केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

AQUIFER MAPPING AND MANAGEMENT PLAN

Panchkula District, Haryana

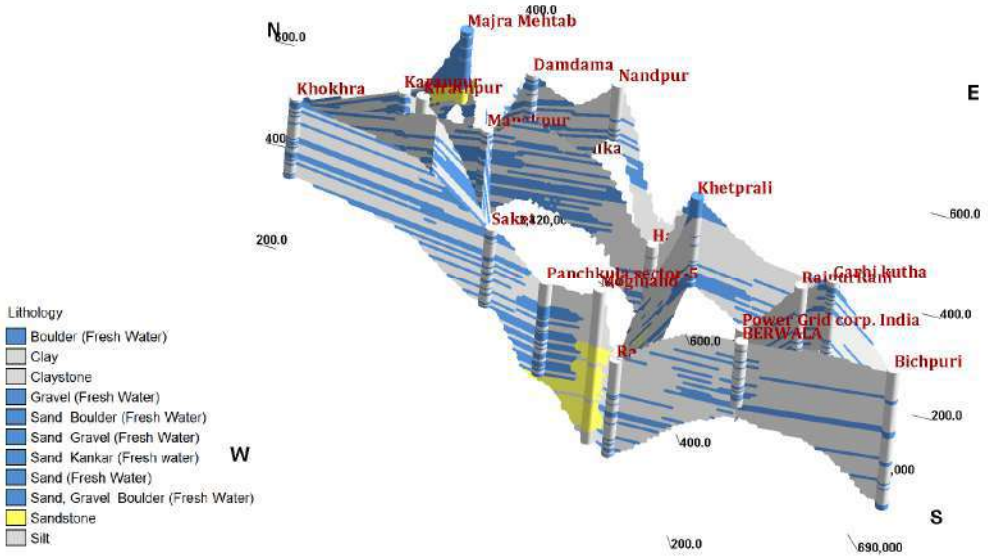
उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

राष्ट्रीय जलभृत मानचित्रण एवम प्रबंधन योजना

पंचकुला जिला

हरियाणा



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उत्तर पश्चिमी क्षेत्र, चंडीगढ़

जल संसाधन मंत्रालय, नदी विकास एवम् गंगा संरक्षण

भारत सरकार

2017

PROJECT TEAM

Regional Director	Dr S.K.Jain
Nodal Officer	S.K.Saigal , Scientist 'D'
Report Compilation	Iti Gupta, Scientist 'B'

Hydrogeology	**Geophysics**	**Chemical Quality**
Tarun Mishra, Scientist 'B Sanjay Pandey, Asstt. Hydrogeologist Anantha Rao. D STA (HG)	S.Bhatnagar Scientist 'B'	K.S.Rawat, Scientist 'B'

AQUIFER MAPPING AND MANAGEMENT PLAN

PANCHKULA DISTRICT (898 Sq Km)

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INTRODUCTION

1.1 GENERAL

Panchkula district is located in Northern part of the State and lies between 30° 26'- 30° 55' North latitudes and 76° 46'- 77° 10' East longitudes. Himachal Pradesh bound the district in North, in east by Uttar Pradesh, in west by Ambala district, in south by Karnal and Kurukshetra districts. Total geographical area of the district is 898 sq. km. It is divided into two tehsils and four development blocks viz. Pinjore, Barwala, Raipur Rani and Morni (Fig1). As per 2011 census the population of the district is 468411. The district is mainly drained by the river Ghaggar and its tributaries.

The district is mainly drained by the river Ghaggar and its tributaries. A small patch of northwest part of the district is drained by northwesterly flowing Sirsa nadi, as its tributaries east –west direction before joining Sirsa nadi, which is tributary of Sutlej river. Panchkula district is bestowed with rich water resources, both surface as well as ground water resources. The ground water is major sources of irrigation in the district. Net irrigated area is 80Km^2 whereas, gross irrigated area 180 Km^2. The climate of Panchkula is subtropical monsoon, mild & dry winter, hot summer and sub-humid. Normal annual rainfall of the district is 1057 mm unevenly distributed over the area in 49 days.

1.2 GEOMORPHOLOGY

Siwalik hill ranges occupy the Northern and North-Eastern fringe of Panchkula district and attain the height up to 950m above mean sea level. The hills are about 500m high with respect to the adjacent alluvial plains. These are characterized by the broad table topography carved into sharp slopes by numerous ephemeral streams from slopes of the Siwaliks. The geomorphological map is shown in fig 2.

A dissected rolling plain in the Northern parts of district is a transitional tract between Siwaliks hills and alluvial plains. It is about 3-8 km wide and elevation varies between 250 and 375m above mean sea level. This tract is part of higher ground between Ghaggar and Chautang and includes high mounds and valleys. In general, the slope is from northeast to southwest. Eurtrochrepts / Udorthents soils are shallow and loamy sands to fine sandy loams are found in the Siwalik range. Udipsamments/ udorthents type soils are loamy sand to sandy loam deep, well-drained, non-saline, non-alkali found in transitional tract between Siwaiks hills and alluvial plains.

Fig 1: Base Map of Panchkula District.

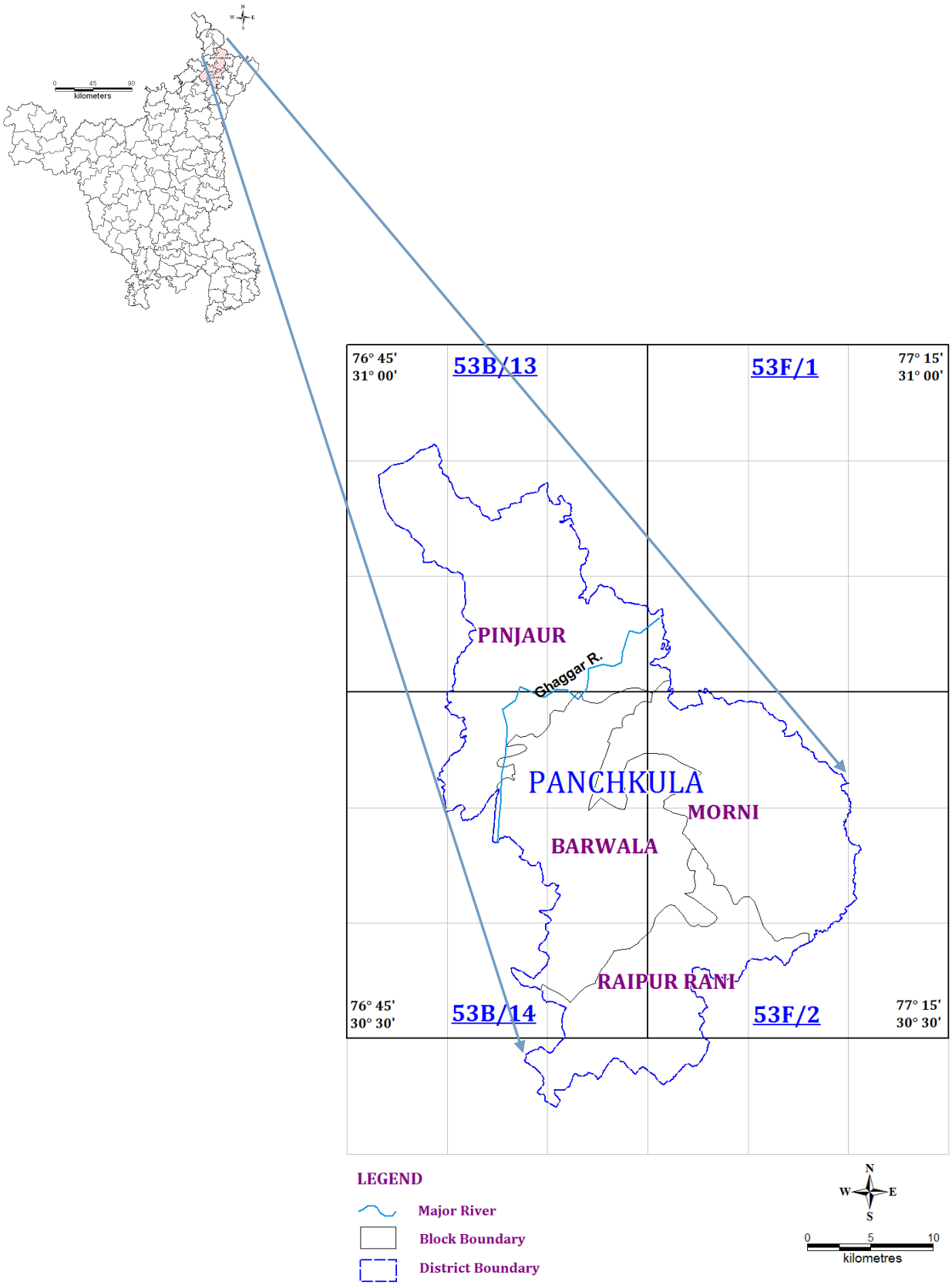
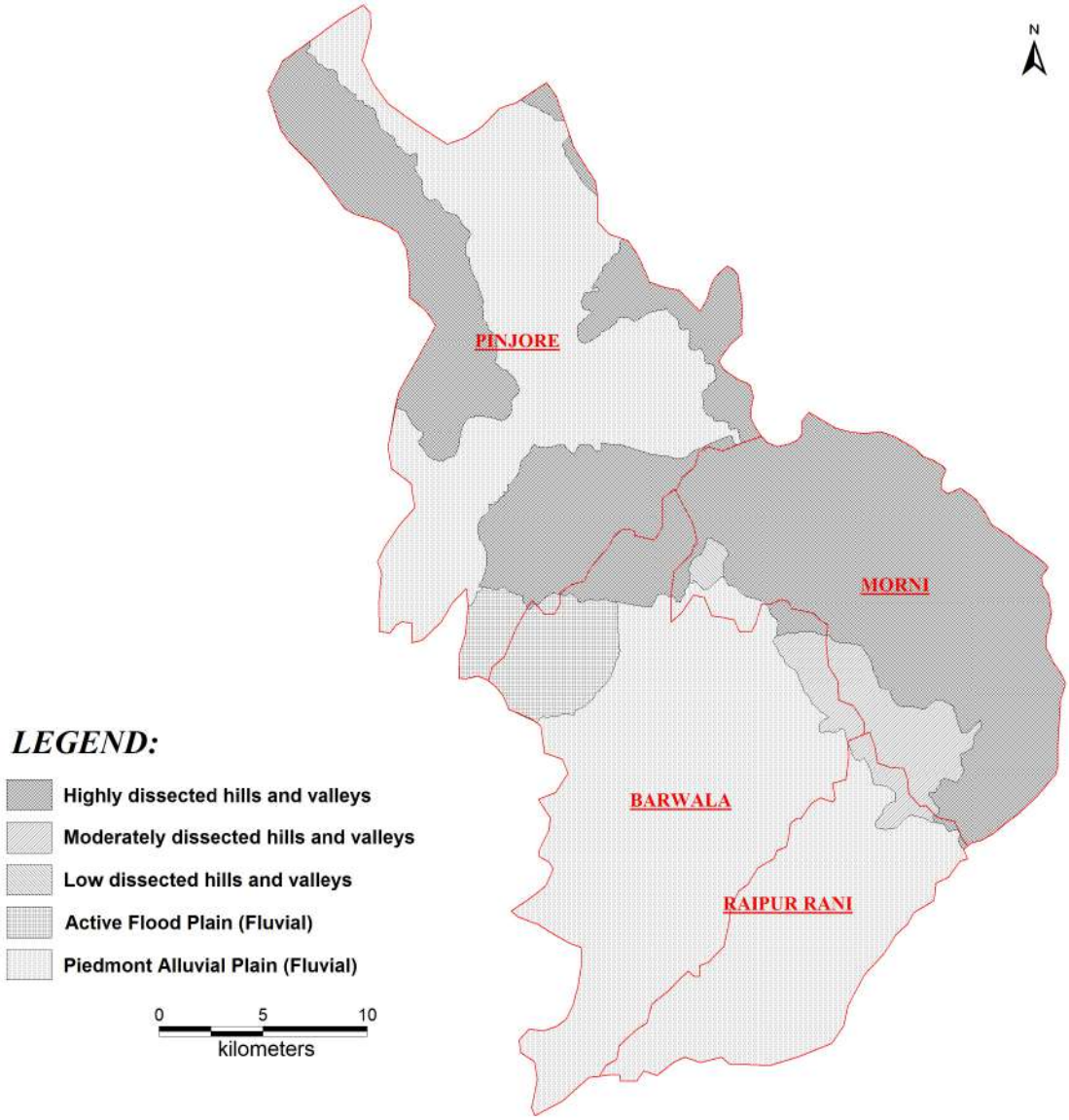


