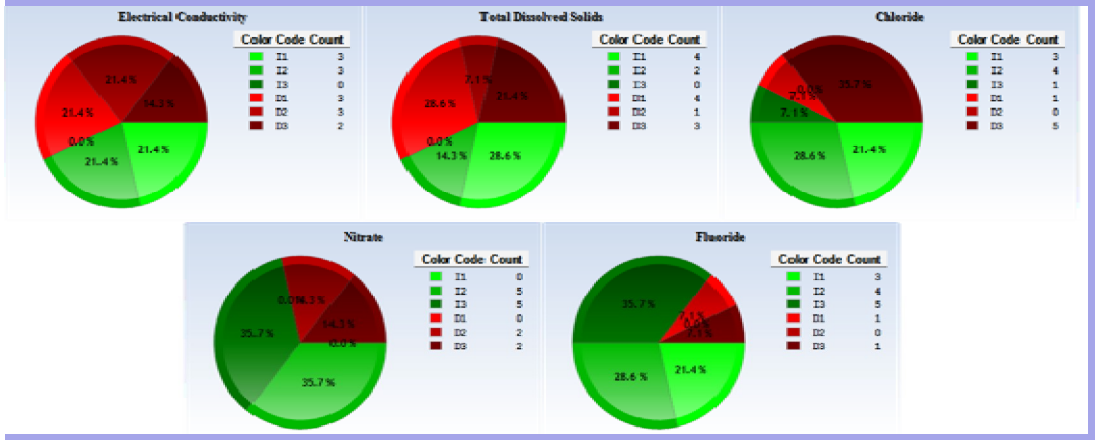
Ground Water Department, Rajasthan

Rolta India Limited

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
Total	**33.94**	**24.21(70%)**
Grand Total	**45.09**	**39.78 (88%)**

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

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

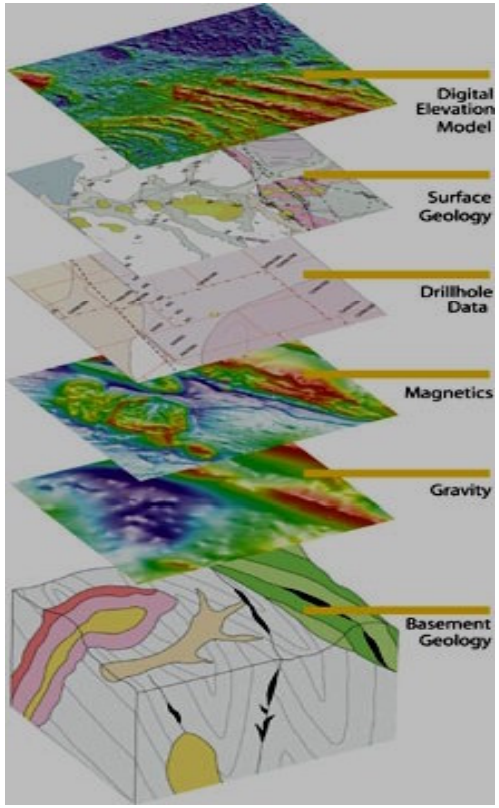
- € 73.5 mn for the government of Rajasthan implementation from 2007 till December 2013
- Remaining € 6.5 mn – Technical Assistance, Monitoring/Evaluation, Audits (EU contracted)

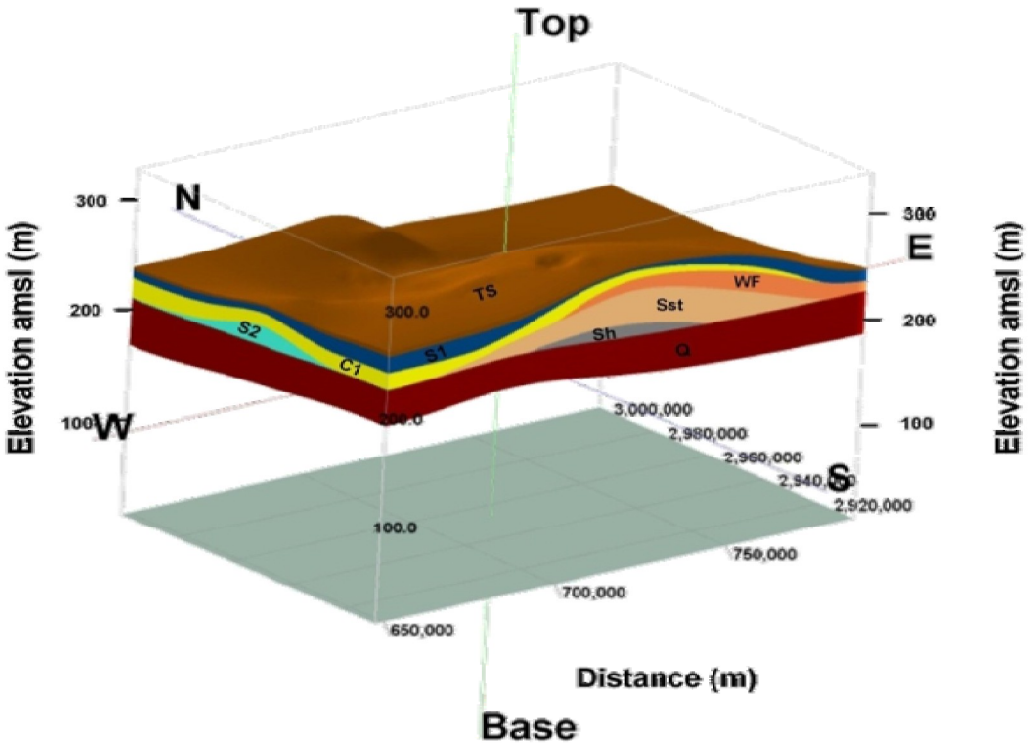
Time period 2007 – 2013 (extended up to Dec. 2015)

Problems in Ground Water Management

- 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

- 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

Computerization of 25 yrs of GW data

Digitization of Maps and linking to database

Digital data linking (Census data etc.)

