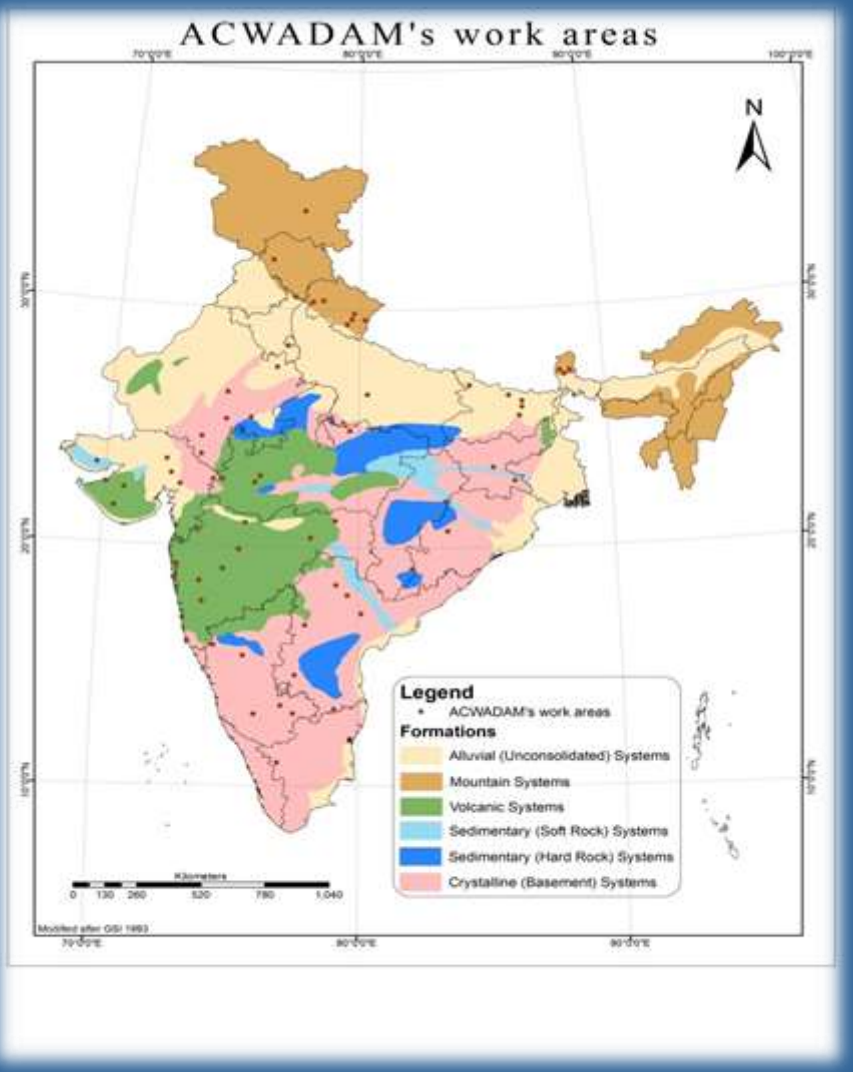
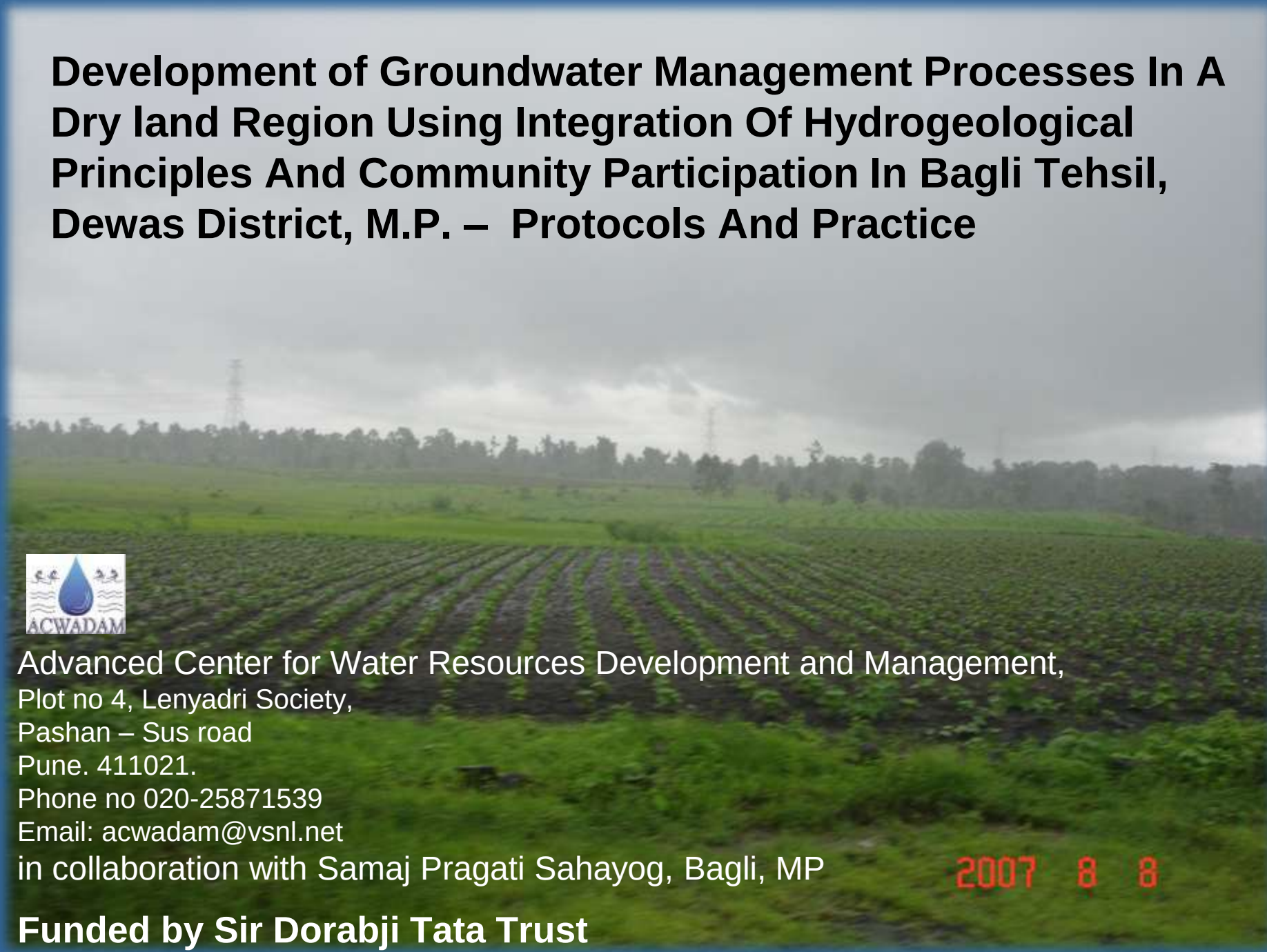
Case Study

Central India



Development of Groundwater Management Processes In A Dry land Region Using Integration Of Hydrogeological Principles And Community Participation In Bagli Tehsil, Dewas District, M.P. – Protocols And Practice



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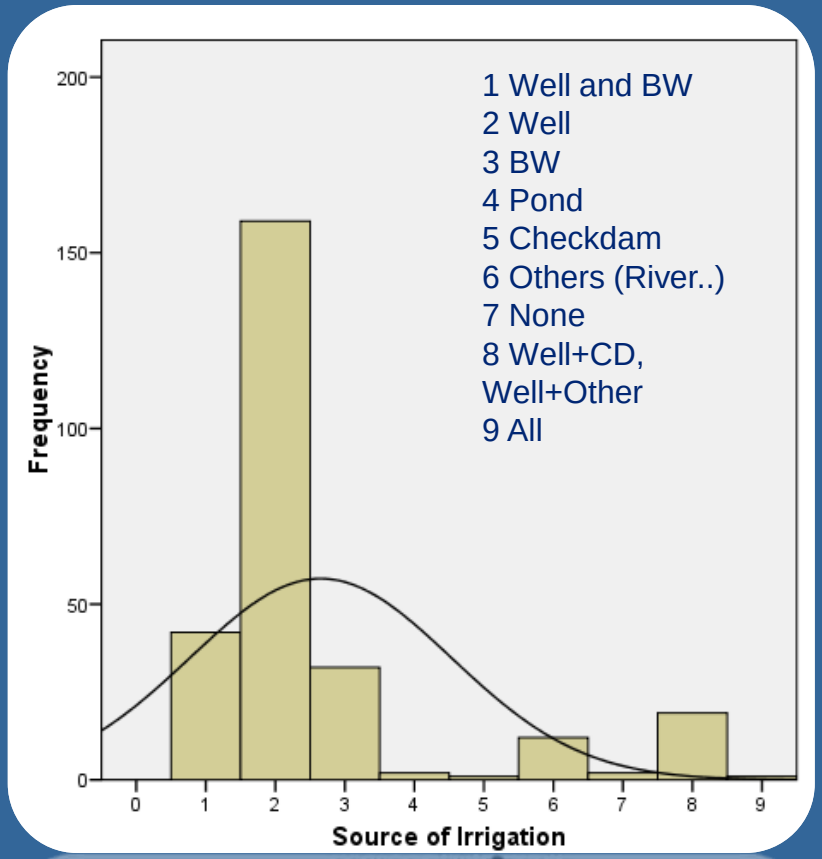
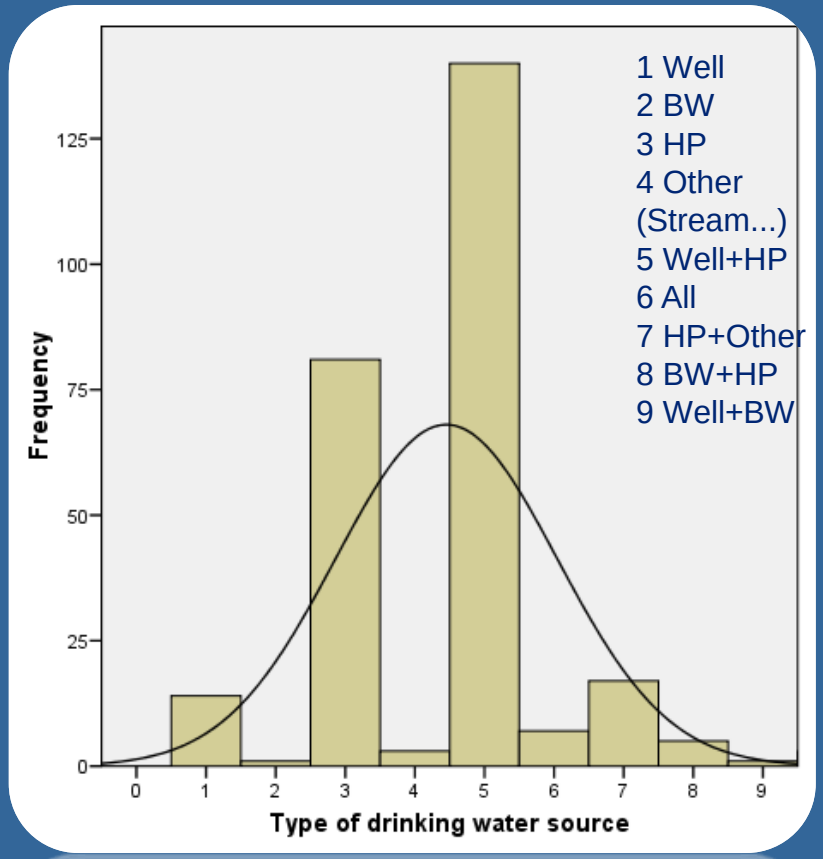
Funded by Sir Dorabji Tata Trust