Fig2: Geo-morphological map of Panchkula District.



2. DATA COLLECTION AND GENERATION

2.1 Exploratory & Geophysical Data

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB, Public Health and Engineering Department (PHED) and private wells have been collected and those supported electrical logs have been validate for aquifer map preparation. Deeper well data of CGWB is available. The details are shown in table 1. The compromised logs derived from lithologs and geophysical well loggings have been taken as reliable data base.

Table 1: Data availability of Exploration Wells in Panchkula District

S. No.	Source	No. of wells	Depth	
			<200m	>200m
1	CGWB	10	6	4
2	Private	46	46	0
3	PHED	34	34	0

2.2 Vertical Electrical Sounding (VES)

Geophysical investigation has been carried out at 33 locations in the district Fig 3. The VES curves obtained in the study area are shown in Fig 4, 5 & 6. Generally H, HK, HQ and AH type of curves have been recorded. The interpreted VES results show three to four geo-electrical layers have been deciphered. On the basis of interpreted results, the geological formation has been inferred from the resistivity value and is given in table 2.

Fig 3: Locations of VES Survey

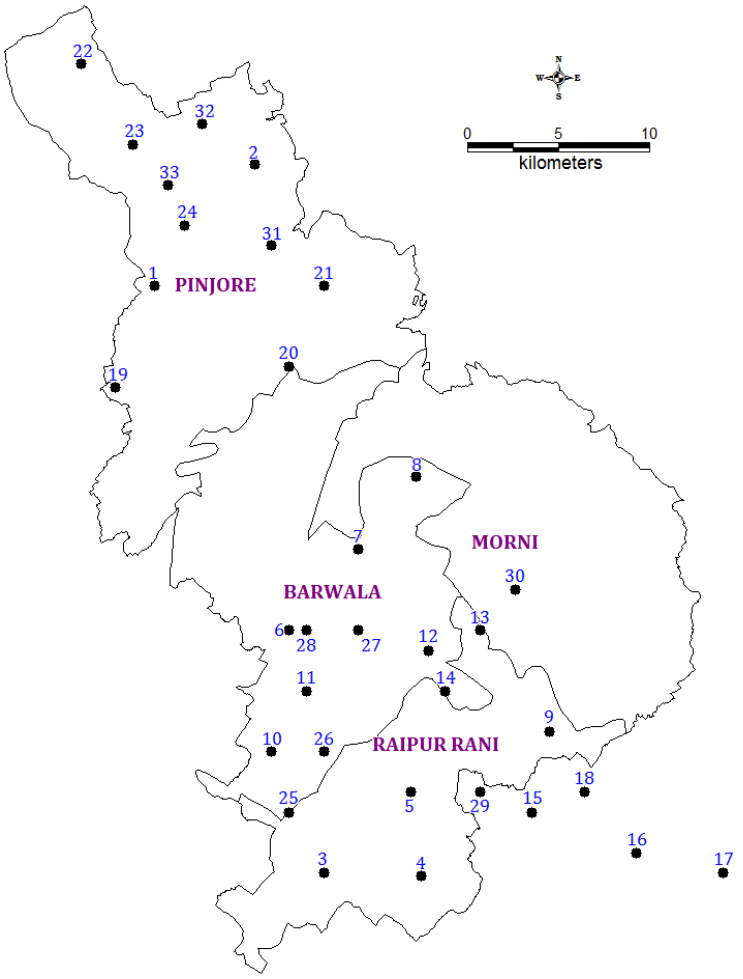


Table 2: Inferred Geology according to the resistivity values.

Inferred Geology	Resistivity ranges (in ohm-m)
Top soil	Within 485
Clay	Less than 20
Pebble and boulder with clay	20 - 60
Sand and pebble with clay	60 - 100
Boulders and pebble with sand	100 - 200
Boulder	More than 200

Fig 4: Representative VES curves in Toposheet No. 53B/13 (Panchkula district)

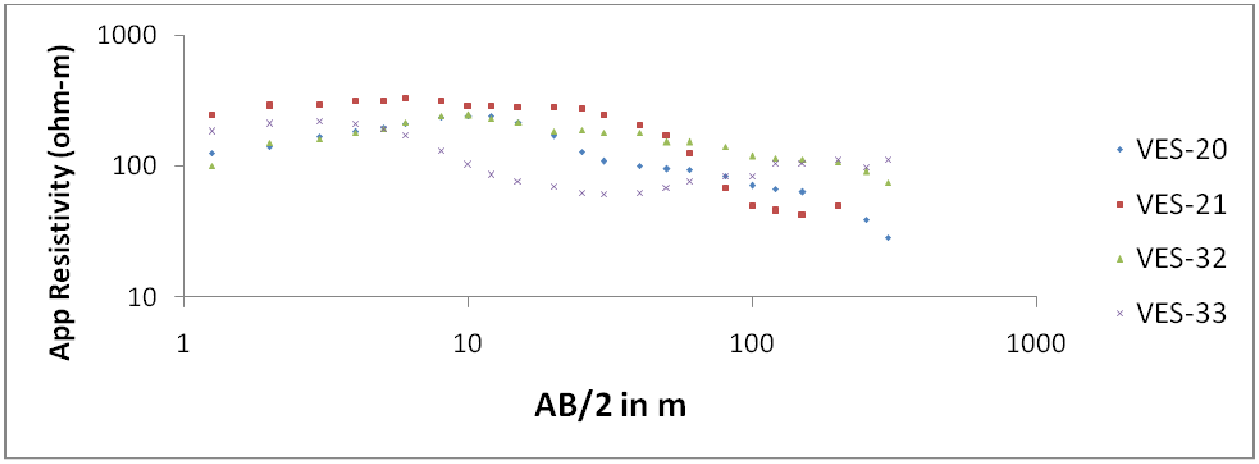


Fig 5: Representative VES curves in Toposheet No. 53B/14 (Panchkula district)