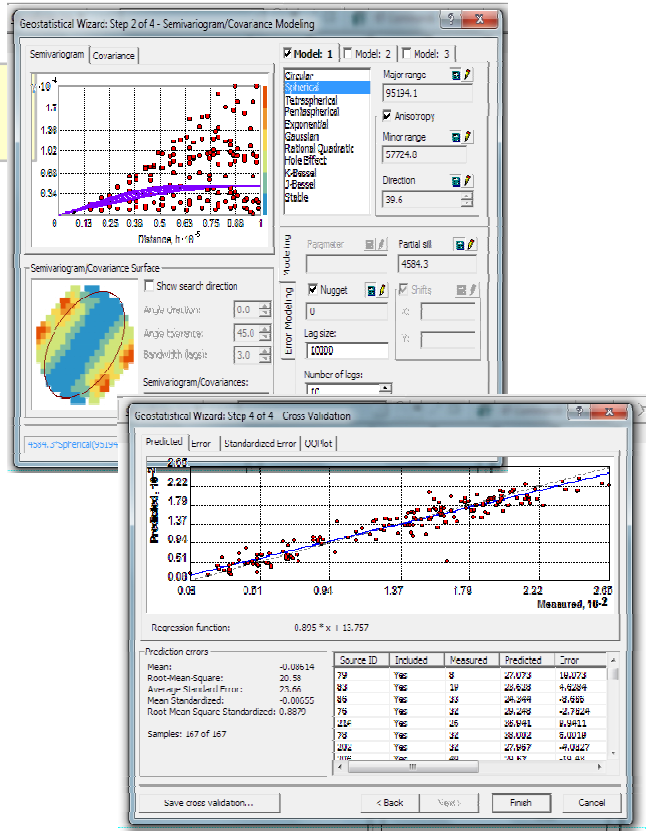
Integrated GIS Database

Interpretation of Lithologs

Cross-sections and 3D Aquifer maps

Overlay Analysis and Geostatistics

Policies/ Guidelines



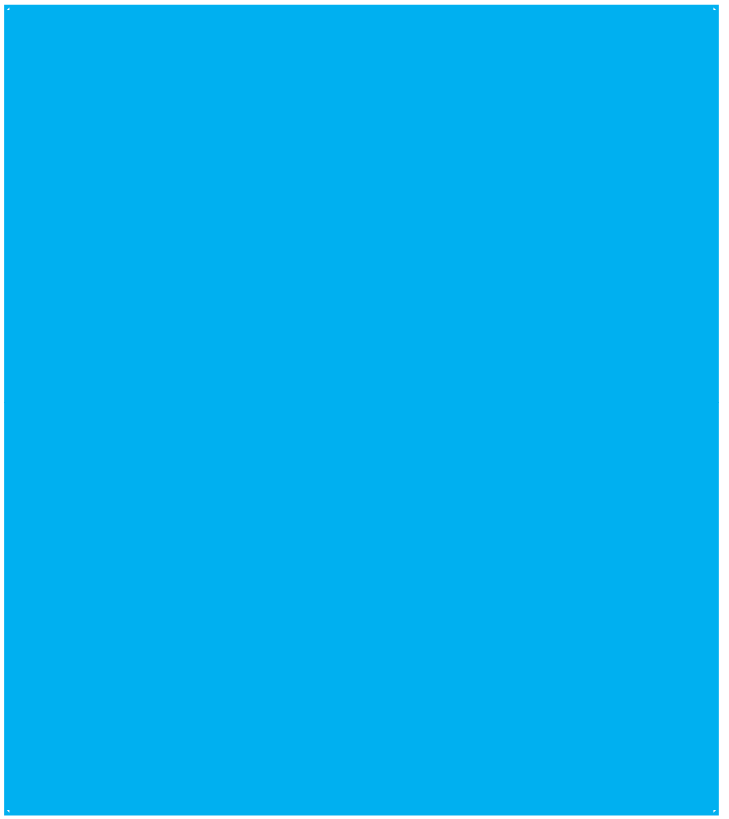
- Aquifer and Basin wise approach adopted
- Monitoring network Benchmarking and Optimization
- Ground Water Resource estimation
- Village level resource apportion
- Recharge potential estimation
- GW Resource estimation methodology improvement
- District wise and Basin wise Ground Water Atlases
- Training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

Rolta Onpoint based Web Portal to host GIS application

Inputs Used

- 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

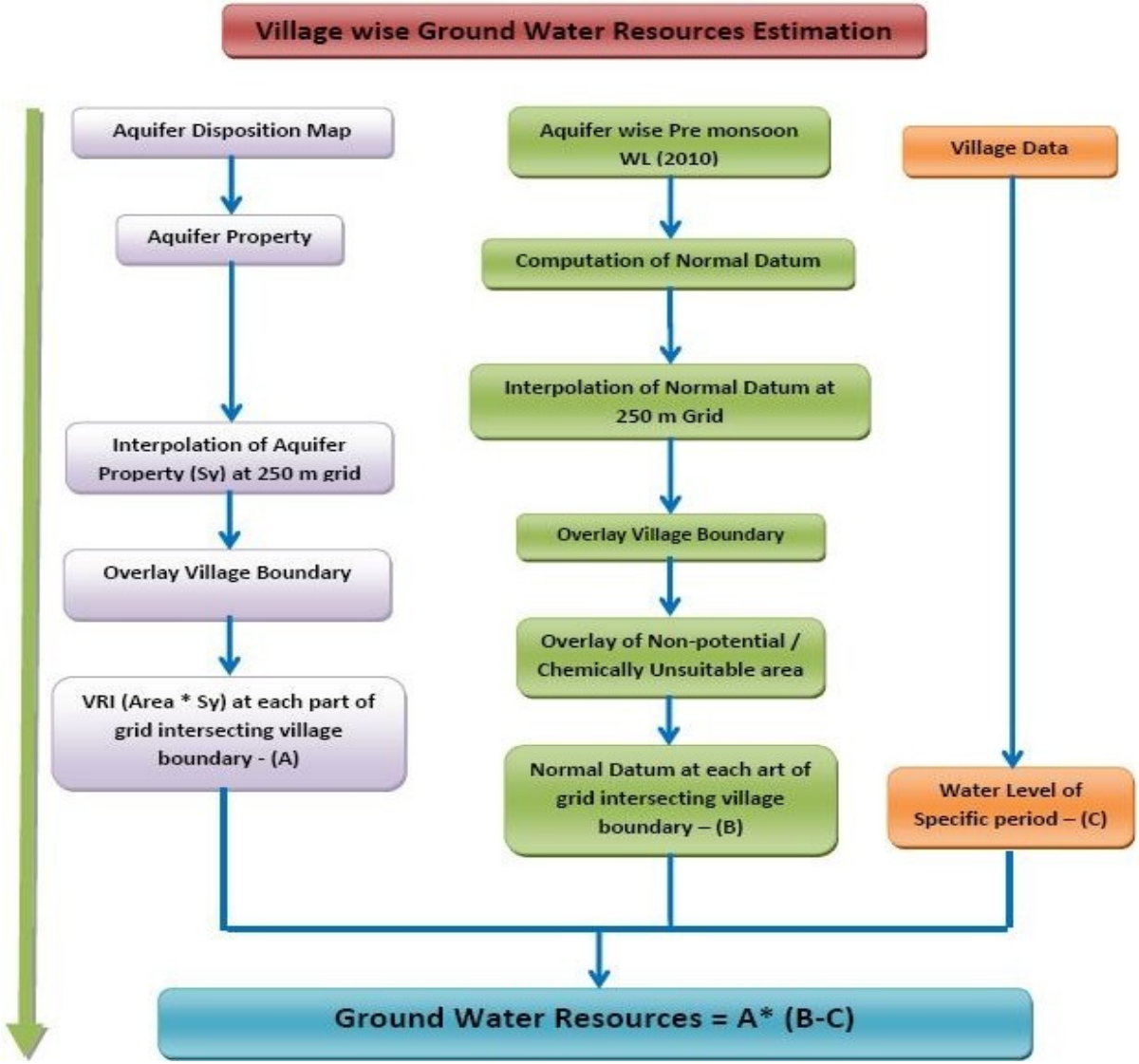
Basin Wise Thematic Maps

- 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

- 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

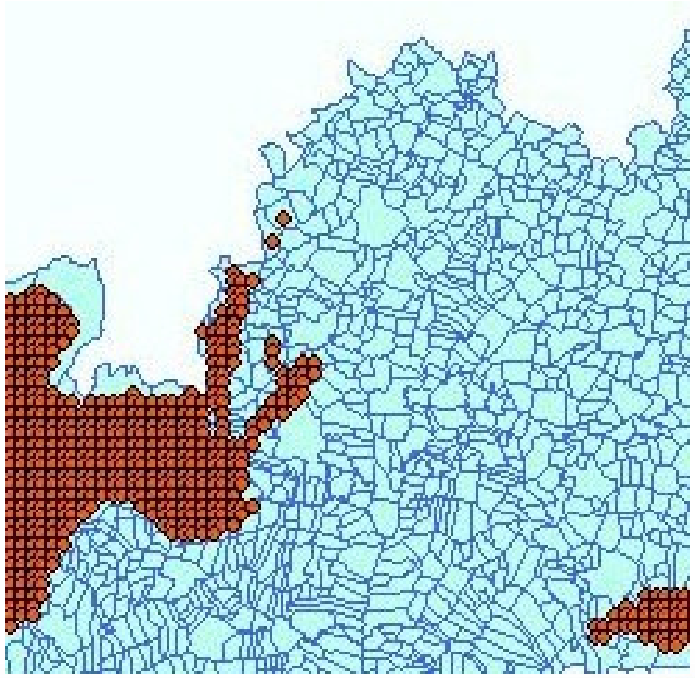
Static and Dynamic GW Resources- Rajasthan

(Aquifer wise)

Aquifer Name	Dynamic Resources * (mcm)	Static Resources * (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
Total	**14,025.82**	**411,094.93**

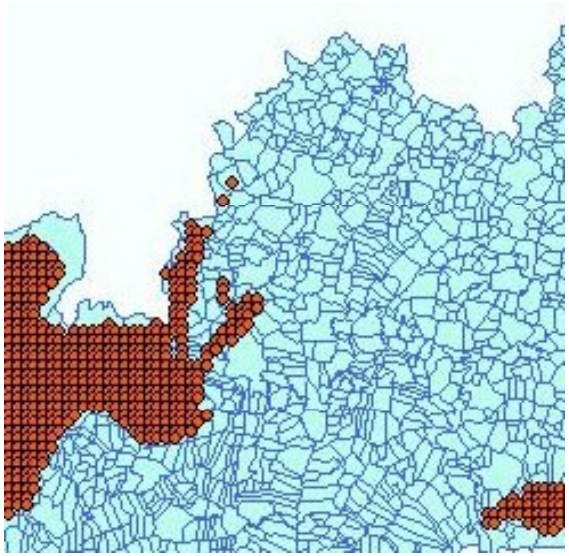
Achievements

- 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.