Project background

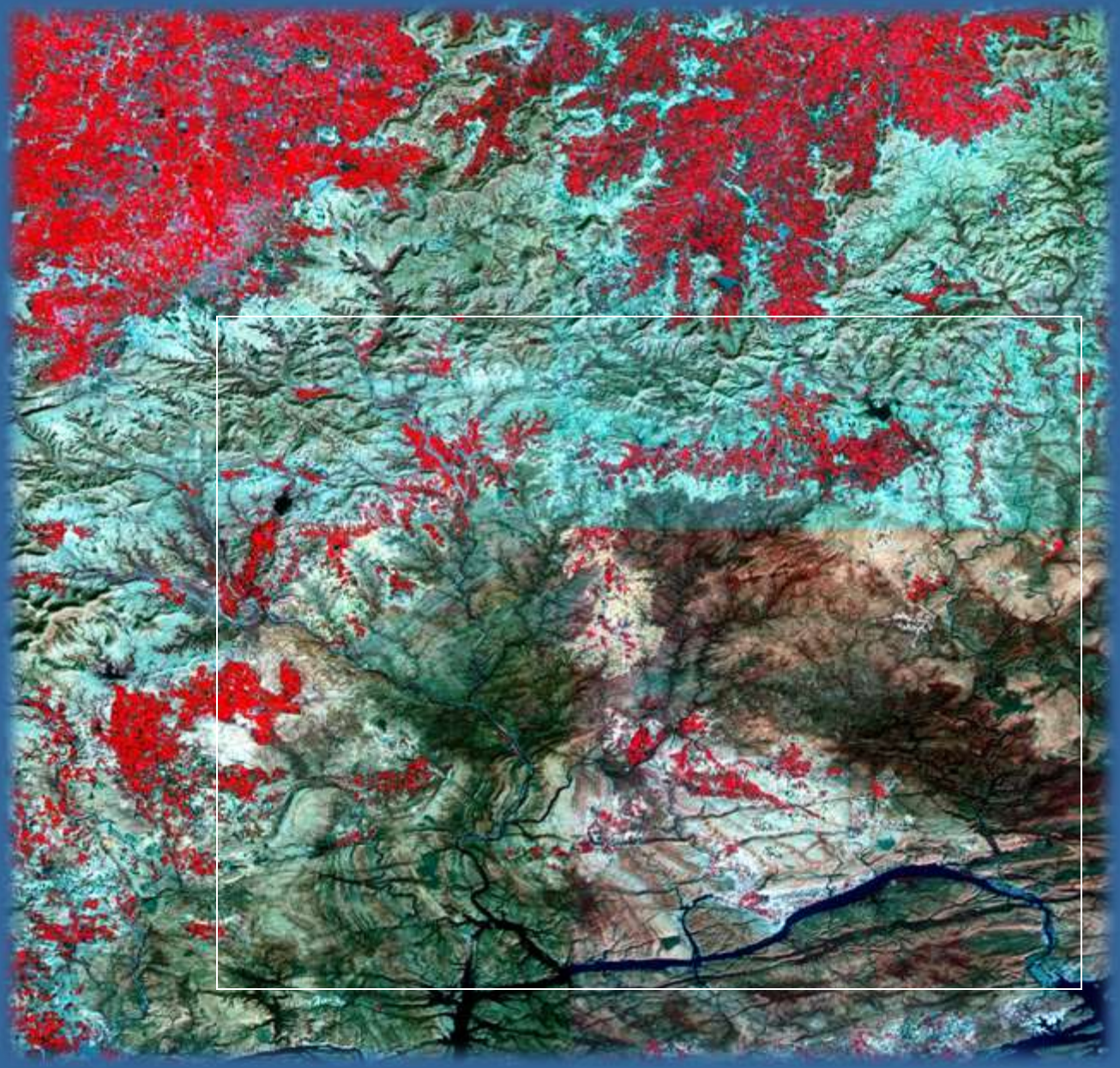
- Increasing dependence on Groundwater.
- Hydrogeological data unavailable and inefficient to provide inputs to the present day planning and policies on Groundwater.
- Hence, a need to develop a proper and complete understanding of the resource on the right scale that helps in sustainable and equitable management of groundwater.

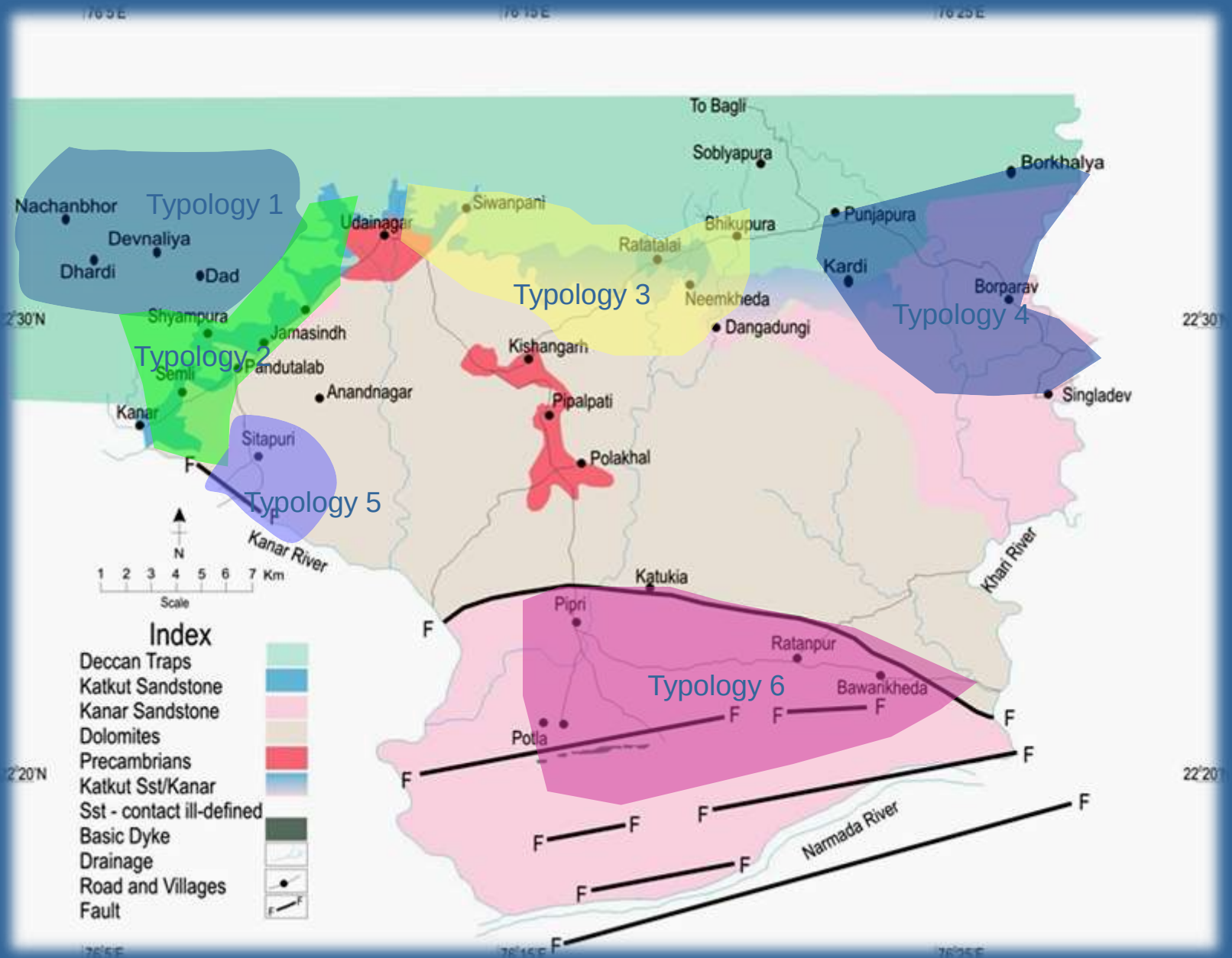
Groundwater dependence – sampled data from 34 representative villages from the project area