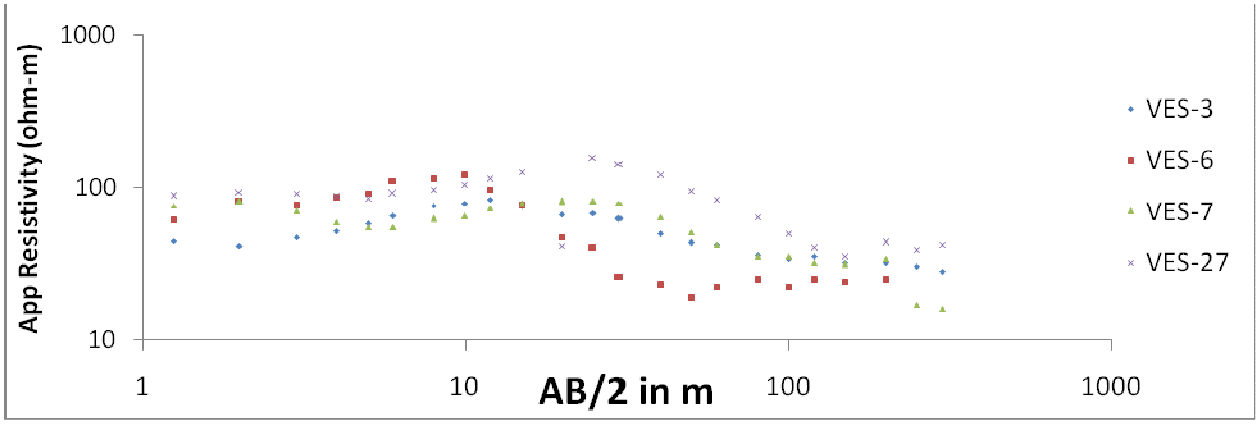
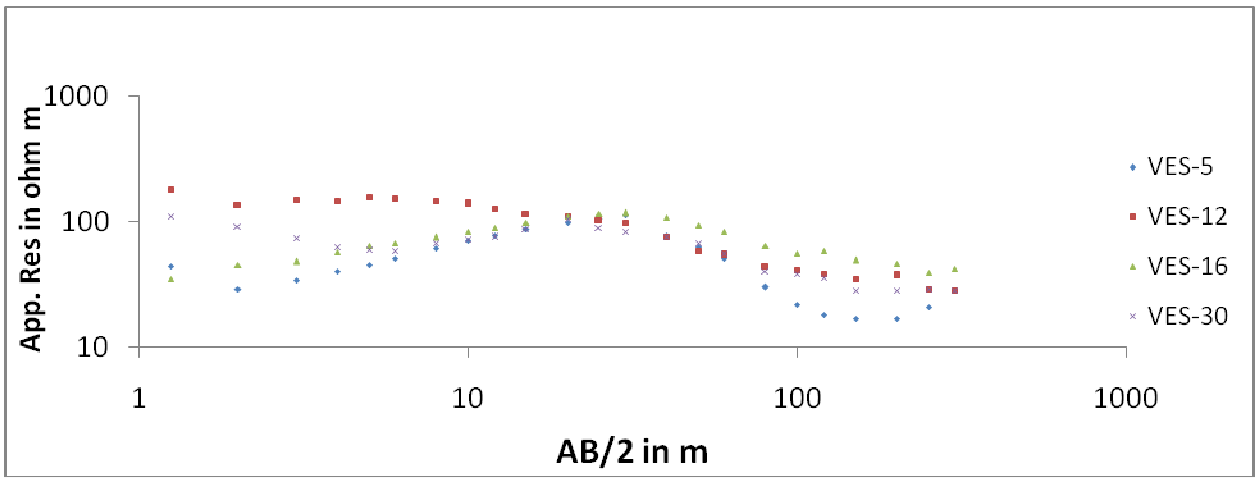


Fig 6: Representative VES curves in Toposheet No. 53F/2 (Panchkula district)



Based on the results of quantitative interpretation of VES data, a geo-electrical study was done to understand lateral and vertical distribution of aquifers in terms of its extent and thickness. The layer resistivity value and its corresponding thickness are given in table 3.

Table 3: Thickness of the different layers based on the resistivity values.

VES Nos.	Layer Resistivity (in ohm-m)					Layer thickness (in m)				Total thickness (in m)
	I	II	III	IV	V	I	II	III	IV	
1	26.5	85.6	33.6	273	30.5	1.02	6.31	35.5	70.1	113
2	78	19.1	398	36.5	-	1.94	5.19	48.7	-	55.8
3	39.9	135	34.5	23.8	-	1.55	7.12	74.8	-	83.4
4	3.1	8.55	2.88	46.7	16.5	1.1	6.12	12.9	223	243
5	24.5	145	8.43	13	-	1.89	12.4	124	-	138
6	29.5	117	30.5	66.7	103	1.39	4.51	18	100	124
7	84.3	47.5	124	28.5	18.9	1.12	3.85	11	156	172
8	16.5	130	56.2	12.5	-	1.15	26.3	113	-	140
9	58.5	130	415	77.2	56.5	1.19	16.5	29.6	104	151
10	148	75.5	262	21.8	10.6	1.78	5.9	19.8	142	169
11	102	969	183	22.1	14	1.05	1.46	13.9	134	150
12	89.7	27.9	157	14.8	35.8	2.47	5.96	23.7	92.2	124
13	94	32.5	175	13.7	28.8	2.25	7.45	19.7	49.4	78.8
14	17	9.54	37.5	8.05	3.93	1.08	1.03	17.1	119	138
15	28.9	73	295	14.3	35.5	1.19	2.4	28.4	92.1	124
16	80.4	221	399	39.5	55.5	1.28	7.01	27.5	61.1	96.9
17	69.6	247	51	77.5	209	1.59	33.9	101	111	212
18	132	395	42.5	156	-	1.14	9.51	149	-	160
19	58	120	484	35.5	219	1.19	12.6	22.1	20.8	56.7

20	115	283	80	59.5	7.45	1.68	7.15	50.6	82	141
21	221	320	32.8	39	-	1.08	23.3	121	-	145
22	61	370	64	27.3	-	8.62	60.4	62.3	-	131
23	65	55.8	174	385	36.5	1.24	5.07	28.9	101	136
24	44.9	85.9	57.5	168	-	1.36	8.64	71.2	-	81.2
25	80	25.9	259	21.5	11.5	1	2.41	38.9	194	236
26	48.5	5.75	45	15	-	1.57	18.7	189	-	209
27	85.8	190	28.9	54	-	4.5	49.1	95.8	-	119
28	80.5	124	23.5	43	-	1.16	33.7	65.1	-	100
29	135	91.5	48.9	25.5	-	1.32	5.97	63.8	-	71.1
30	236	100	363	36.5	11.5	1.35	4.06	16.8	207	229
31	6.15	4.63	1.99	2.55	-	1.46	11.3	19.1	-	31.9
32	156	488	178	47.5	-	1.16	7.68	86.4	-	95.2
33	282	64.5	173	33.5	387	3.78	26.2	67.9	103	201

It can be concluded after considering all the observations from VES data that:

i. The resistivity of the top layer in the study area is within 650 ohm-m with varying thickness 1.15 to 8.84m.

ii. The formation containing sand with pebble and gravel are productive zones.

iii. In general the resistivity more than 200 ohm m corresponds to boulder formation.

iv. The quality of ground water is fresh and potable.

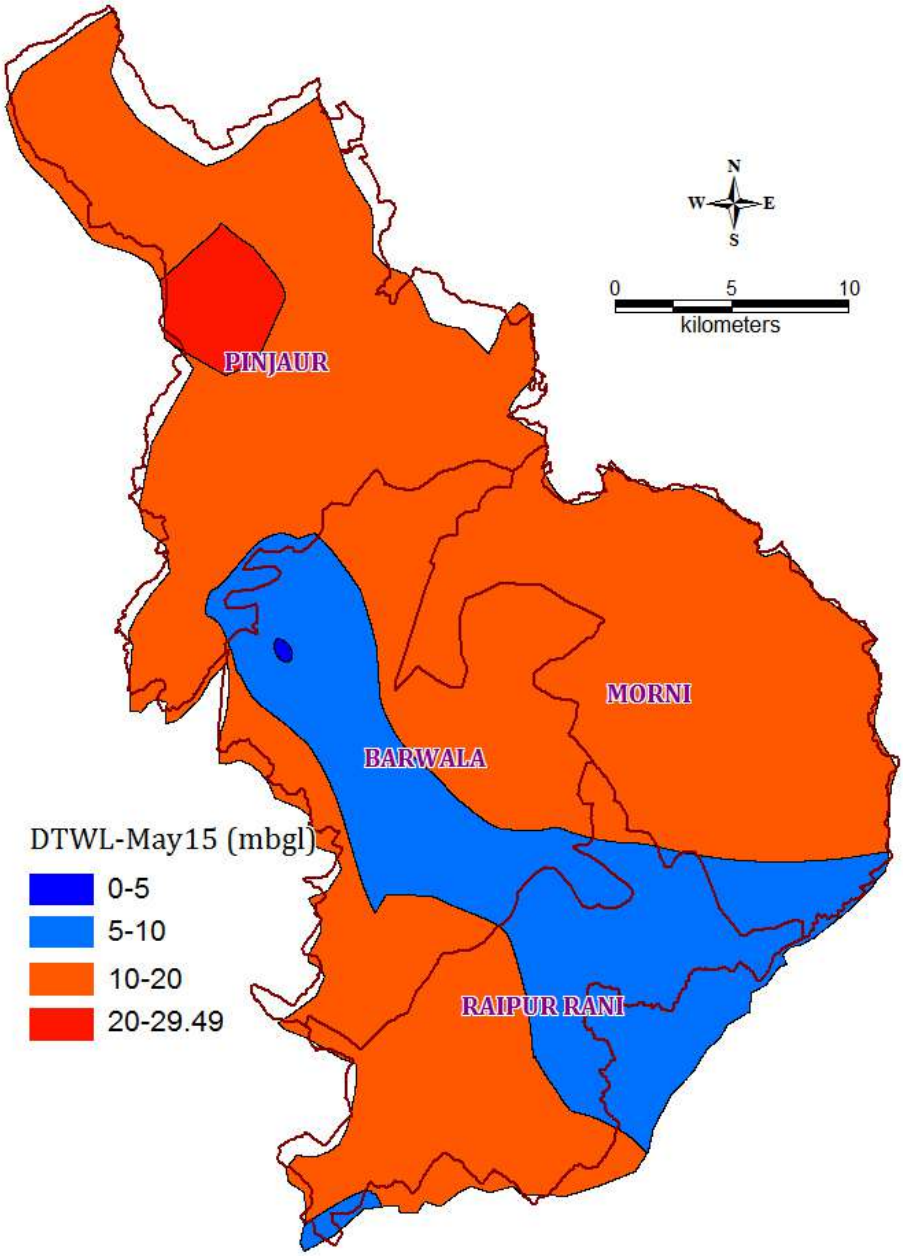
2.3 Water Level Behaviour (2015)

The depth to water level ranges from 4.6m bgl at Nadha to 29.52m bgl at Khera during pre-monsoon (fig 7) and 3.02m bgl to 34.75m bgl during post-monsoon. Majority of the wells showing rise in the water level in post-monsoon which ranges from 0.25m at Devinagar to 4.66m at Dharampur. The fall in the water level ranges from 0.08m at Parwala to 3.12m at Patwi. The depth to water level data and its fluctuation is given in Annexure I.