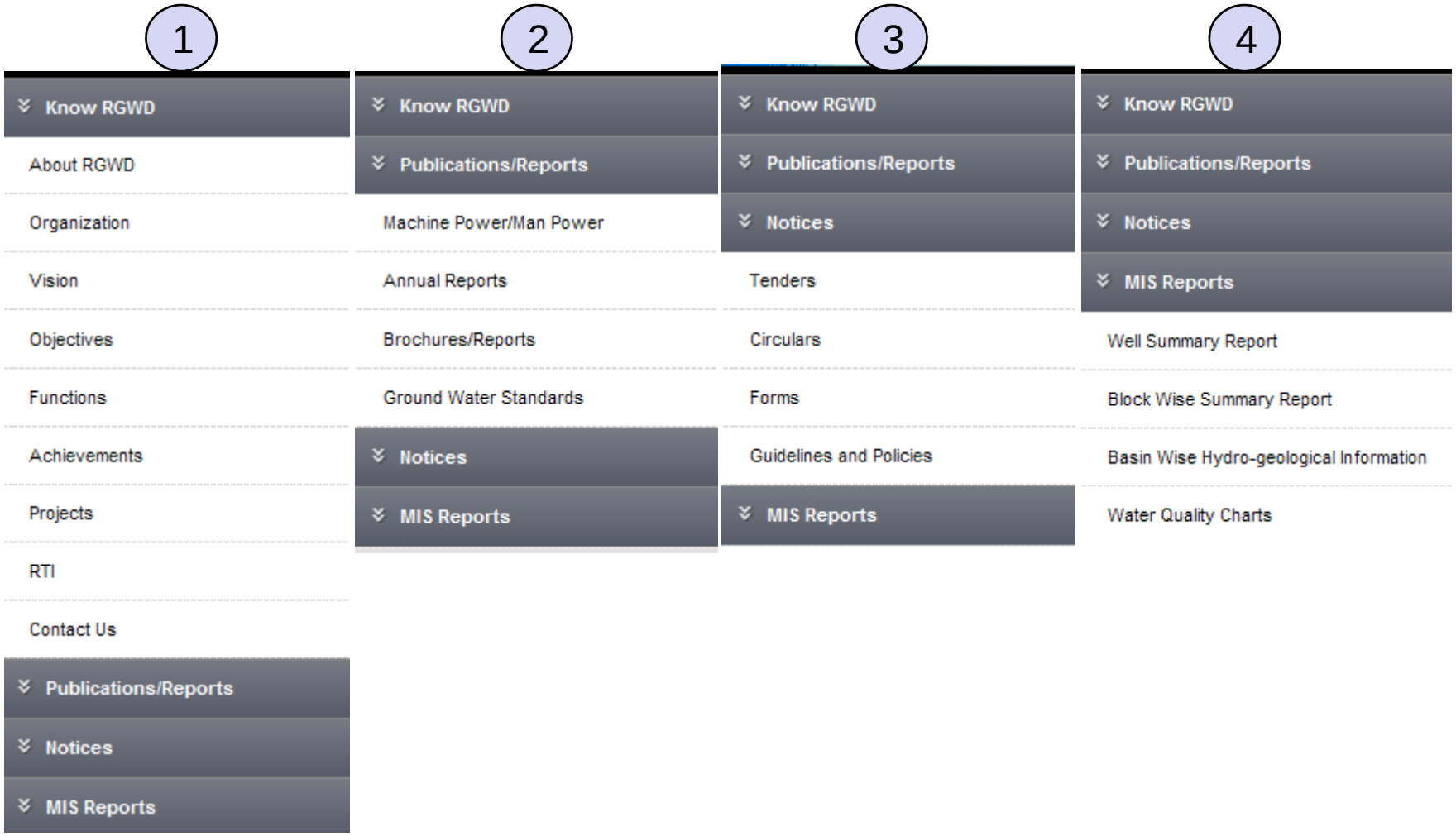


Final outcome of the project implementation

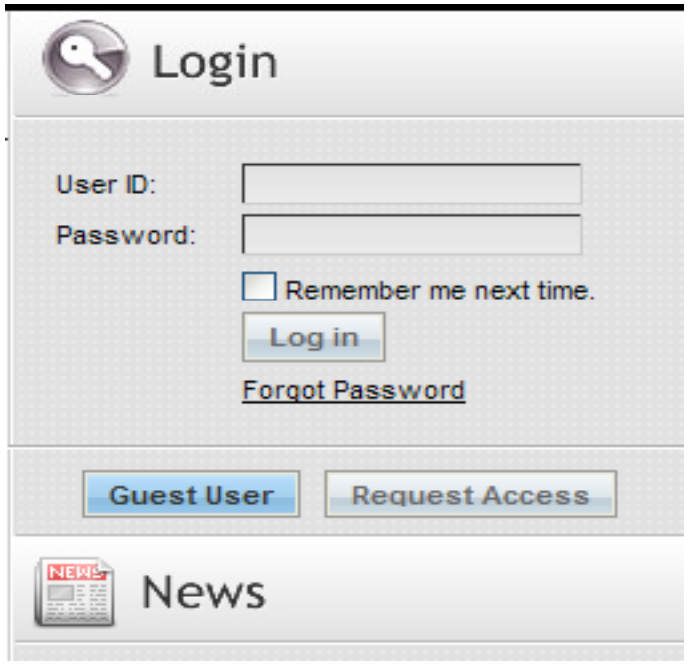
–One Point based Web GIS Solution

Link: http://gwd.rajasthan.gov.in

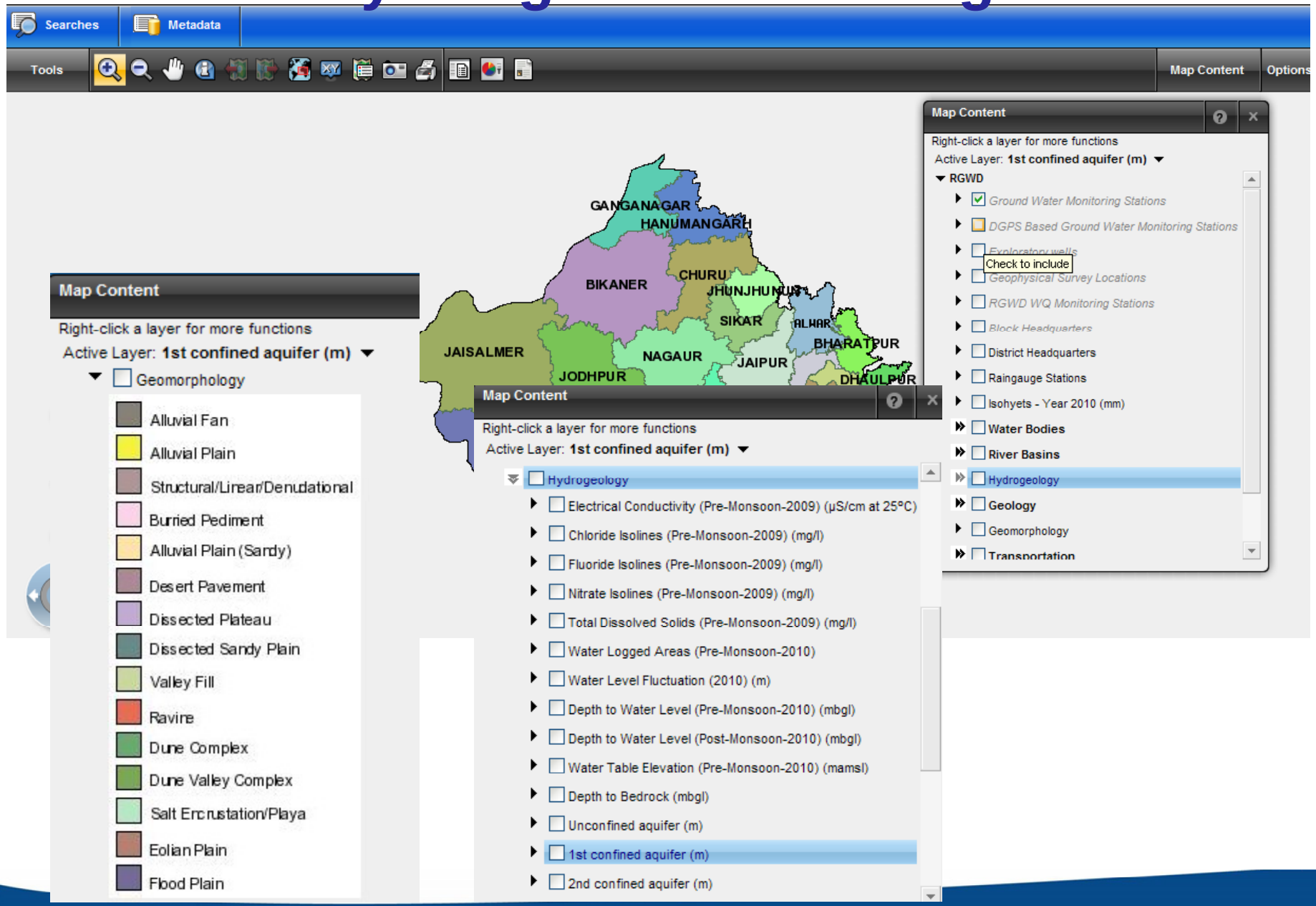
Detailed navigation on the first page



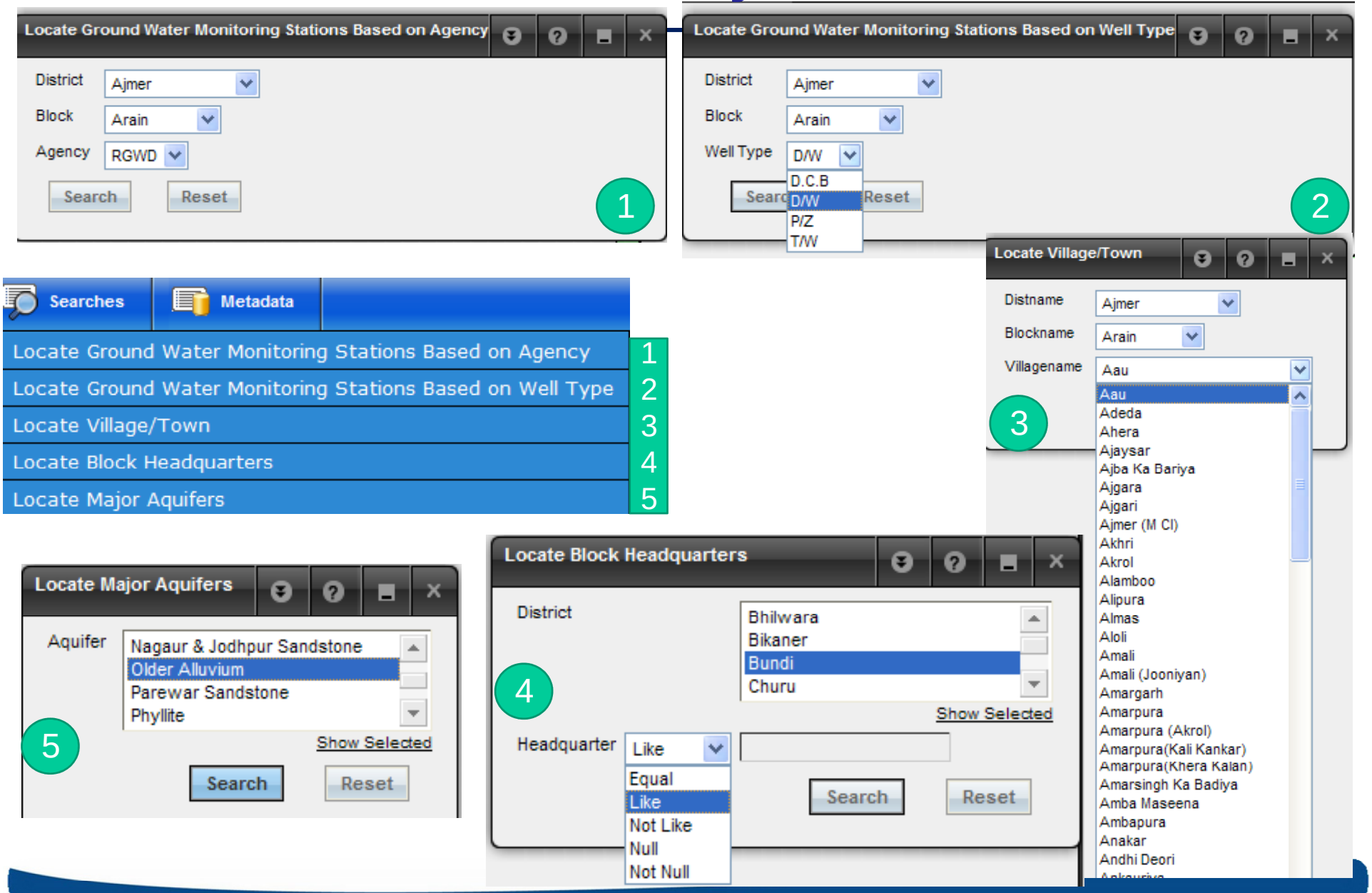
Login Module



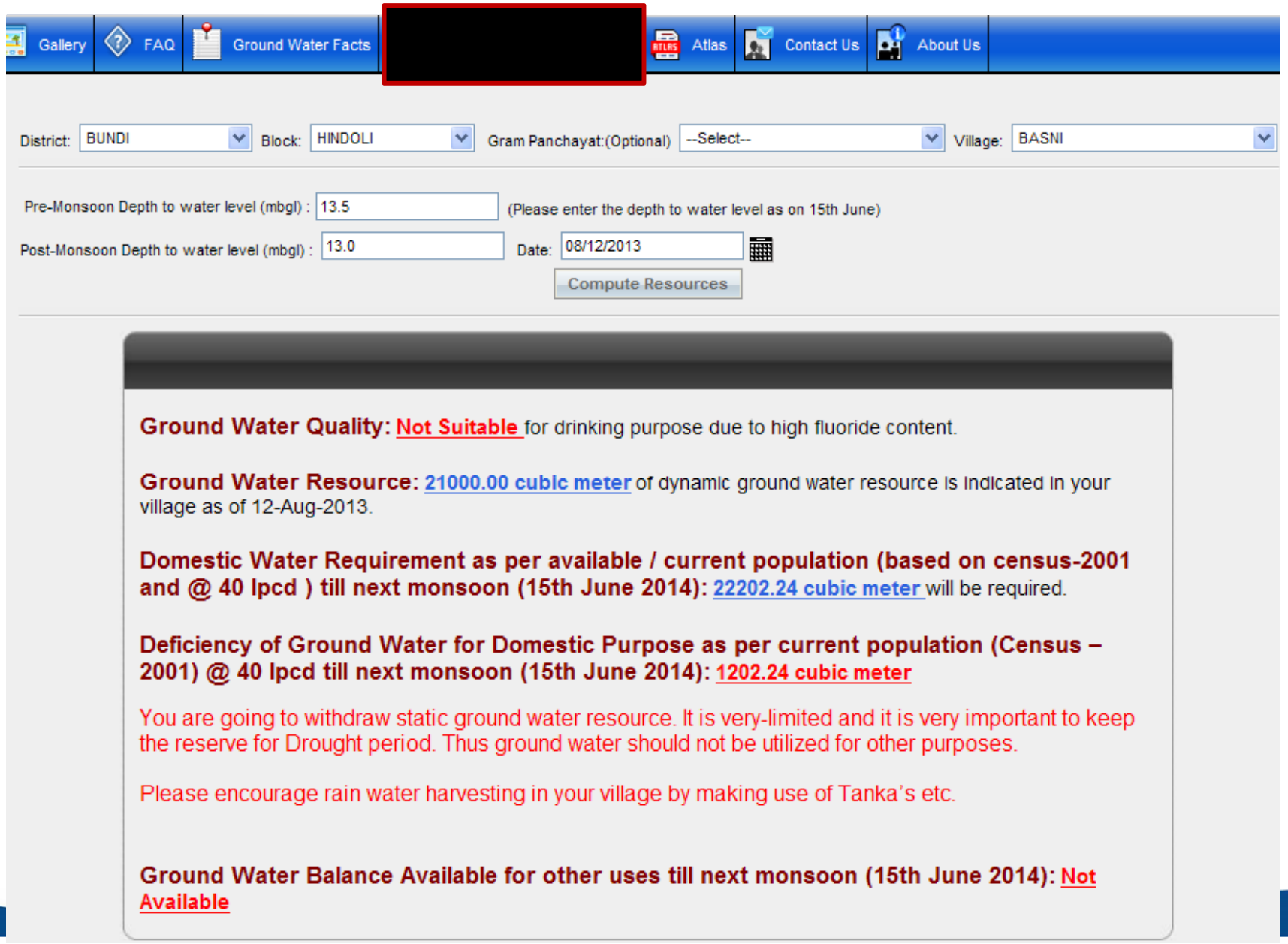