Satellite Image of the study area




To Bagli
Soblyapura
Borkhalya
Nachanbhor
Typology 1
Devnaliya
Dhardi
Dad
Udainagar
Siwanpani
Ratatalai
Bhikupura
Punjapura
Kardi
Borparav
Typology 3
Neemkheda
Typology 4
Dangadungi
Shyampura
Jamasindh
Typology 2
Semli
Pandutalab
Kishangarh
Anandnagar
Pipalpati
Singladev
Kanar
Sitapuri
Polakhal
Typology 5
Kanar River
N
1 2 3 4 5 6 7 Km
Scale
Katukia
Khari River
Pipri
Ratanpur
Typology 6
Bawankheda
Potla
Narmada River
Index
Deccan Traps
Katkut Sandstone
Kanar Sandstone
Dolomites
Precambrians
Katkut Sst/Kanar
Sst - contact ill-defined
Basic Dyke
Drainage
Road and Villages
Fault

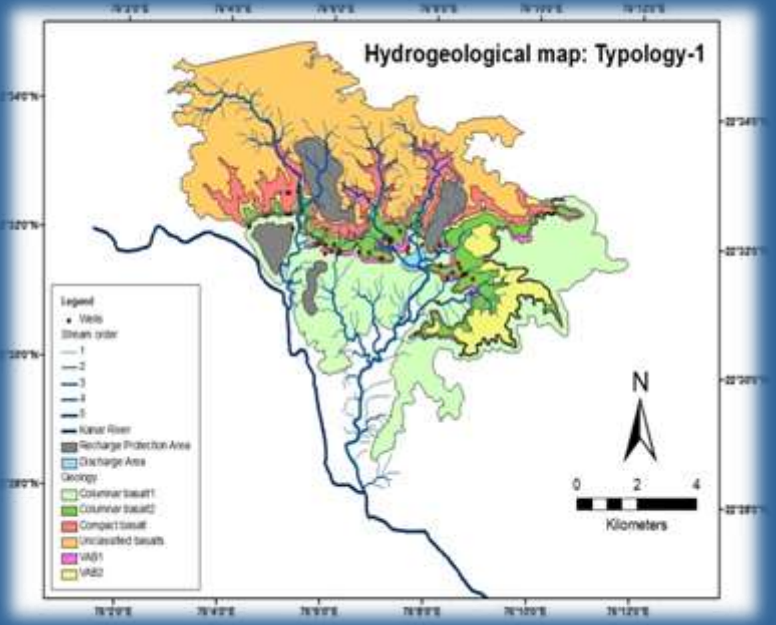
Typologies

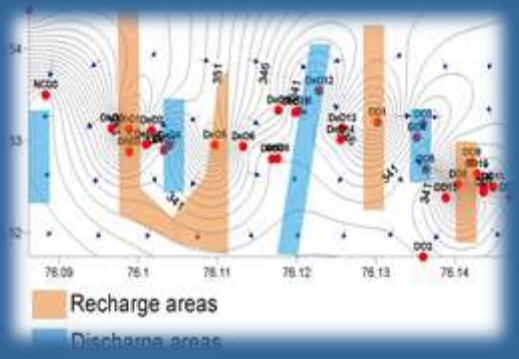
Instrumentation on Site

- Automated Weather Station at the Baba Amte Loksashaktikaran Kendra
- 3 Pan evaporimeters
  - Pandutalab
  - Seed Plot
  - Kendra
- 5 Rain gauges
  - SPS campus (Jatashankar)
  - Kendra
  - Borkhalya
  - Pandutalab,
  - Dhardi
- 12 Observation Bore holes
  - 8 near Neemkheda dam
    - 7 Shallow observation bore holes (15.5 m in depth)
    - 1 Deeper observation bore hole (92 m in depth)
  - 3 in Pandutalab (2 deep & 1 shallow)
  - 1 in Palasi (Deep)

Methodology

- Geological Mapping
- Data Collection
- Data Analysis
- Data Output / Findings
- Development of Protocols