The long term trend in the water level reflected by water level hydrographs is indicative of the change in ground water storage in phreatic zone with time. The ground water observation wells (GWOW) which are indicating a rise in water level trend, this may be due to local hydrological conditions prevailing in the area. Whereas hydrographs showing declining water level trend may be due to over-exploitation of ground water and these area

require careful management of surface water and conjunctive use of surface water and ground water. Some of the hydrographs neither showing any substantial rise nor major decline thus indicating that the dynamic storage of phreatic aquifer is being maintained which is being utilized before the monsoon and gets recharged post monsoon.

Fig 7: Depth to water level map (Pre-monsoon, 2015).



2.4 Ground Water Flow

The north and north eastern part of the district is having hilly area therefore, the major ground water flow is from north and north-eastern part to the centre and southern

part of the district. The ground water table varies from 281.57m amsl in the centre to 567.40m amsl in the northern part of the district which also indicates the flow towards the central portion of the district i.e. towards Barwala block.

2.5 Ground Water Quality

The distribution of chemical constituents in ground water as per ground water observation wells data 2015 is tabulated in annexure II. The ground water is alkaline in nature. The pH values range from 7.8 at Dharampur to 8.95 at Golpur. The EC of ground water ranges from 265 µS/cm at Fatehpur to 2500 µS/cm at 25°C at Kakar Majra. In most of the water samples, EC is below 1000µS/cm. The hardness value of ground water ranges from 93 mg/l at Fatehpur to 722 mg/l at Kakar Majra. Among cations, the concentration of calcium ranges between 12mg/l at Bataour to 103 mg/l at Kakar Majra. Magnesium concentration ranges between 2.5 mg/l at Gariran to 113 mg/l at Kakar Majra. In all the ground water samples, calcium and magnesium concentrations are less than 100 mg/l except at site Kakar Majra. The sodium content varies widely from 16mg/l at Mehranwali to 325 mg/l at Golpur whereas potassium content ranges from 0.9 mg/l at Gariran to 4.2 mg/l at Abdullapur. Among anions, bicarbonate is the dominant anion. Carbonate is found to be less in quantity and bicarbonate concentration ranges between 24 mg/l at Kona to 512 mg/l at Golpur. The chloride concentration in ground water samples is within the desirable range of 250mg/l (BIS 2012) except at site Kakar Majra with the value of 361mg/l. The chloride concentration varies between 6.9 mg/l at Fatehpur to 139 mg/l at Patwi & Golpur. The sulphate content in many of the ground water samples is below the detection limit and varies up to 205 mg/l at Kakar Majra. The nitrate (NO^3) concentration ranges from 3.6 mg/l at Bataur to 305 mg/l at Kakar Majra. The fluoride (F) content in ground water of the district ranges from trace to 0.72mg/l at Kakar Majra.

Arsenic concentration of 0.001 mg/l has been found at site Gariran and Kona which is less than the permissible limit and other sites are having arsenic below the detection limit. Iron concentration in ground water ranges from below detection limit to 0.1594 at site Chandipur but it is more than the permissible limit at only one site Patwi having a value of 0.6369mg/l.

2.2 SPATIAL DATA DISTRIBUTION

The data of CGWB wells (Fig 8) and all the wells from PHED and Private in the area are plotted on the map of 1:50000 scale with 5'X5'grid (9 x 9km) and is shown in fig 9 & 10 respectively. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation.