GIS Layer Organization and Legends



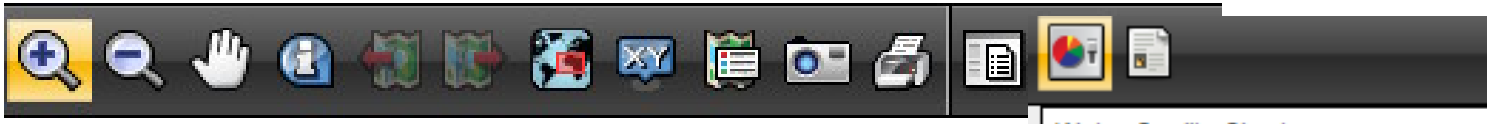
Search Functionality – Menu Based



Village Resource Tool – Scenario 2



Charts



Water Quality Chart

Chart

year Rainfall

Chart

Chart

riation Charts

Water Level Chart

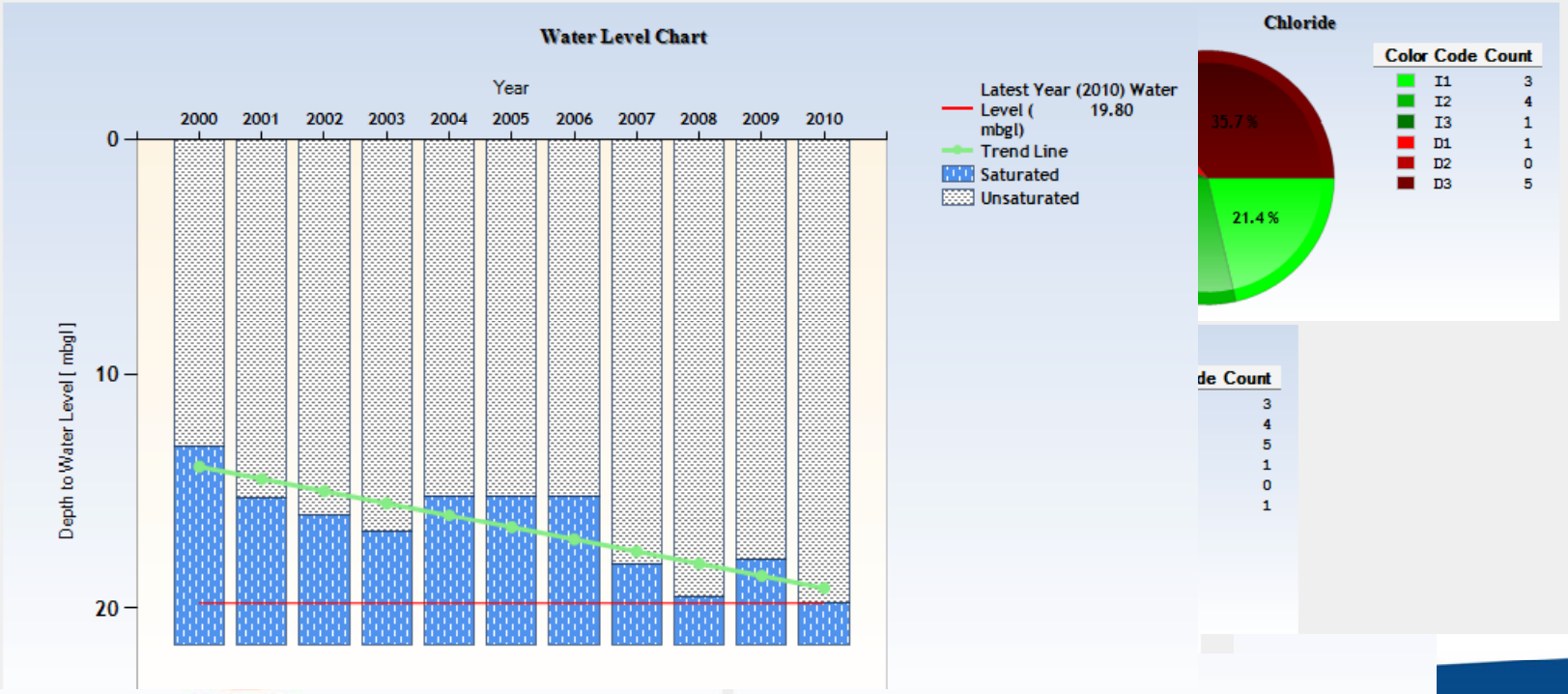
From year: 2000 To year: 2010 Pre Monsoon Search