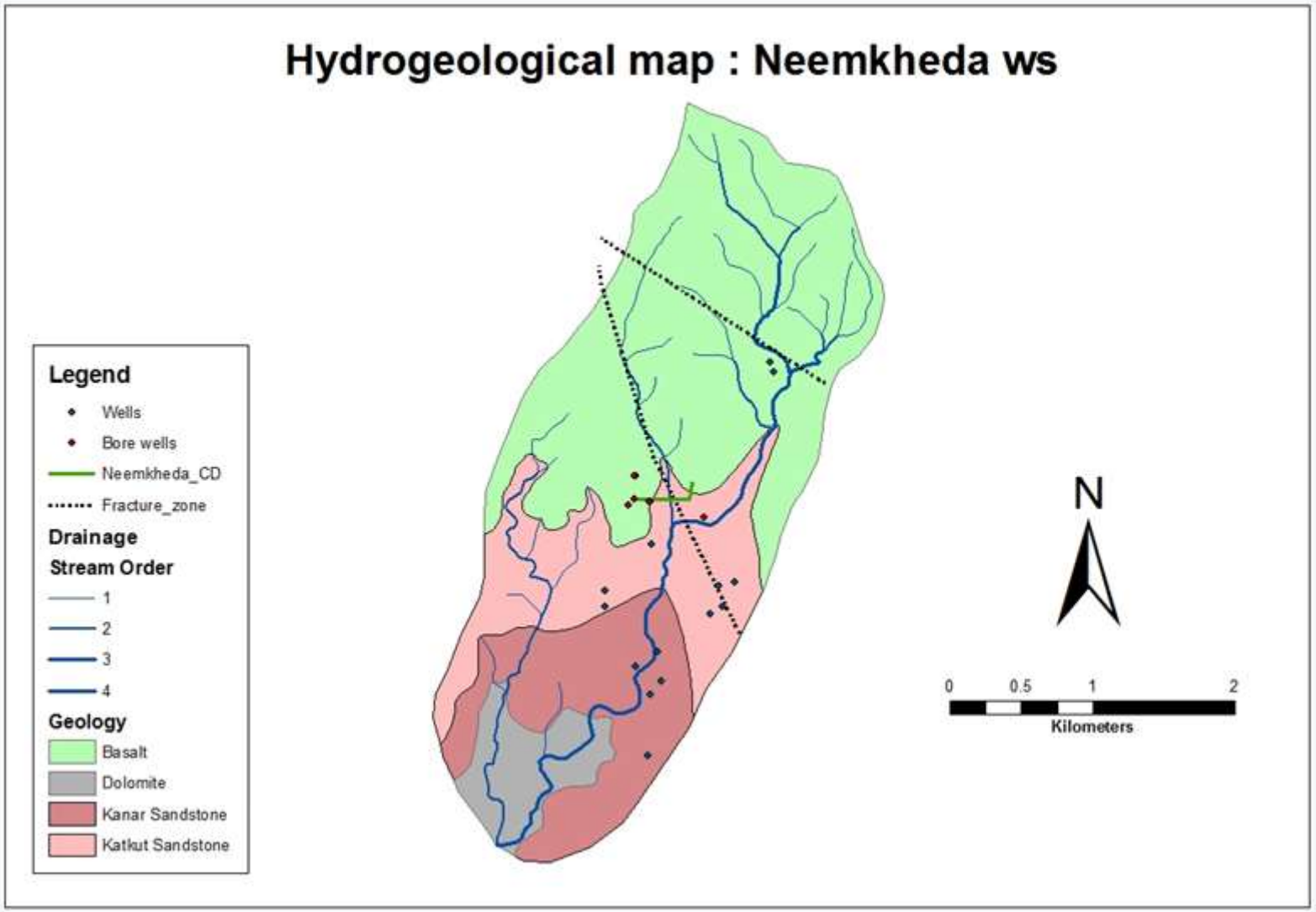




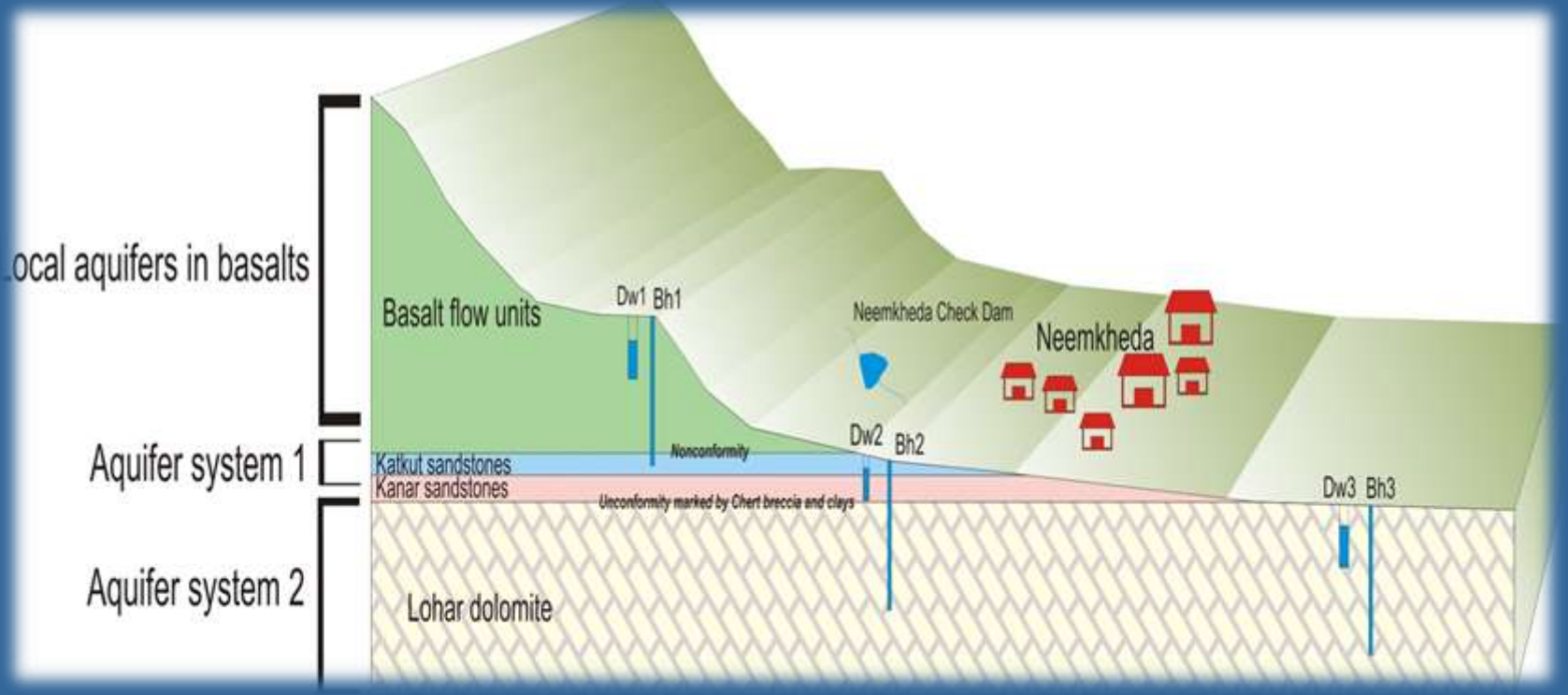
Hydrogeology knowledge base

- Water levels *(Monthly):*
  - Groundwater flow.
  - Groundwater recharge and discharge areas.
  - Aquifer delineation.
- Aquifer characterization:
  - Pumping tests - Aquifer and Well properties.
  - Modeling - Protection zones.
- Water quality:
  - Spatial variation.
  - Seasonal variation.
  - Recharge and discharge conditions.

