGA RIVER BASIN – Hydrogeological Cross-sections



# BANGANGA RIVER BASIN –

## 3D Aquifer Model

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# Monitoring Network Strengthening

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- DGPS survey for establishment of sub-meter accurate X, Y and Z of more than 8000 wells,
- Geostatistical techniques in GIS were used for carrying out benchmarking and optimization of monitoring network,
- Separate analysis for water quality and water level have been carried out at sub-aquifer level,
- Recommendations for both reduction network of wells in areas where possible and strengthening in other areas made. Use of AWLR/DWLRs also made,