Well Id: KOTAWL_136 Total depth (m): 21.60

Village: BOODHANI Gram Panchayat: KHARIYA Block: SANGOD District: KOTA

Return to Map

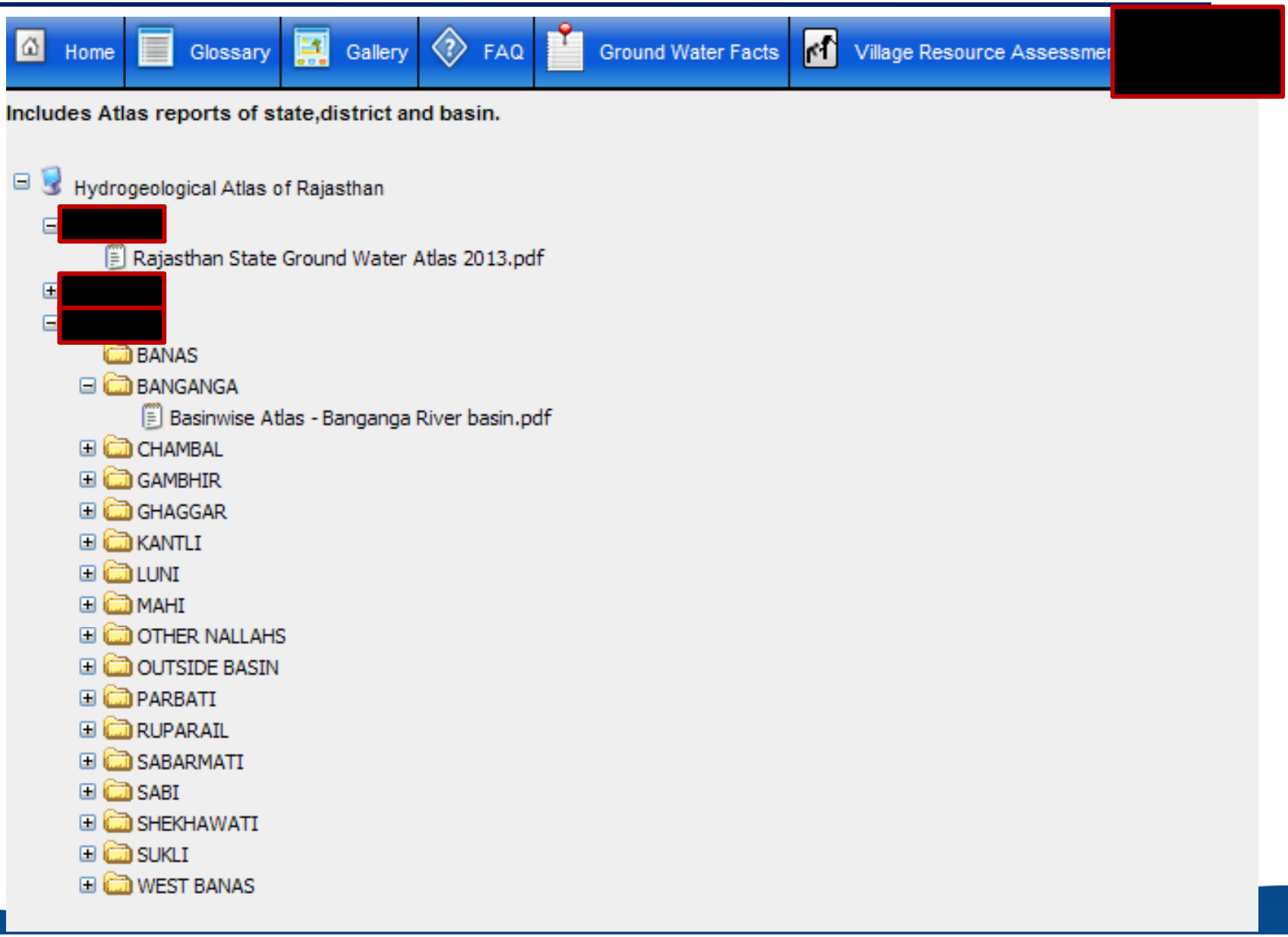
D3 : >50% Deterioration



de Count

3
4
5
1
0
1

Accessing Atlas Library



Published Reports

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

Benchmarking

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

Road Ahead

- 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 Seeks Water..... the water as well Seeks Thirsty" —Rumi..

Additional slides
(if required)

A typical basin approach walk through – Banganga basin

BANGANGA RIVER BASIN - Topography

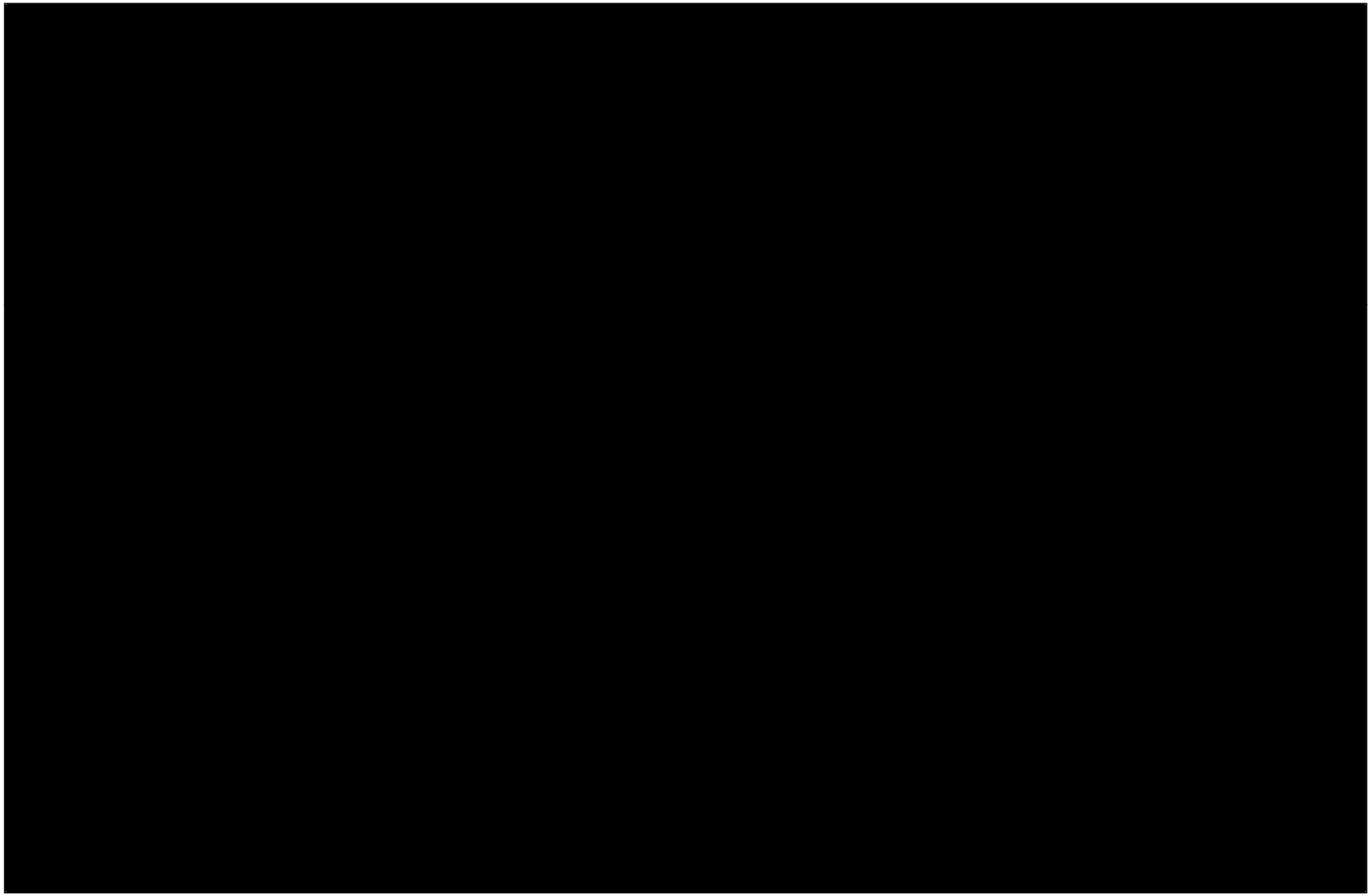
BANGANGA RIVER BASIN - Aquifer Distribution