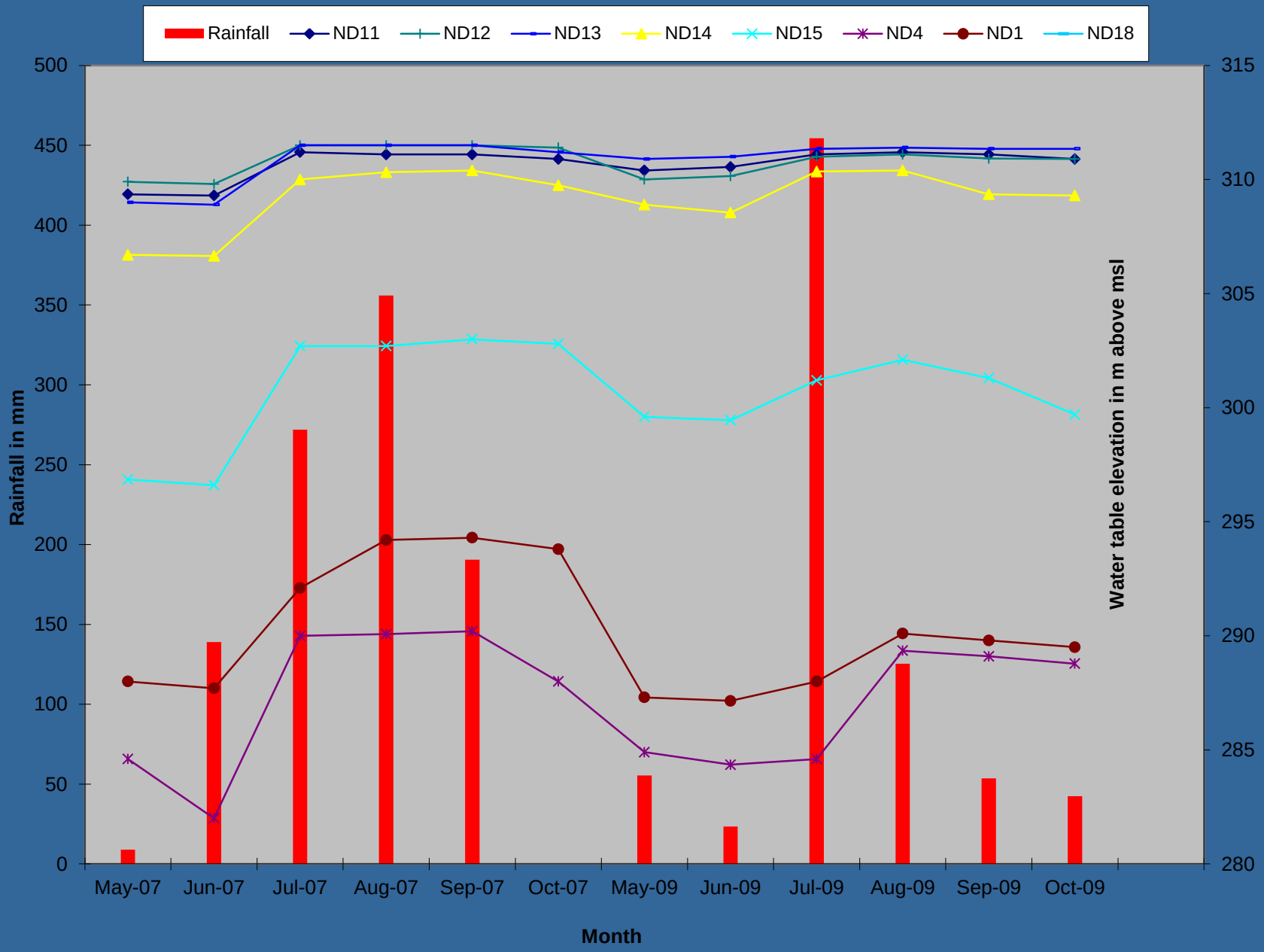
Hydrogeological map : Neemkheda ws



Conceptual model of Aquifers: Neemkheda WS

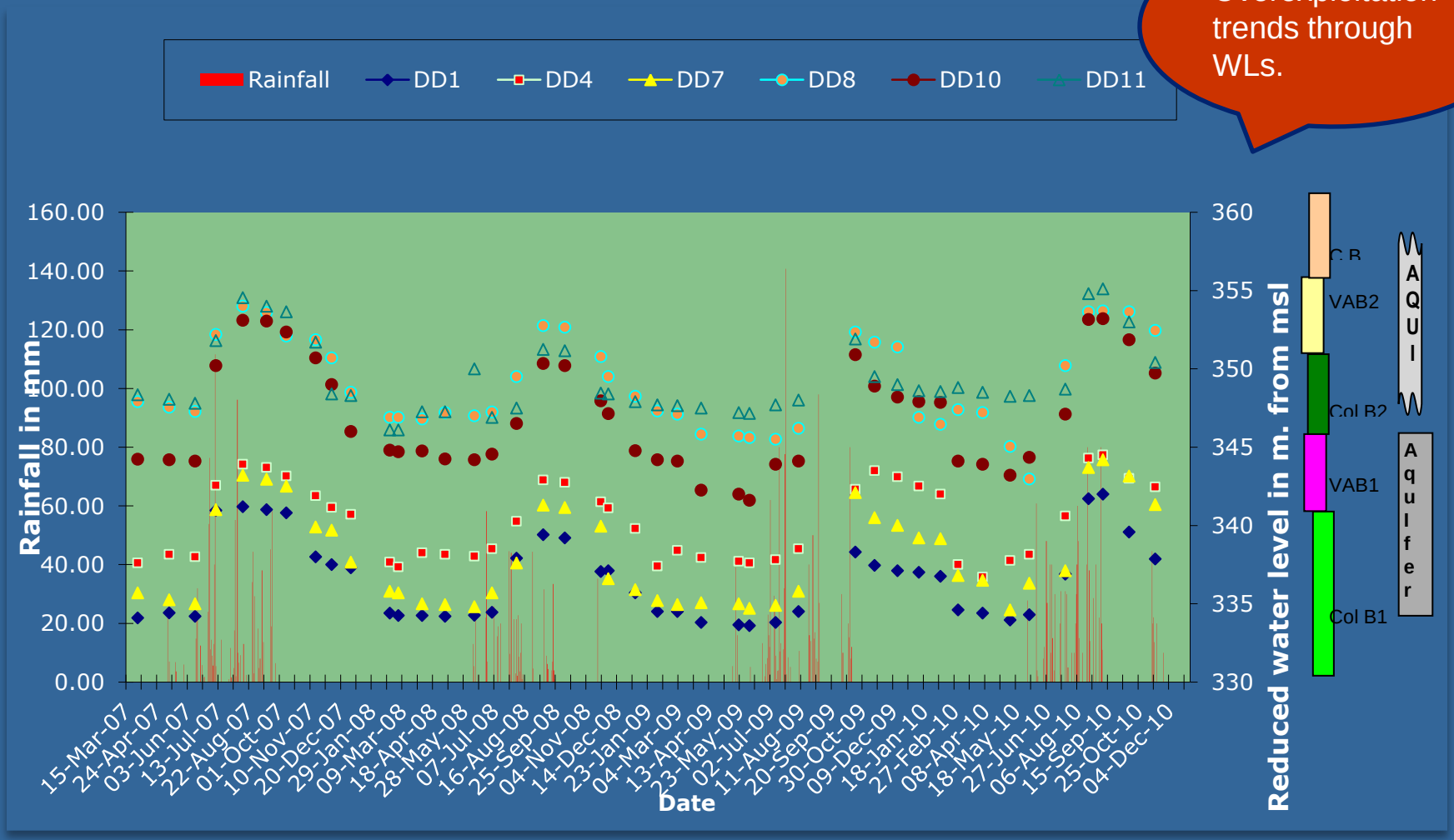


Comparative water levels across Neemkheda WS

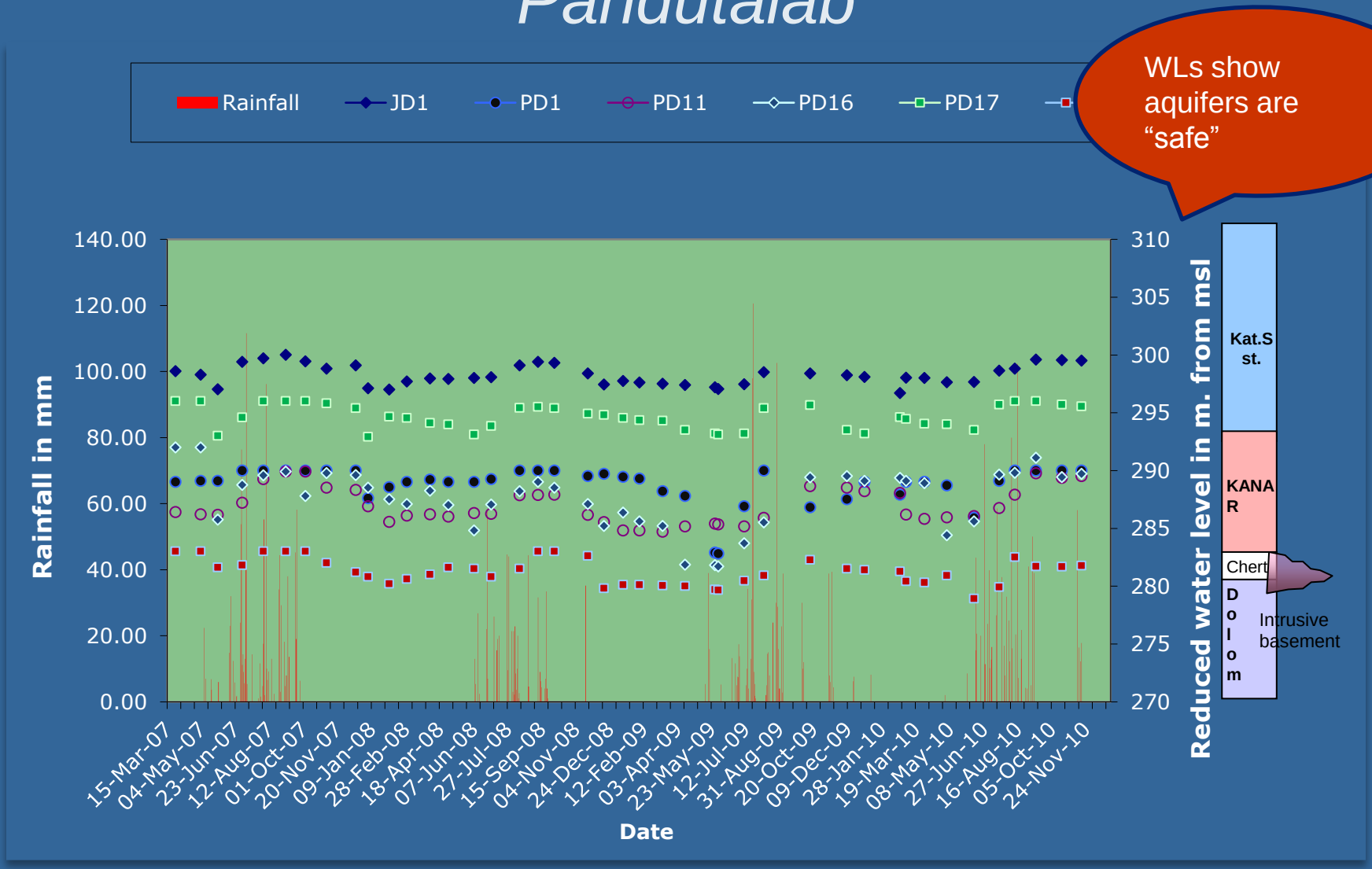


Typology 1: Hydrograph
Dad, Devnaliya

Overexploitation trends through WLs.