Fig 8: Location of CGWB wells

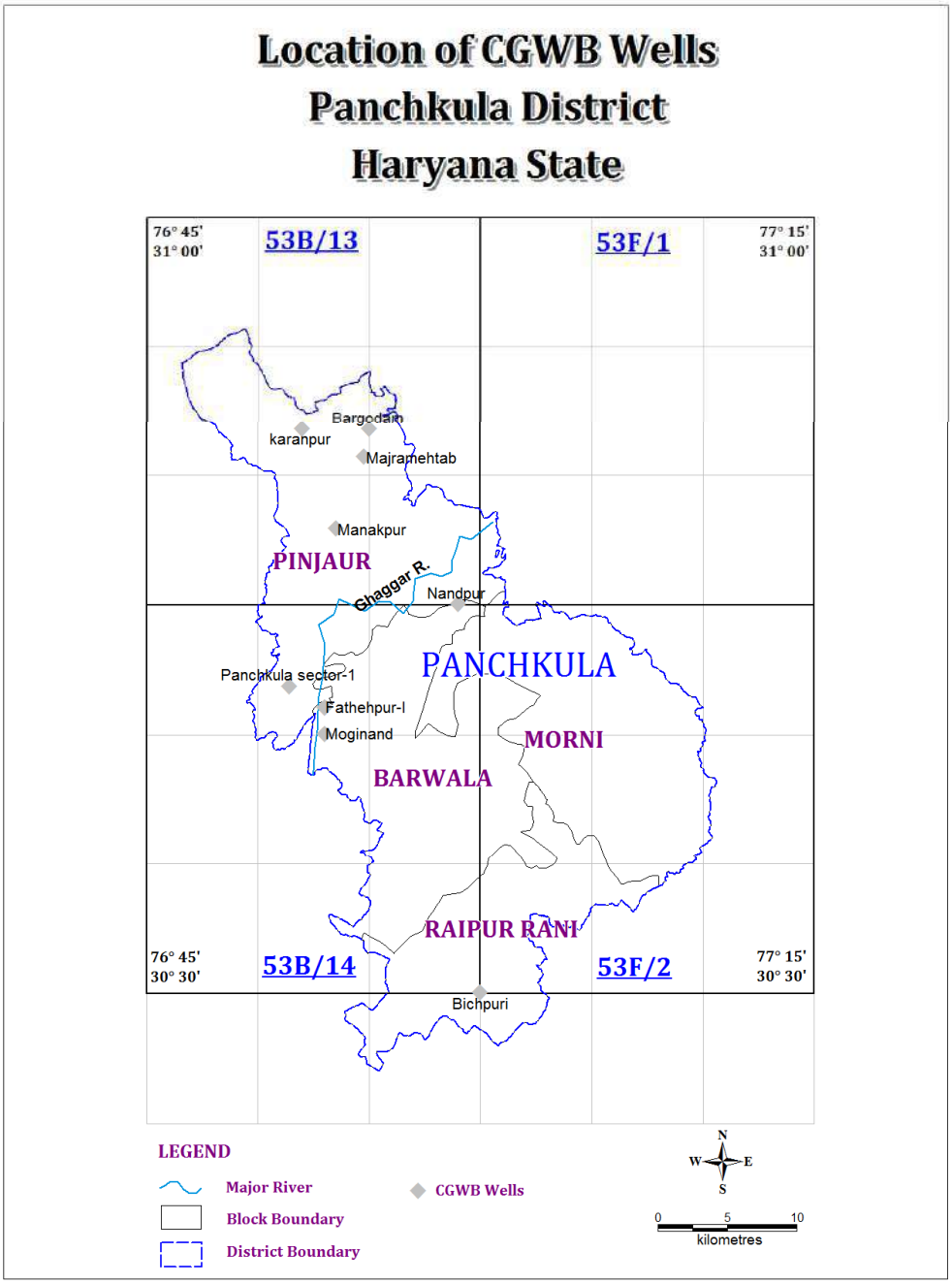


Fig 9: Location of PHED wells

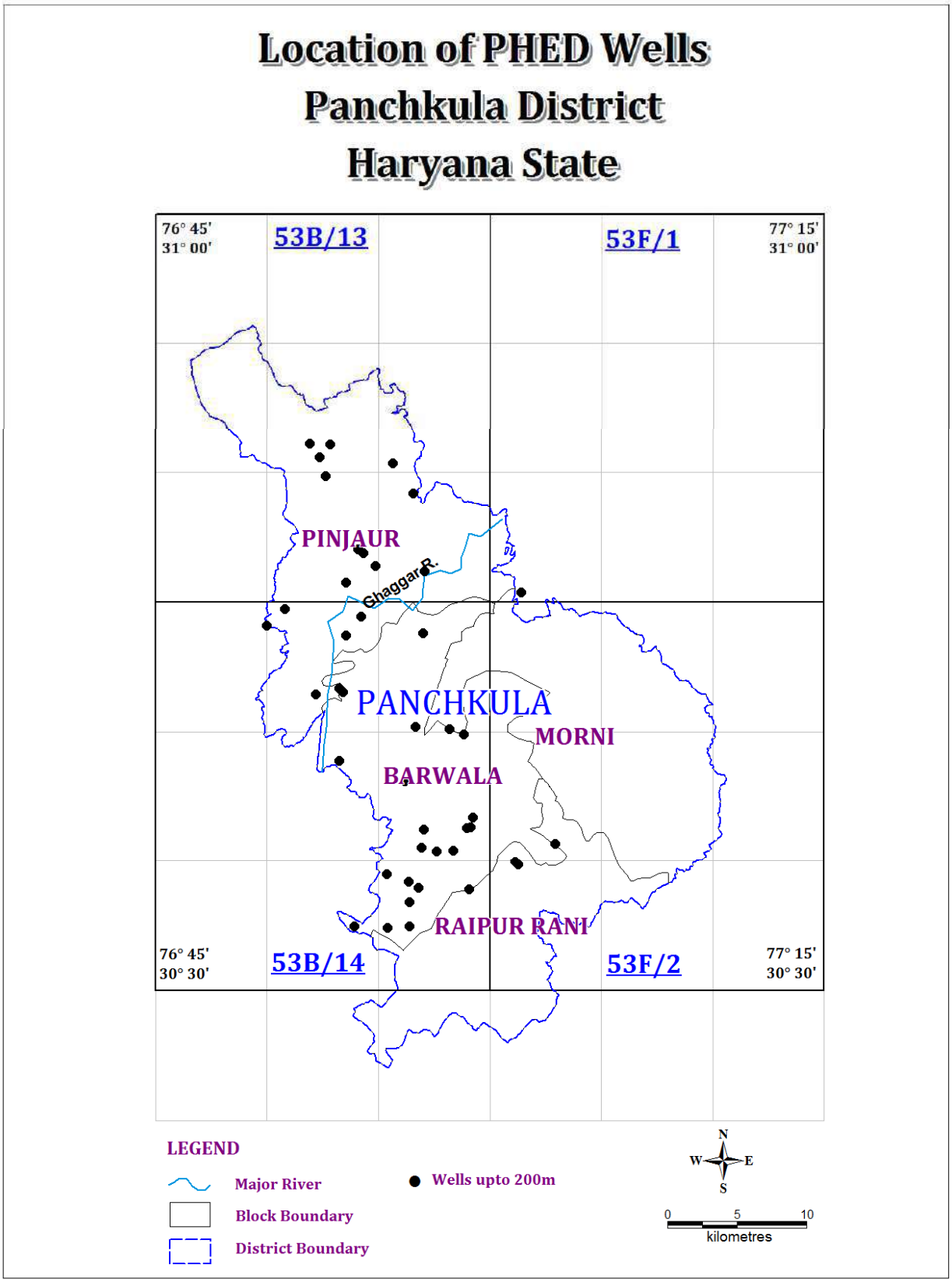
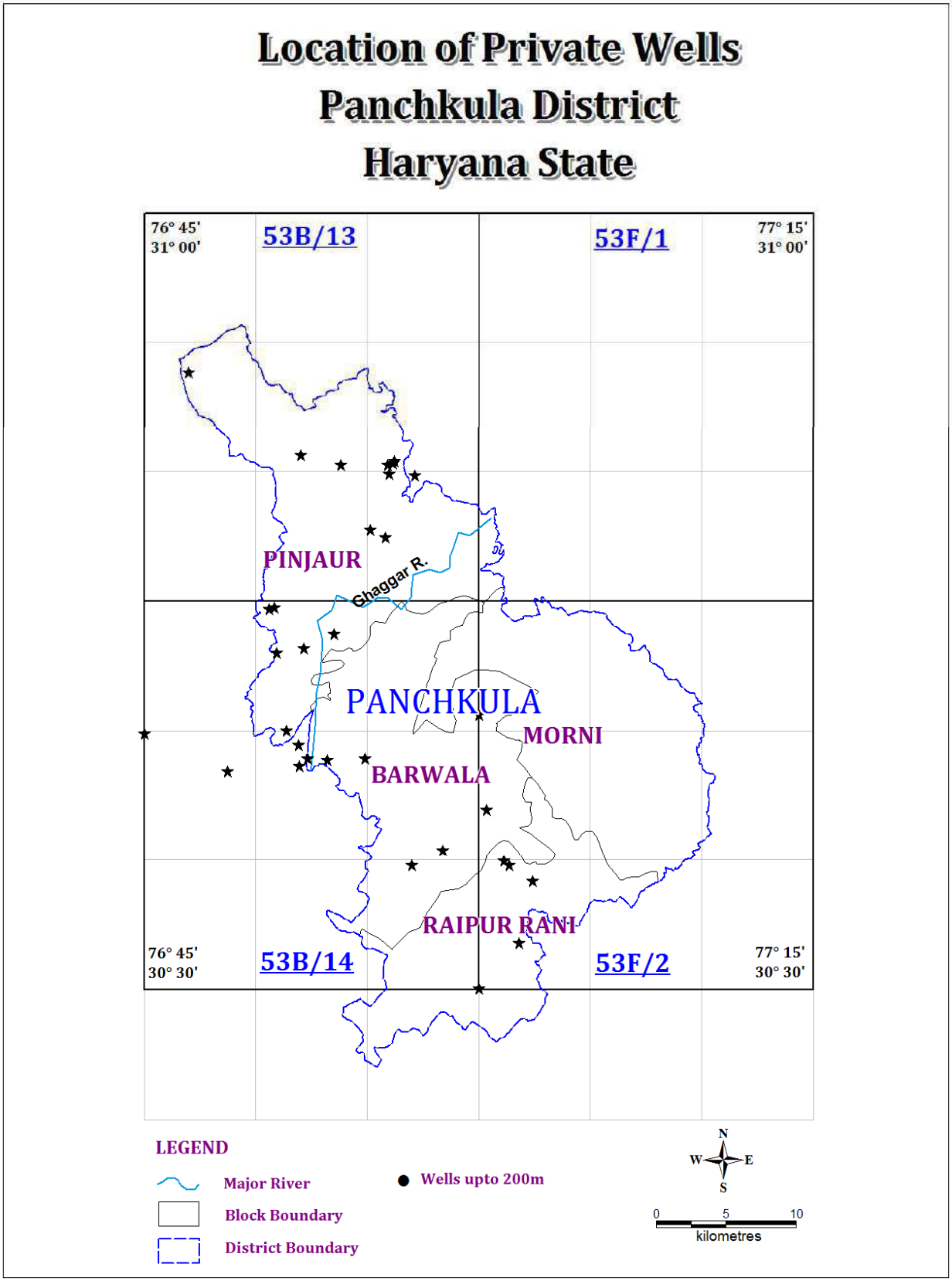