BANGANGA RIVER BASIN –

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

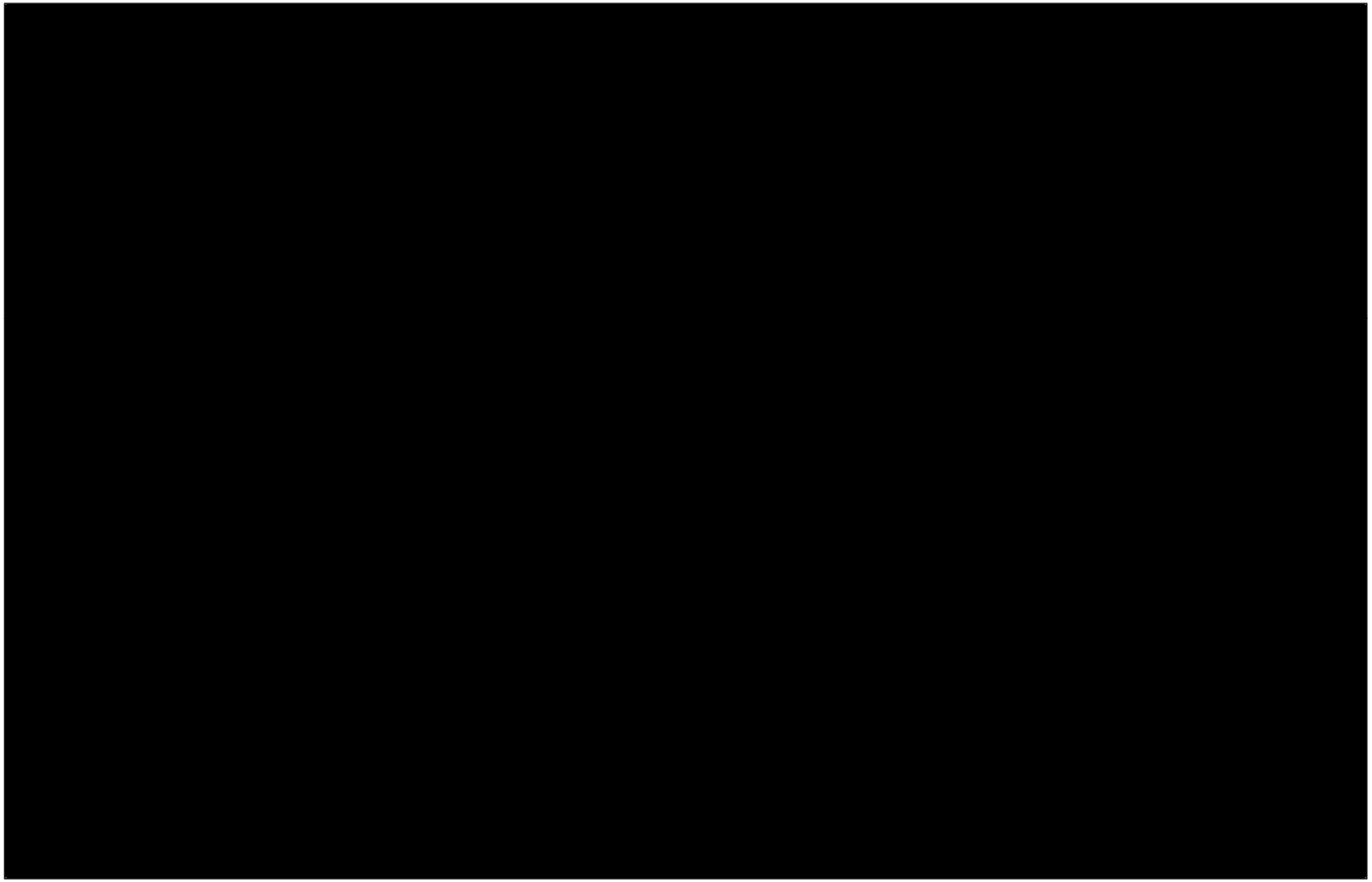
BANGANGA RIVER BASIN –

Water level fluctuation (Pre-Post Monsoon, 2010)