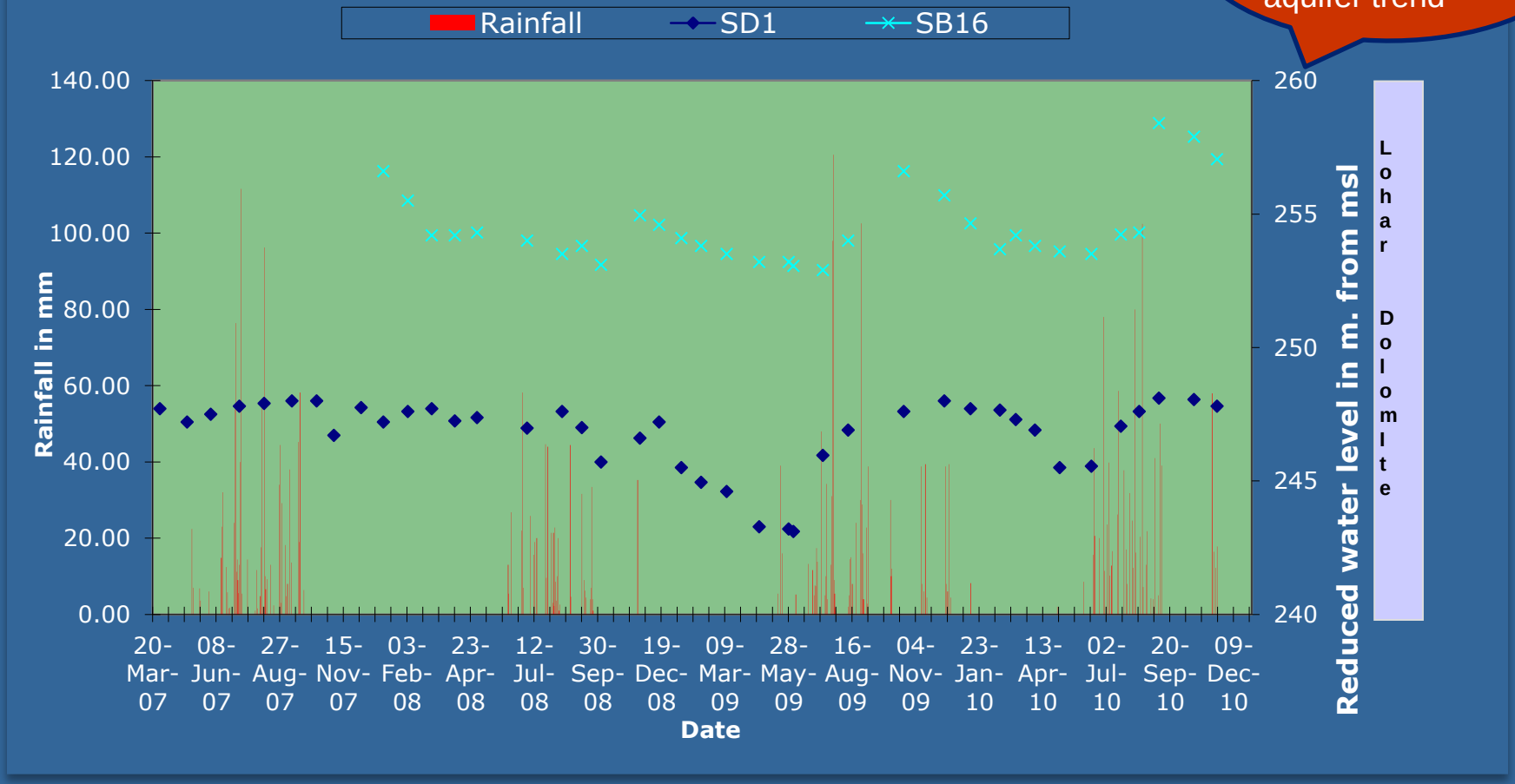


Typology 2: Hydrograph
Pandutalab

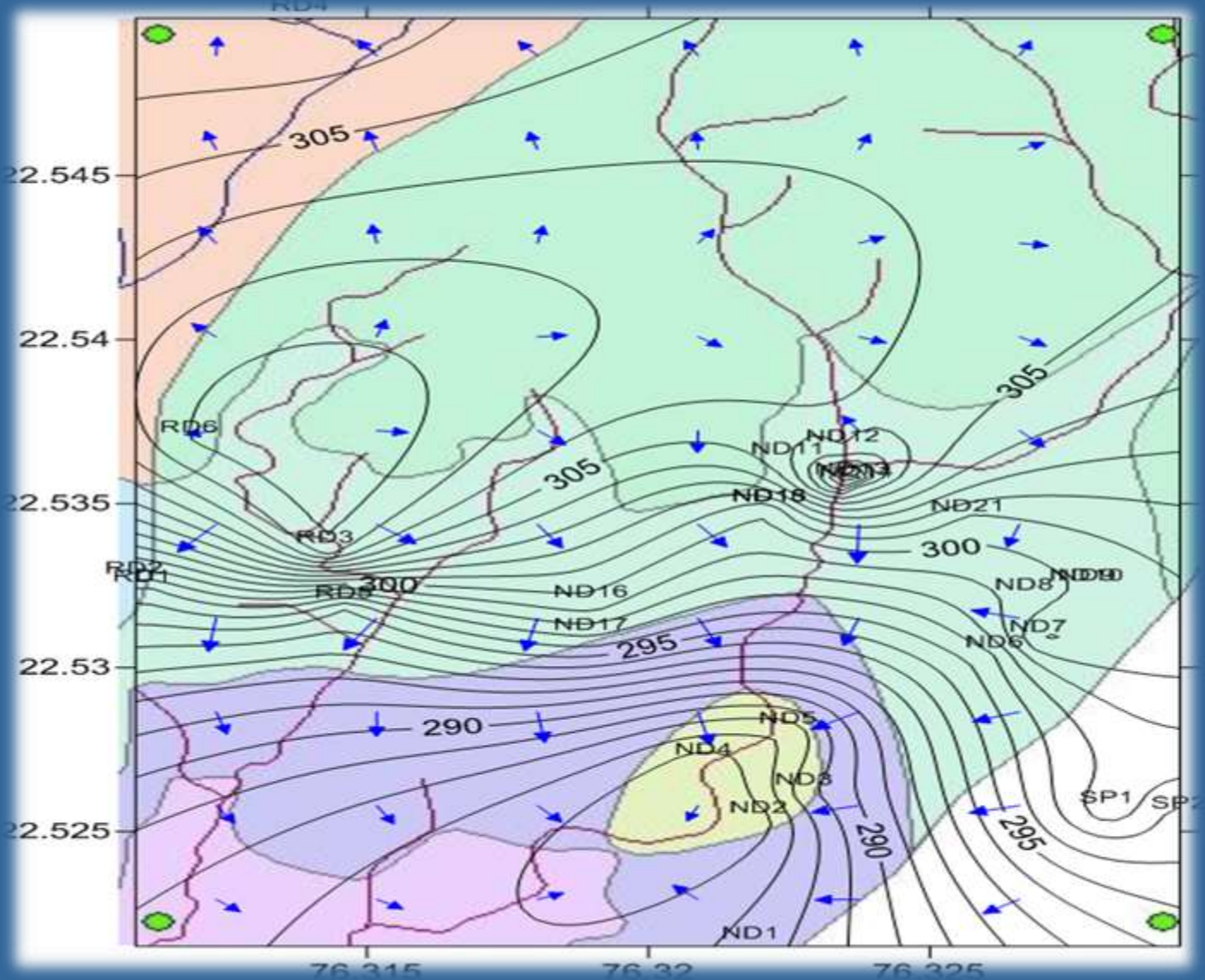


Typology 5: Hydrograph
Sitapuri

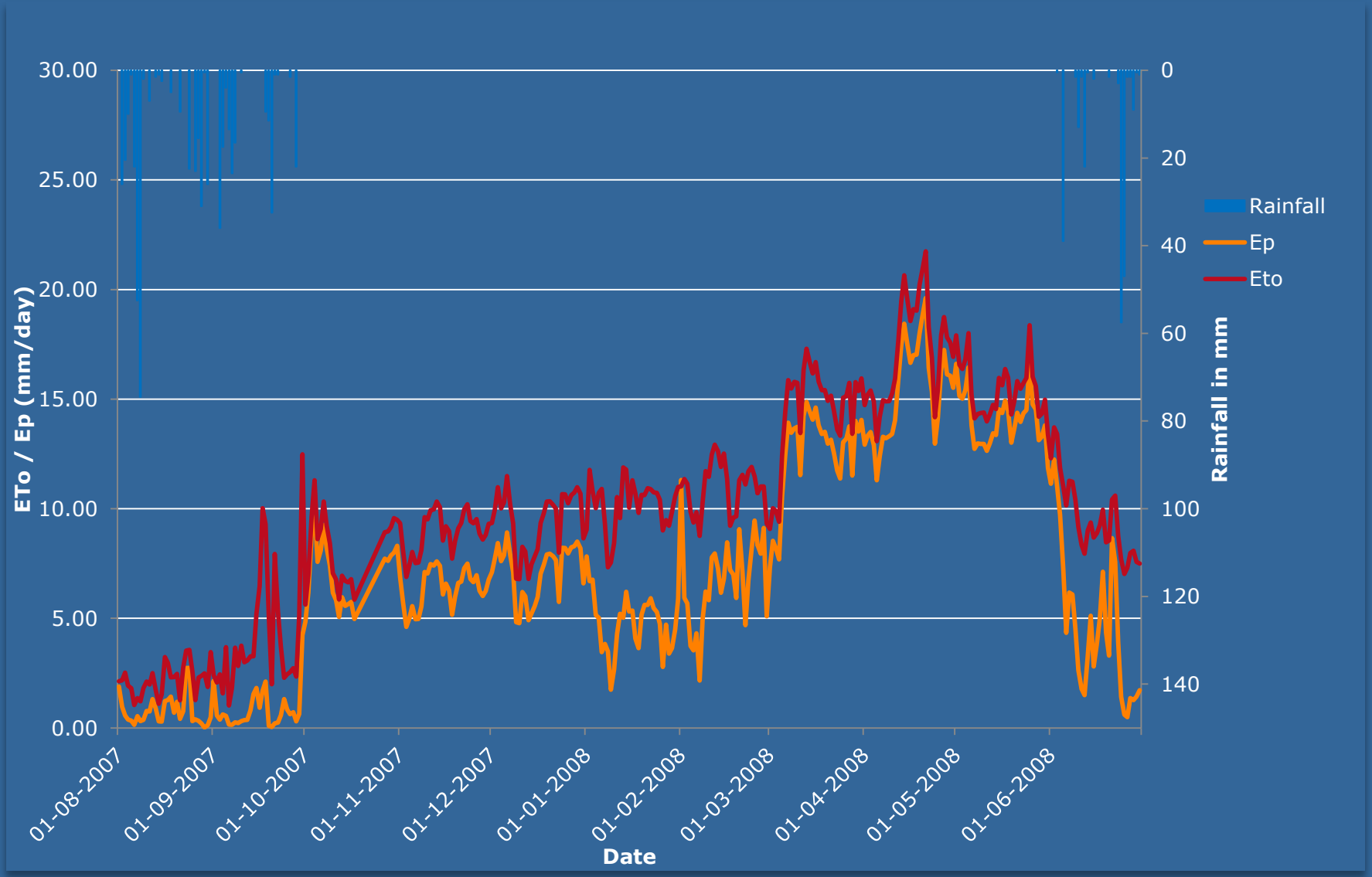
Overexploitation
Complex deep and shallow aquifer trend