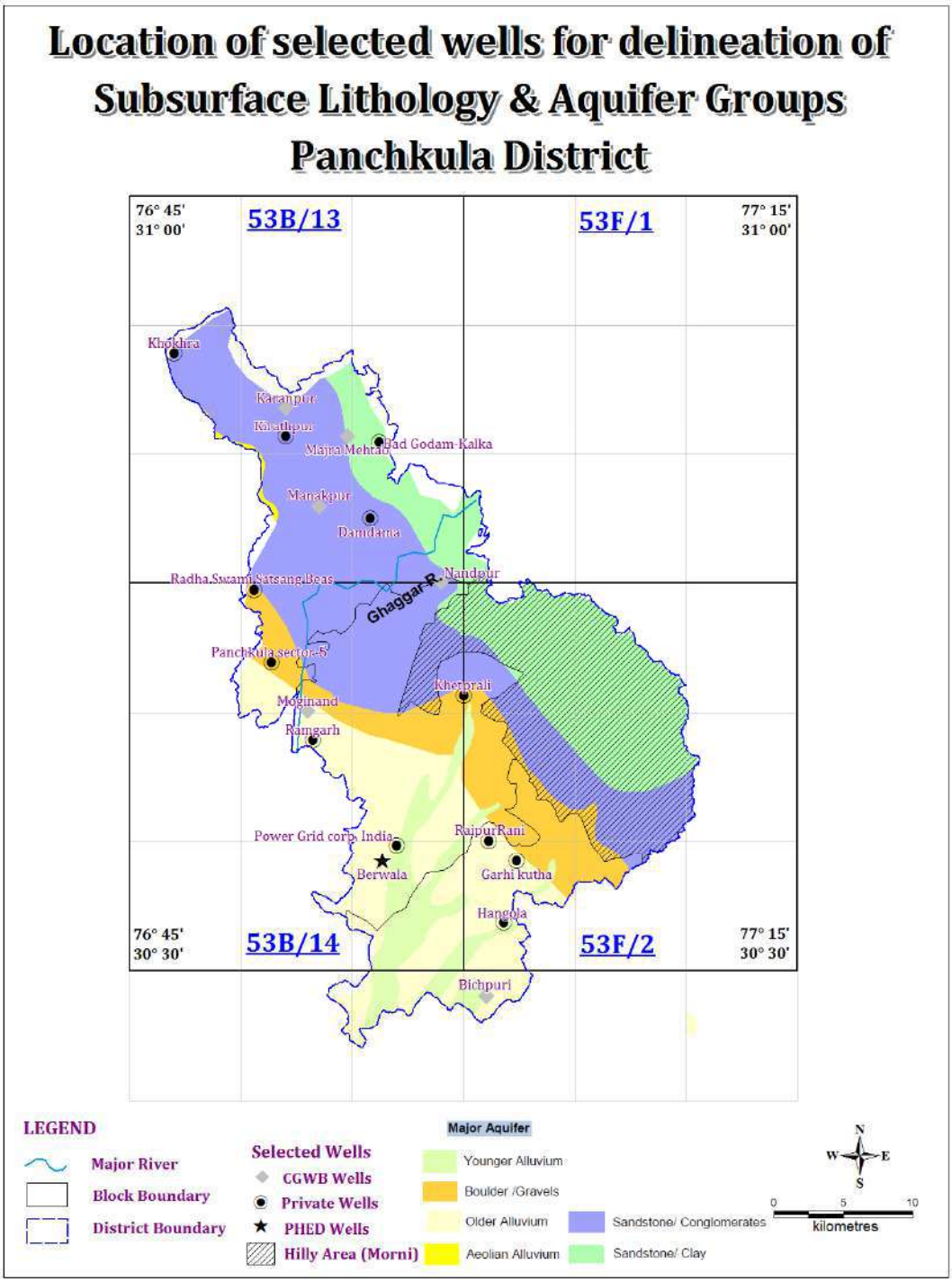
Fig 10: Location of Private Wells



2.3 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

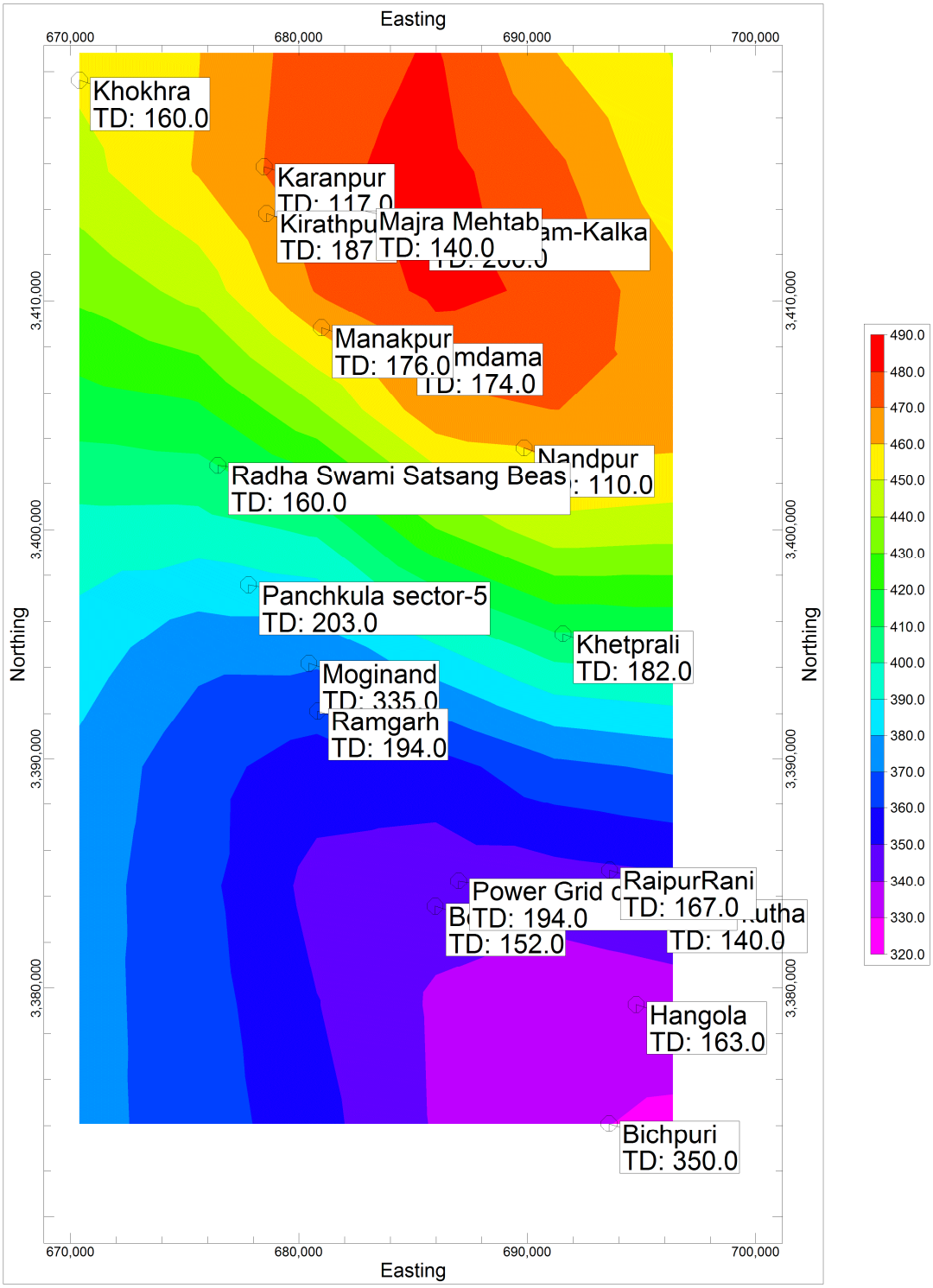
All the available data have been validated for consideration to generate aquifer map. The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig 11. Details are given in Annexure III.

Fig 11: Validated Exploration Data of Panchkula District



The topography values has been plotted to prepare the elevation contour map and is shown in fig 12. The locations of validated wells are plotted and litholog is shown in fig 13.

Fig 12: Elevation Contour Map – Panchkula district

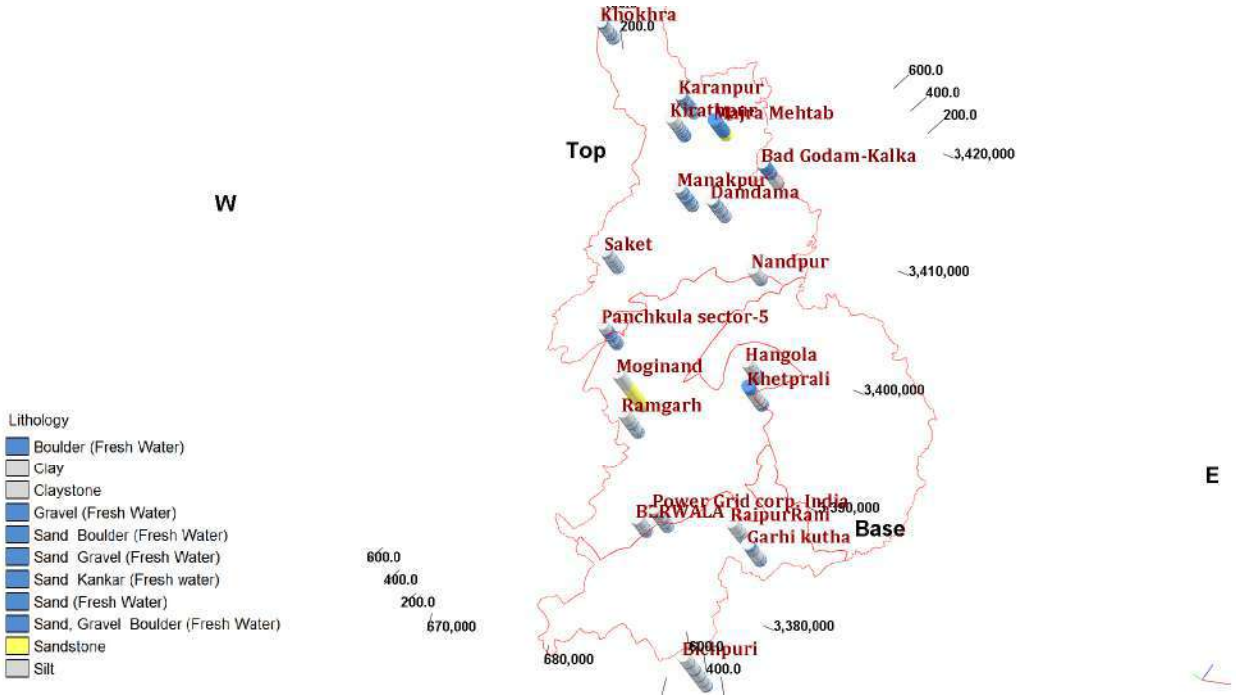


Summarized details of the validated and optimized wells are given in table 4.

Table 4: Summary of optimized exploration wells

Block	**Toposheet and grid Number**		No of Well & Depth range (m)				Location with depth (m)
			>300	200-300	100-200	<100	
Pinjaur	53B/13	2A	-	-	1	-	Khokra (160m)
		2B	-	-	3	-	Kirathpur (187m), Karanpur (117m), Majra Mehtab (140m)
		2C	-	-	1	-	Bad Godam-Kalka (200m)
		3B	-	-	1	-	Manakpur (176m)
		3C	-	-	1	-	Damdama (174m)
	53B/14	1B	-	1	1	-	Saket (160m) & Panchkula sector-5 (203m)
		2B	-	-	1	-	Ramgarh (194m)
	53F/1	3A	-	-	1	-	Nandpur (110m)
Barwala	53B/14	2B	1	-	1	-	Moginand (335m)
		1C	-	-	1	-	Khetprali (182m)
		2C	-	-	1	-	Power Grid corp. India (194m)
		3C	-	-	1	-	Berwala (152m)
Raipur Rani	53F/2	2A	-	-	1	-	Raipur Rani (167m)
		3A	-	-	2	-	Garhi Kutha (140m) & Hangola (163m)
	53F/3	1A	1	-	-	-	Bichpuri (350m)

Fig 13: 3Dimension location of validated Exploratory Wells with litholog



3. HYDROGEOLOGY

3.1 PREVIOUS WORK

The ground water exploration in the district reveals that clay group of formations dominates over the sand group in the district area. The ground water occurs in pore-spaces of alluvial formation including Kandi belt stretching to Siwalik foothills under water table and in semi-confined conditions. These aquifers consist of sand, silt, gravels and kankar associated with clay and form highly potential aquifers. In alluvium, the permeable granular zones comprising fine to medium grained sand and occasionally coarse sand and gravel. Their lateral and vertical extent is extensive.

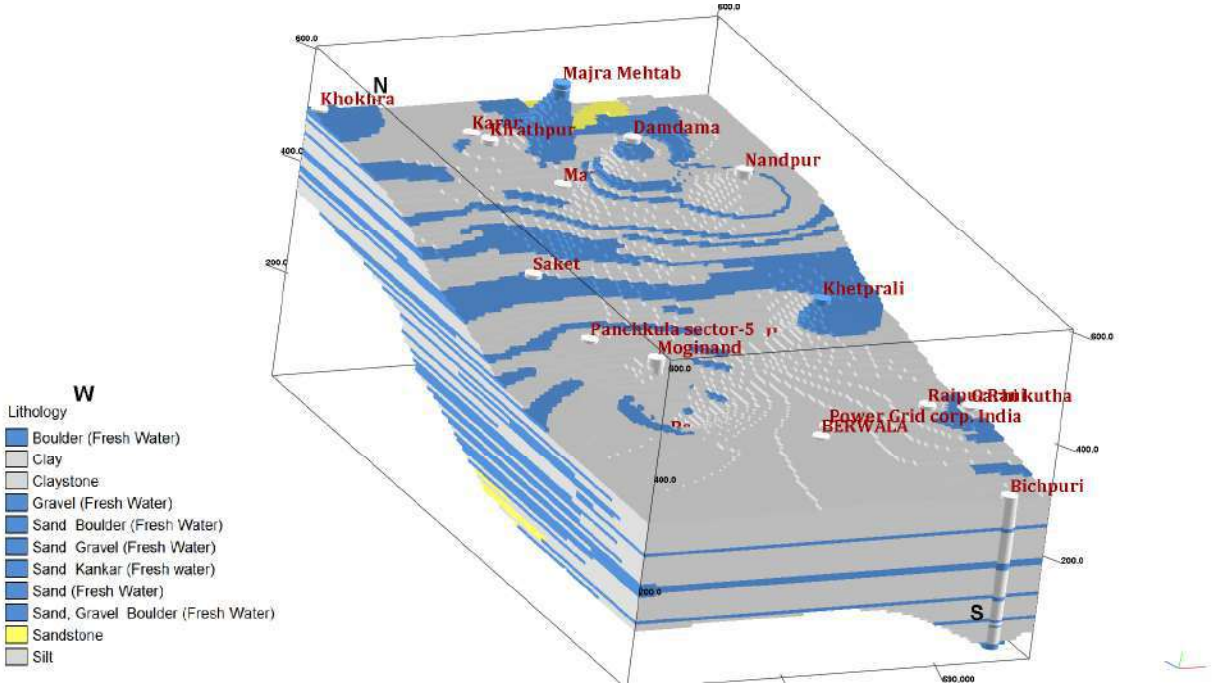
In Kandi belt, which has not been explored, fully boulders cobbles and pebbles, constitutes the major aquifer horizon. Siwalik Hills occupy marginal areas in the northeastern parts of the district constitute a low potential zone. In Kandi areas, the shallow aquifers are isolated lenses embedded in clay beds whereas aquifers in alluvial areas occur in regional scale and have pinching and swelling disposition and are quite extensive in nature. These aquifers generally consists sands (fine to coarse grained) and