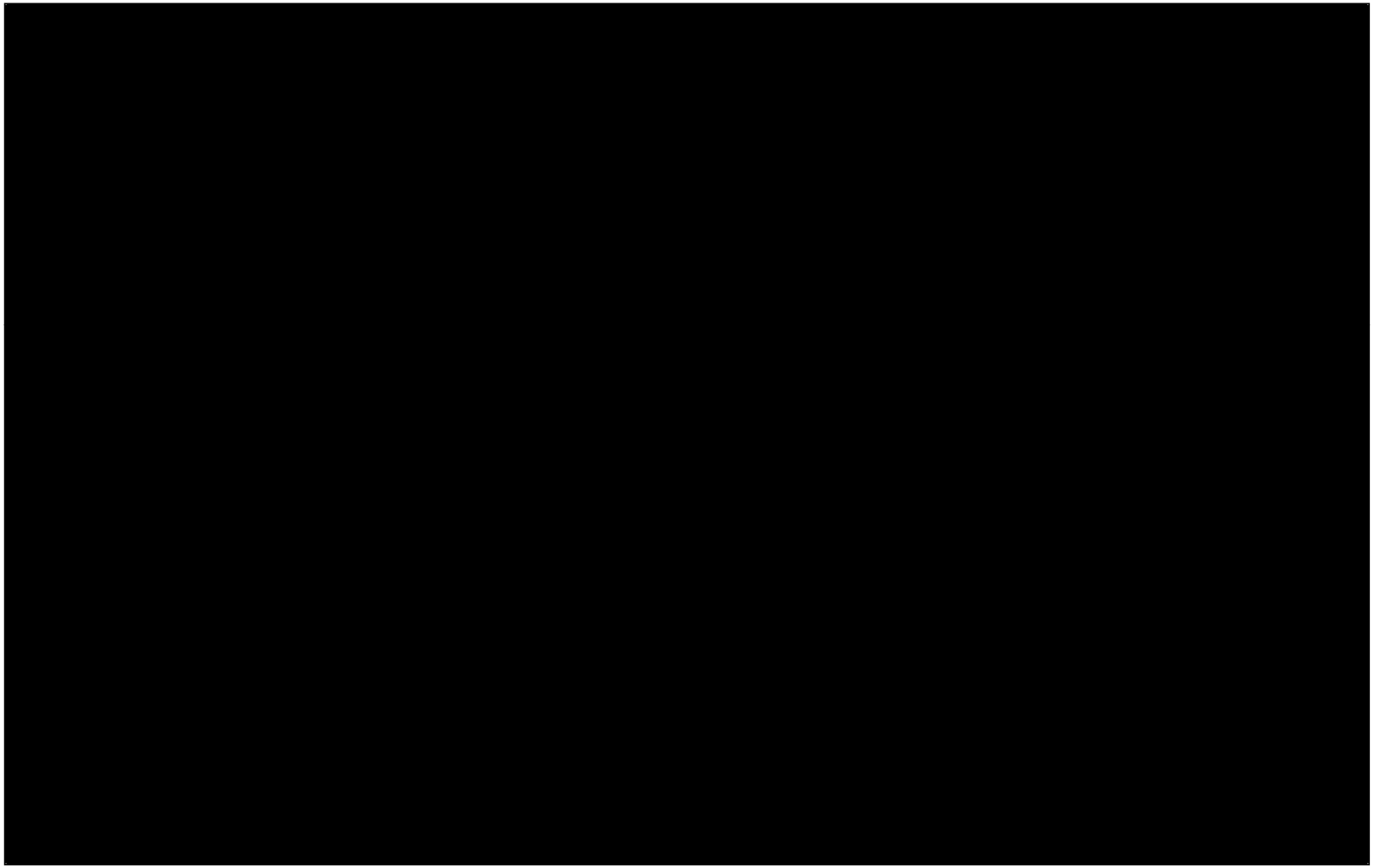
BANGANGA RIVER BASIN –

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



BANGANGA RIVER BASIN –

Thickness of Unconfined Aquifer



BANGANGA RIVER BASIN –

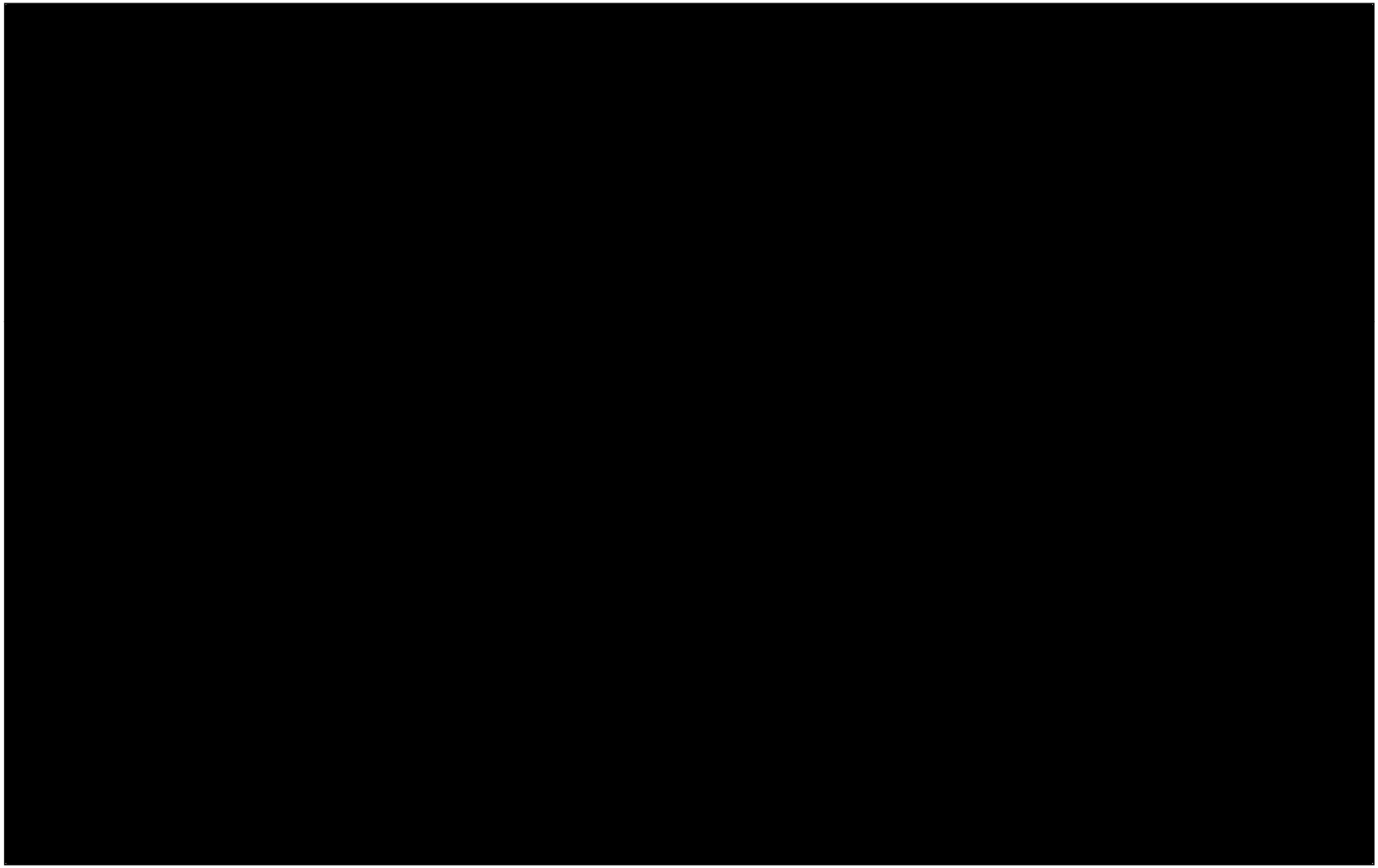
Thickness of First Confined Aquifer

BANGANGA RIVER BASIN –

Thickness of Second Confined Aquifer

BANGANGA RIVER BASIN –

Depth to Bedrock



BANGANGA RIVER BASIN –
Hydrogeological Cross-sections

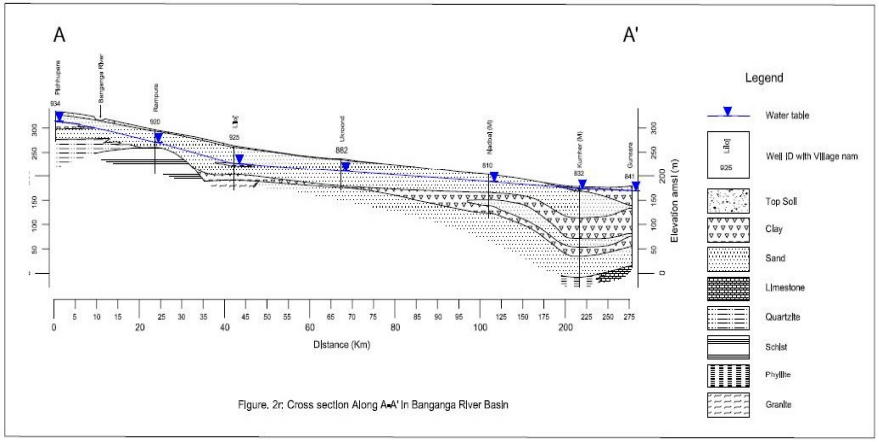