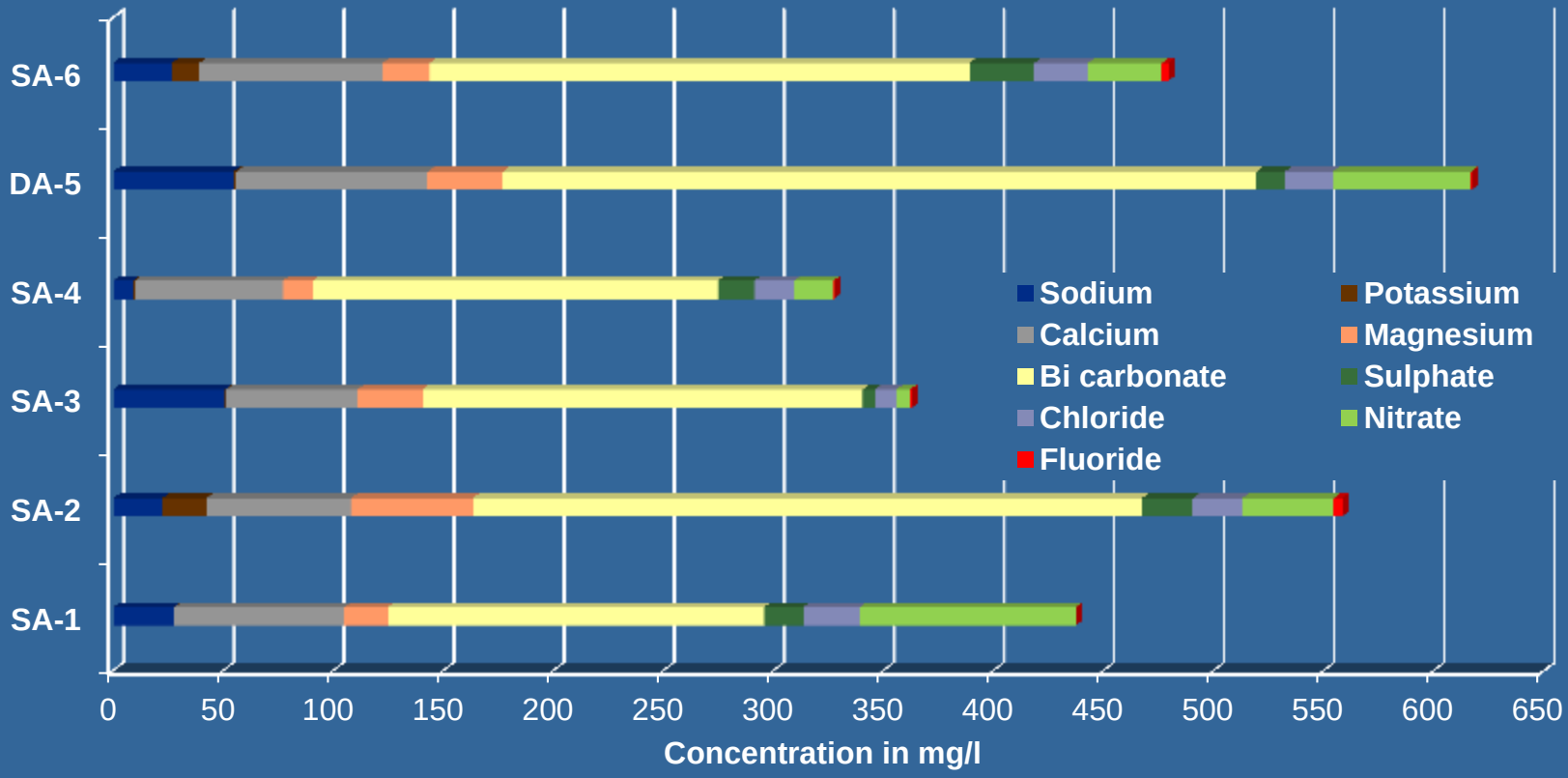
Water Table Contour Map – Typology 3



Rainfall – ET plot for drylands

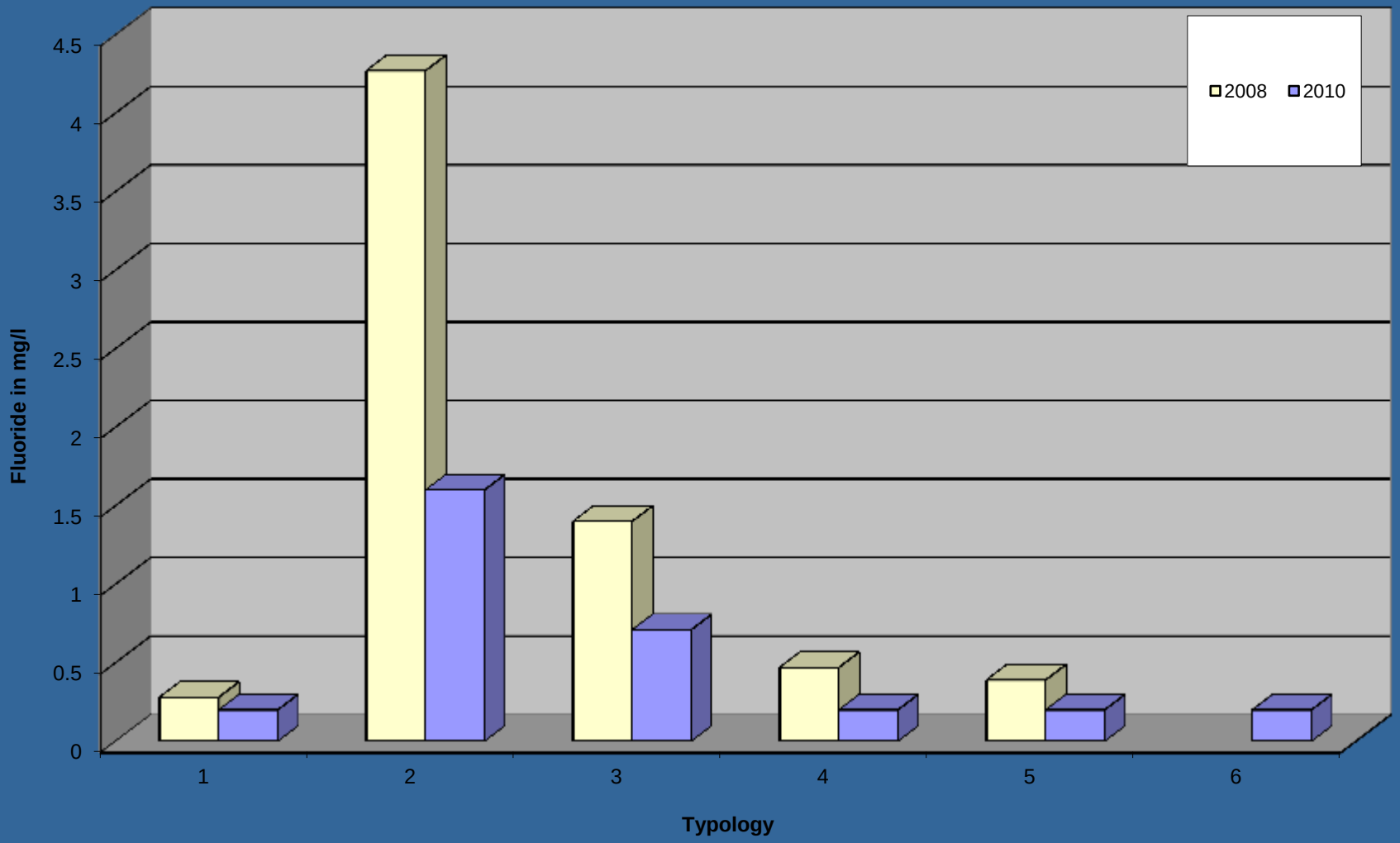


Variation in groundwater quality

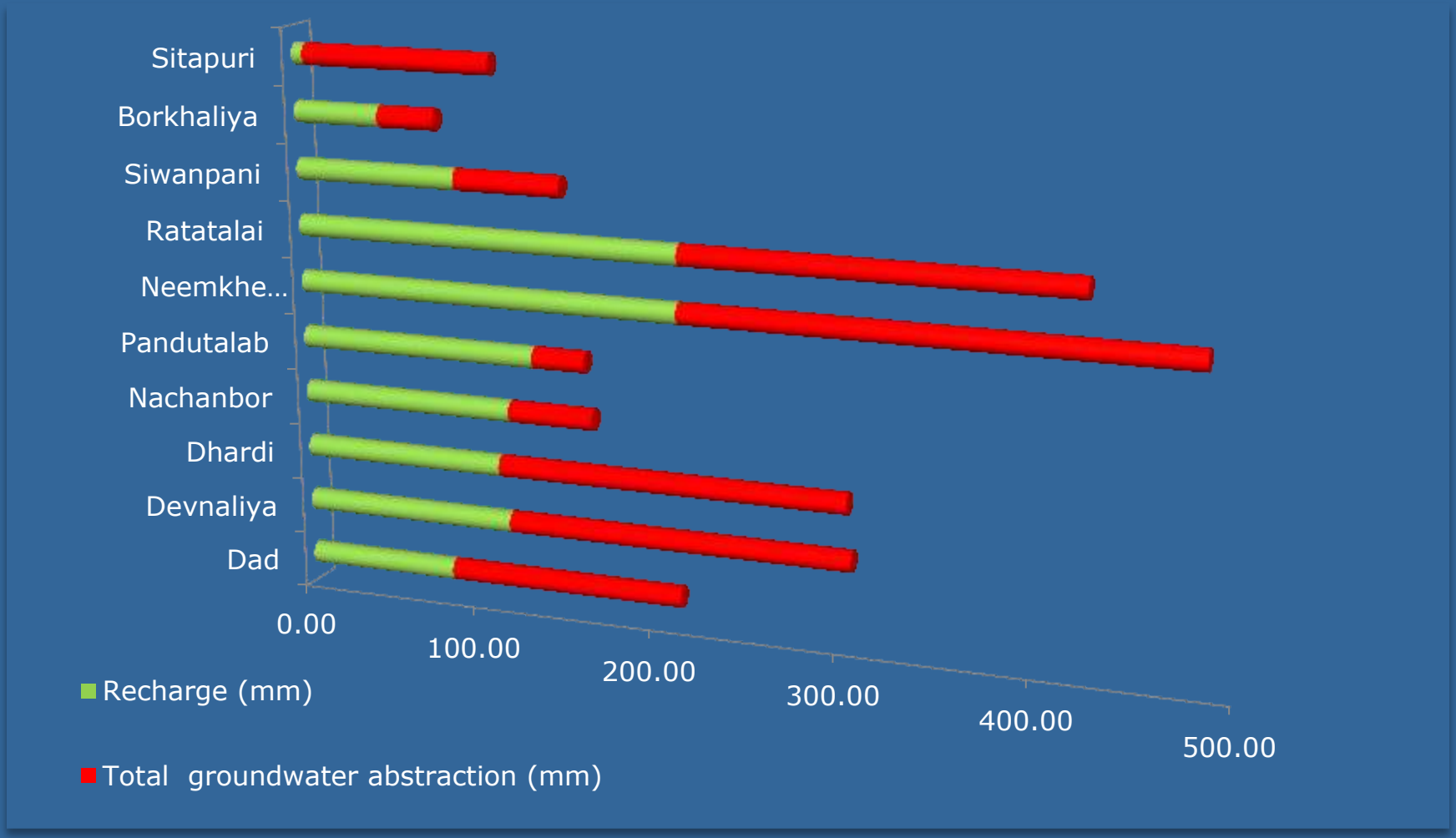


Sample no.	Sodium	Potassium	Calcium	Magnesium	Bi carbonate	Sulphate	Chloride	Nitrate	Fluoride
Typo_1 (Shallow Aqui)	27.32	0.59	77.26	19.52	171.14	17.64	25.81	98.03	0.2
Typo_2 (Shallow Aqui)	22.29	20	65.67	55.36	304	23.28	22.32	41.54	3.87
Typo_3 (Shallow Aqui)	50.84	0.6	59.64	29.5	200	5.52	9.85	6.13	0.92
Typo_4 (Shallow Aqui)	8.92	1	67.27	13.59	184	16.65	18.25	17.74	0.2
Typo_5 (Deep Aqui)	54.63	1.38	86.92	34.16	342.28	12.85	21.84	62.84	0.2
Typo_6 (Shallow Aqui)	26.75	12.5	83.28	21.37	245.28	29.47	24.33	33.61	0.4

Comparative content of fluoride



Aquifer-wise recharge vs groundwater abstraction



Broad water balance of Neemkheda watershed

- Area= 9 km^2
- Rainfall= 890 mm
- Water level rise = 5.3 m
- Aquifer thickness = 10 m
- Storativity = 0.04
- Total Recharge = 212 mm
- Total groundwater abstraction = 269 mm
- Aquifer Storage = 400 mm

NEEMKHEDA AQUIFER

Neemkheda aquifer is exposed over an area of 352 ha. in the Neemkheda watershed, one of the innumerable catchments draining off the Malwa ridge and forming a part of the Narmada basin. This aquifer falls in the Survey of India Toposheet no. 55 B/6 and is bounded between latitudes 22°30' 55" and 22°32' 31" N and longitudes 76° 18' 27" and 76° 19' 51" E. It is located in Bagli tehsil, Dewas district in Madhya Pradesh.