gravels and are often intercepted by clay and kankar horizons. These aquifers are also unconfined to semi-confined conditions and support a large no. of shallow tubewells within the depth of 50m only. The discharge of these tubewells varies between 100lpm and 500 lpm for moderate drawdown values. Under ground water exploration programme fourteen exploratory wells were drilled in the district. On an average 4-6 granular zones have been deciphered within the depth range of 355m bgl. Exploratory wells were drilled in depth range of 132 and 355 mbgl, yield range between 205 to 3000 for Drawdown upto of 3.2 and 21.9m and Transmissivity of aquifers range between 2493 and 4928 m^2/day. Storativity of formation is $1.3*10^{-2}$

3.2 Present NAQUIM study

To understand the sub surface lithology and its disposition, the lithological data of the optimized wells drilled by CGWB, PHED and Private Agencies is plotted using the RockWorks15 software and a lithological model has been prepared and is shown in fig 14. The 3D lithological fence diagram has been prepared using the lithology model and is shown in fig 15.

Fig 14: 3-Dimension Lithological Model of Panchkula District



According to the major aquifer system found in the Panchkula district shows that there is a large variability in the aquifer system, it varies from sandstone/clay in north-east

to sandstone/conglomerate to boulder/gravels to alluvial deposits towards south-west. This is also found in the lithologs of wells located in the study area. The complete district is a clay dominated area. The major lithological units in the district and its maximum thickness is given in Table 5.

Table 5: Major lithology and its maximum thickness in Panchkula District.

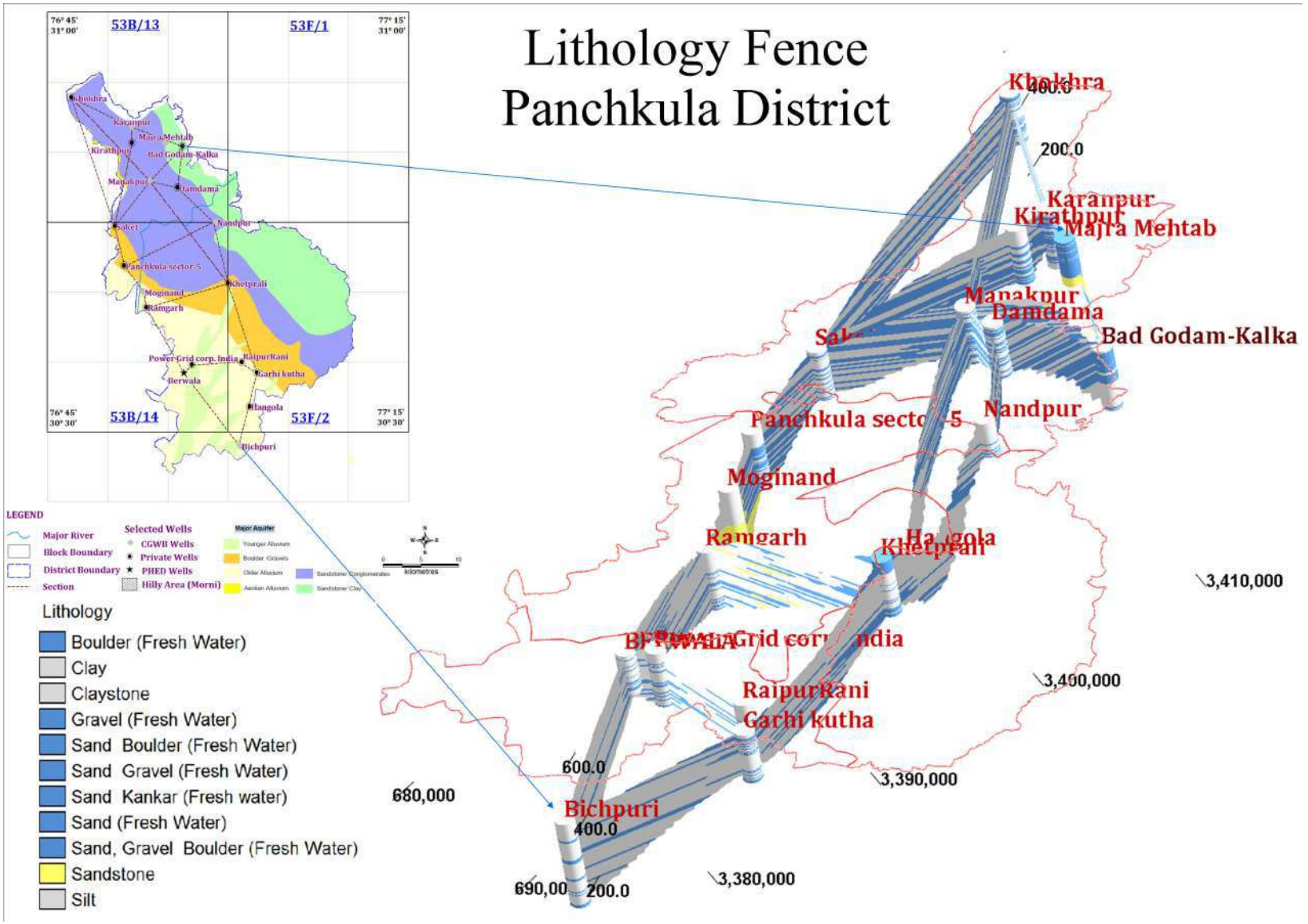
Lithology	Maximum thickness (m)
Boulder	54
Gravel	18
Sand mixed with boulder	41
Sand mixed with gravel	12
Sandstone	64.5
Sand	14
Clay	108.5

The lithology along W-E direction shows that there is an occurrence of sand, gravel & boulder mixed with sand interbedded with clay layers and along NW-SE to western side of the district; sand, boulder, boulder & gravel mixed with sand and sandstone (site Moginand) interbedded with clay are found. There is a large variation in the topography along NW-SE to eastern side of the district which shows the variation of lithology from boulder, boulder & gravel mixed with sand in the north to sand in the south-west interbedded with clay. The lithology from the highest elevation point in the NW to the lowest elevation point in the SE indicates the change in the aquifer system from boulder to sand with gravel to sandstone to sand with thick layers of clay. The 3D lithology fence represents clear presentation of the variation in sub-surface lithology as well as the topography.

3.2.1Ground Water Exploration

Ground water exploration was carried out in Panchkula district under NAQUIM. Two piezometers (shallow and deep) have been constructed in Barwala block. The depth of the shallow and deep piezometers is 56 and 196m bgl respectively. is The shallow tubewell is tapping the zones between 31 to 53 mbgl and the deeper one is tapping between 141 to 193 mbgl. The samples for bacteriological, pesticides and major cations-anions have been collected and the analysis is under process.

Fig 15: 3Dimension Lithological Fence of Panchkula District



4. GROUND WATER RESOURCES

Ground water resource estimation of the area have been carried out by taking Dynamic and Static/In-storage resources of unconfined aquifer and confined aquifers present upto 300m depth. The assessment of dynamic ground water Resources of the study area have been carried out jointly by CGWB and Ground Water Cell, Department of Agriculture, Haryana on the basis of Ground Water Estimation Committee (1997) methodology based on data available and as per the revised methodology for the year as on 31st March 2013.

The occurrence of potential aquifers (productive granular zones) upto 300 m depth has been demarcated on basis of aquifer wise subsurface mapping. The total saturated thickness of granular zones was derived from the exploratory borehole data of a particular block. The granular zones occurring below the zone of water level fluctuation up to the first confining layer has been considered as static unconfined zone. The ground water resource of this zone has been calculated considering 12% specific yield of the formation. The specific yield value for the unconfined aquifer has been taken as 60% of 0.12 which comes as 0.072 whereas for the confined aquifer, the storativity value has been considered. Since the specific yield is likely to reduce with increase in depth due to compaction of overlying sediments.

Hence, the major data elements considered in this estimation are thickness of granular zones, specific yield/storativity, and area of both fresh water and saline/brackish water. It has been observed that in some of the blocks sufficient data on probable occurrence of granular zones was not available. In those cases, the existing exploratory data of adjoining block/district has been either extrapolated or interpolated to derive such parameters required for estimation. This assessment of total groundwater resources has been computed based on the available data with CGWB & Ground Water Cell, Department of Agriculture, Haryana.

5.1 Unconfined aquifers

Dynamic Resources

The assessment of total availability of ground water resources encompasses two components namely dynamic resources and in-storage resources. Block wise dynamic resource figures so obtained based on GEC, 1997 norms have been taken as the 1st

component for unconfined aquifer. Further in pursuance to the methodology recommended by CGWB to assess total availability of Ground Water Resources, the following procedure has been adopted to calculate in-storage resources and total availability of Ground Water Resources.