Figure. 2r: Cross section Along A-A' In Banganga River Basin

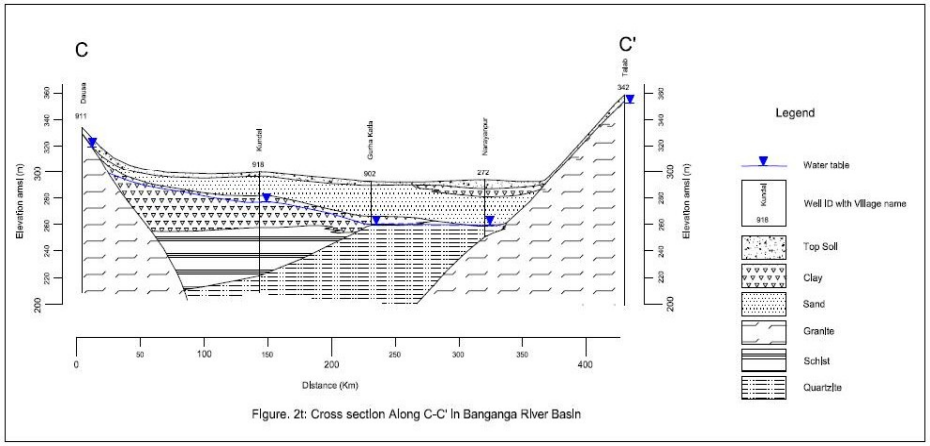


Figure. 2t: Cross section Along C-C' In Banganga River Basin

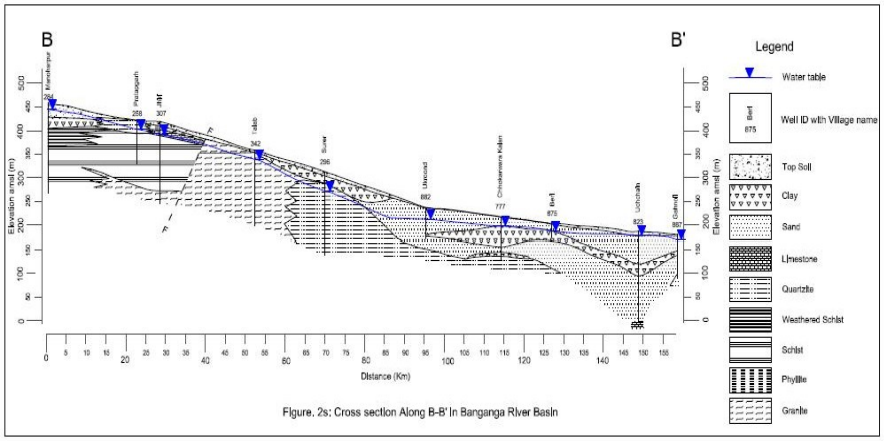


Figure. 2s: Cross section Along B-B' In Banganga River Basin

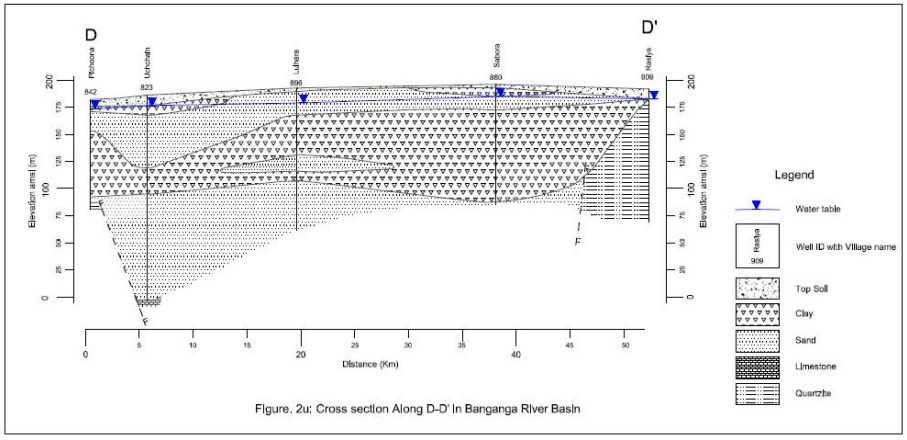


Figure. 2u: Cross section Along D-D' In Banganga River Basin

BANGANGA RIVER BASIN –

3D Aquifer Model

Monitoring Network Strengthening

- 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,