Neemkheda aquifer is constituted by two sandstones; a coarse grained, calcareous sandstone forming the upper portion of the aquifer and a fine grained, ferruginous sandstone, somewhat indurated and horizontally fractured, forming the lower part. These two sandstones are in hydraulic continuity with each other, particularly in Neemkheda watershed. The coarse grained, calcareous sandstone shows good primary porosity and is quite friable in nature, due to extensive weathering; it acts as the major water-bearing unit of Neemkheda aquifer. The underlying fine grained, indurated sandstone has limited primary porosity but has horizontal fractures developed due to the release of overburden during the process of weathering.

Neemkheda watershed also shows Deccan basalts in the upper reaches, some of which act as minor aquifers. The dolomite, exposed in the lower reaches is separated from Neemkheda aquifer by an impermeable chert-breccia, although these dolomites hold deeper, confined groundwater.

Neemkheda watershed shows the succession of lithologies illustrated in Table below :

Rock unit	Exposed range (elevations above msl) and range of thickness (in m)	Hydrogeologically significant features	Type of aquifer
Basalt	312 m to 340 m (28 m)	Basalt with columnar joints which percolates water downward	Minor aquifer
Coarse grained calcareous sandstone	302 m to 312 m (10 m)	Friable sandstone with cavities and openings have good yield of water	Neemkheda aquifer
Fine grained indurated sandstone	280 m to 302 m (22 m)	Sandstone with weak horizontal partings have moderate yield	
Dolomite (capped by Chert Breccia)	Below 280 m	Karstic effect on a local scale, with confinement by Chert Breccia	Deep aquifer but currently not tapped

Geology of Neemkheda watershed is constituted by Deccan basalt marking the ridges and sedimentary rocks underlying the plains. The coarse grained calcareous sandstones belong to the Cretaceous age and may be considered to be equivalent to the Bagh Beds of central west MP. The fine grained, indurated sandstones are a part of the Vindhyan Supergroup. These sandstones are separated from the underlying Lohar dolomites (also Vindhyans) by an unconformity. The separation between the sandstones and the dolomites is either in the form of a chert breccia horizon and/or very fine ferruginous clays.

Neemkheda aquifer outcrops over one-thirds of the area of Neemkheda watershed. It is an unconfined aquifer with an impermeable base in the form of the chert breccia / ferruginous clays. The aquifer is constituted by the coarse grained calcareous sandstones exhibiting both primary and secondary openings, which overlie the finer grained indurated sandstones (Vindhyans). These two separate stratigraphic units (lithologies) are in hydraulic connection with each other. The upper, coarse sandstones being calcareous also show large secondary openings due to weathering and erosion whereas the lower, more indurated sandstones show horizontal partings due to weathering and jointing.

Neemkheda aquifer shows Transmissivity ranging between 36 and 94 m^2/day while its Storativity is about 0.04. The aquifer, when fully saturated can hold about 630000 m^3 of water. Watershed development measures have been in tune with the hydrogeological setting of Neemkheda watershed. The stage of current groundwater development for Neemkheda aquifer, is 67%.However, base flow behaviour indicates that the effects of conservation and recharge have been impacted by increased groundwater abstraction. Groundwater quality for Neemkheda aquifer is generally within normal limits. Some wells show abnormal nitrate values (more than 30 ppm). which needs further investigation, although a combined effect of open access sanitation and fertilizer residues is the most likely reason.

Groundwater Management Strategy

1. Watershed management: There is little scope for major watershed development activities, except in terms of soil conservation on the basalt-dominated upstream regions; the areas in the vicinity of the two fracture zones traversing the basalt units in the upper catchments (as indicated in the map).

2. Regulation of deep drilling: Proliferation of deep irrigation wells in Neemkheda will dewater Neemkheda aquifer and hamper the sustainability of groundwater in the aquifer. Irrigation wells should not be deeper than a datum of 280 m above msl (representing the chert breccia which marks the base of Neemkheda aquifer).

3. Well spacing: Irrigation wells (under the current pumping situation) will influence water supply from drinking water wells, especially within distances in the range of 70 to 80 m (from the drinking water source). Irrigation wells should be spaced at least 40 to 50 m apart in order to minimise interference.

4. Pumping rate: Present rates of pumping from more than 50 odd irrigation wells (average 380 lpm) implies an annual groundwater depletion scenario where a compounded effect of all such pumping has reached the lateral boundaries of Neemkheda aquifer, with possible changes in the hydraulic geometry of the aquifer and its influence, especially on Ratatalai aquifer. Considering that duration of pumping remains the same as of today, pumping rates will need to be regulated to about 250 lpm.

5. Well pooling / scheduling: Current rates of pumping can be sustained if only 30 wells tap the Neemkheda aquifer, possible through a pooling / sharing effort.

6. Cropping pattern: With the above measures, major cropping pattern changes are not envisioned. However, varieties of current crops with low water requirement can be encouraged to back-stop other measures of sustainably managing Neemkheda aquifer.

7. Neemkheda water agreement: Revival of Neemkheda water agreement, including the above suggestions could lead to a comprehensive water management strategy.

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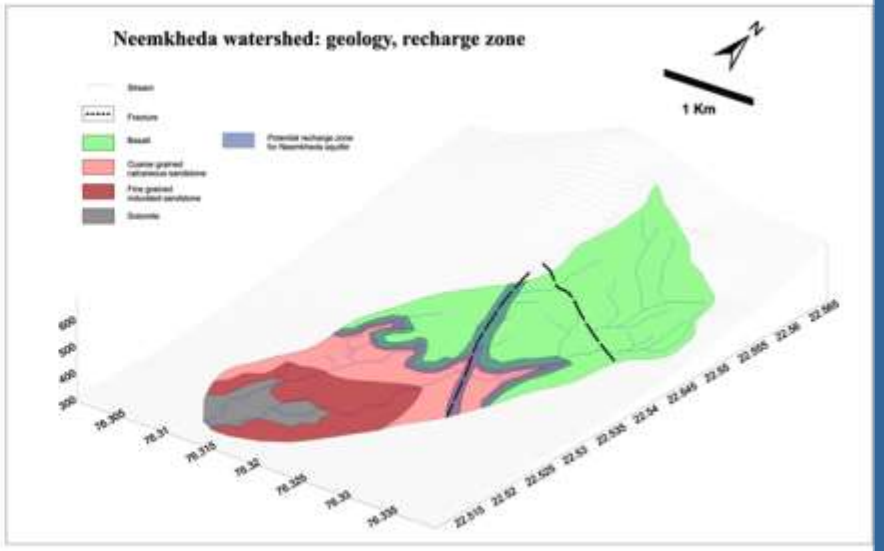

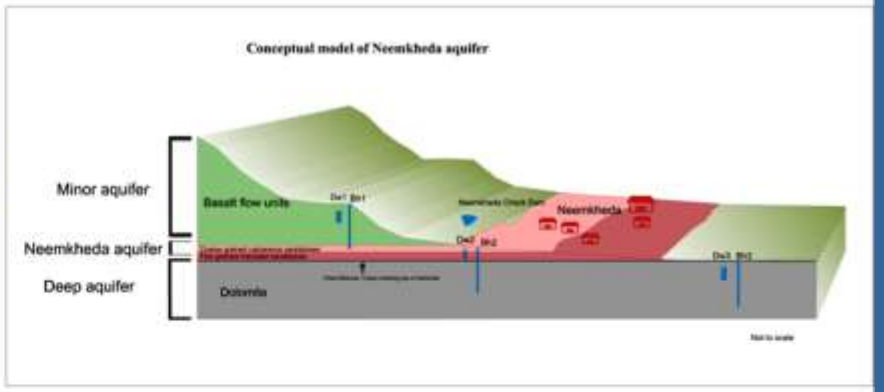

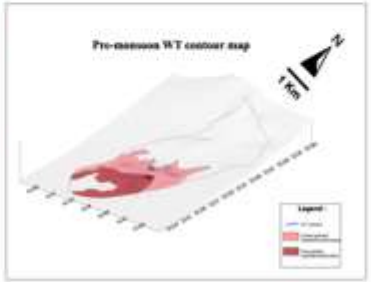

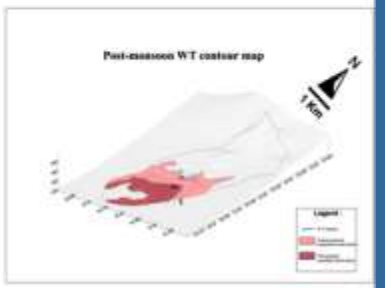

Development of Protocols

- Geohydrology in WSD
- Protection of recharge areas
- Efficient well use
- Pump capacity regulation
- Distance (wrt drinking water well) regulation
- Depth Regulation (wrt drinking well)
- Regulation of Agricultural water use
- Groundwater management through sharing

Thank You