The block wise ground water resource potential in the district has been assessed as per GEC-97 as on March 2013.The stage of ground water development ranges between 58% (block-Pinjore) to 100% (block- Raipur Rani). The total replenishable ground water resource in the district is 145.53 mcm. The net ground water draft is 116.52 mcm. The stage of ground water development in the district is 80% (Table 6). Morni block of this district is completely having hilly area; therefore, it has not been assessed.

Table 6: Dynamic Ground Water Resource (as on 31.03.13)

Assessment Unit/ Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses	Provision for domestic, and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development (10-11-14)	Stage of Ground Water Development {(13/10) * 100} (%)
Barwala	69.33	52.42	5.85	58.27	1.51	15.40	84
Pinjore	42.46	10.21	14.40	24.61	1.05	31.20	58
Raipur Rani	33.75	25.99	7.65	33.64	1.21	6.55	100
TOTAL	145.53	**88.62**	**27.90**	**116.52**	**3.77**	**53.14**	**80**

*all the given figures are in mcm

5.2 Confined Aquifer

The availability of ground water resources in confined aquifer have two components: Storage under pressure (using Storativity concept) and Storage under desaturated (gravity drainage) condition (using Specific Yield concept) (source: Assessment of Ground Water Resources; A Review of International Practices, 2014) and is shown in Fig 16. However, since ground water withdrawals from confined aquifer are known to have serious environmental degradation effects, the preliminary assessment of ground water resources in confined aquifer is restricted to the estimation of ground water storage under pressure conditions only but here the storage under de-saturation is also computed.

Storativity Concept:

ii)	In-storage Ground Water resources (within the Peizometer)	=	Thickness of the water column in Peizometer of particular confined aquifer up to the top layer of same confined aquifer	×	Storativity of the confined aquifer	×	Areal extent of the confined aquifer group

Specific Yield Concept:

ii)	In-storage Ground Water resources (within the aquifer thickness)	=	Thickness of the confined aquifer (granular/ productive zone) down to the bottom layer of confined aquifer or exploitable depth of 300 m	×	Sp. Yield of the aquifer	×	Areal extent of the confined aquifer group

Preliminary assessment of the ground water resources in confined aquifer does not imply that the assessed resource is available for exploitation. The objective of this exercise is to have an overview of the ground water regime in the particular confined aquifer. It should be kept in mind that any significant ground water withdrawal from confined aquifer may invoke serious environmental degradation problem. Therefore, in case the preliminary assessment reveals that ground water is being withdrawn in significant quantity for any confined aquifer, that particular aquifer should be identified for detailed assessment using numerical modelling approach.

Total Availability of Ground Water Resources = Dynamic Resources + In-storage Resources.

Block wise instorage ground water resources of Aquifer is given in table 7. Total block wise ground water resources are given in table 8.

Fig 16: Methodology for Resource Estimation in Unconfined and Confined Aquifer System.

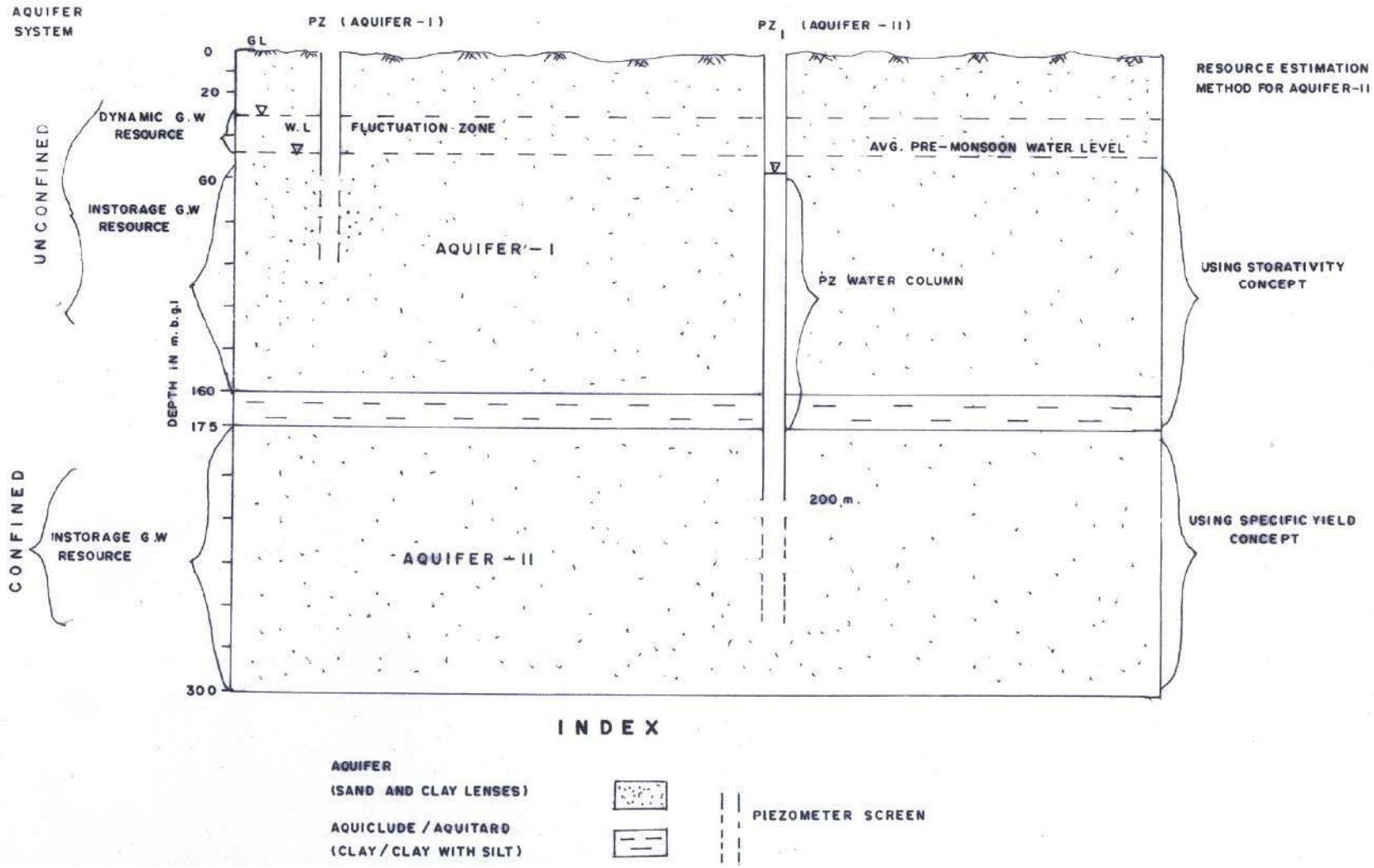


Table 7: BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED SINGLE AQUIFER SYSTEM (UP TO 300m DEPTH)

Name of Assessment Unit/ Block	Type of rock formation	Areal extent (ha)				Average Pre-monsoon Water Level (m bgl)	Average explored depth (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (8-7)	Thickness of the Granular Zone in unconfined aquifer below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources [(5)*(10)*(11)*] FRESH (ham)
		Total Geographical Area	Assessment Area								
			Total	Fresh Water	Brackish /Saline Water						
1	2	3	4	5	6	7	8	9	10	11	12
Barwala	Alluvium	18401	18401	18401	0	12.95	270	257.05	48.89	0.072	64773
Pinjore	Alluvium	21760	10660	10660	0	17.08	182	164.92	76.54	0.072	58746
Raipur Rani	Alluvium	13698	10498	10498	0	10.96	187	49.63	49.63	0.072	37513
Dist. Total (ham)		**53859**	**39559**	**39559**	**0**						**161032**
Dist. Total (bcm)											**1.610**

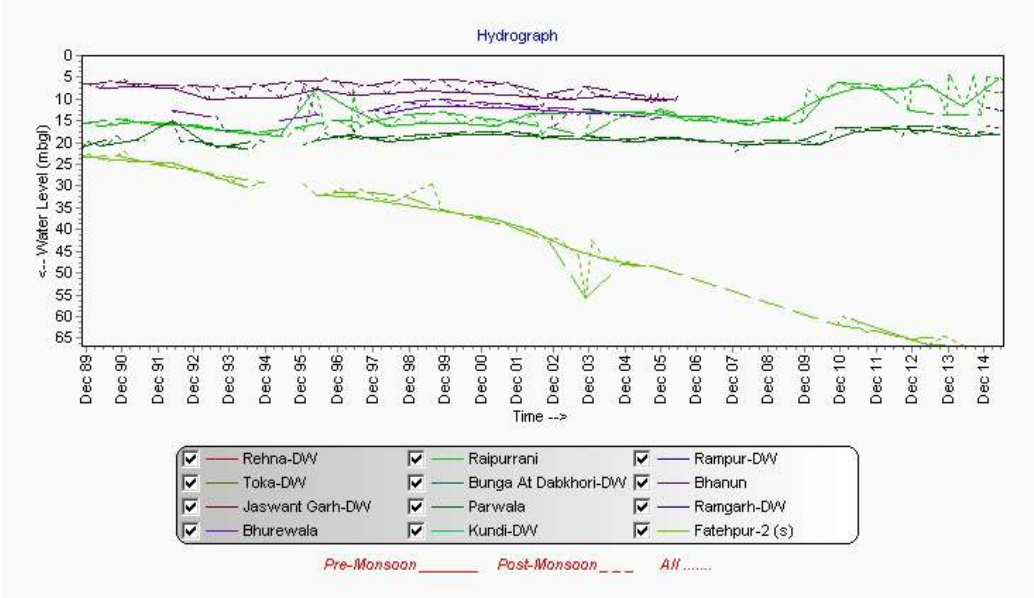
Table 8: BLOCK WISE TOTAL AVAILABLE GROUND WATER RESOURCES IN AQUIFER UP TO 300m DEPTH

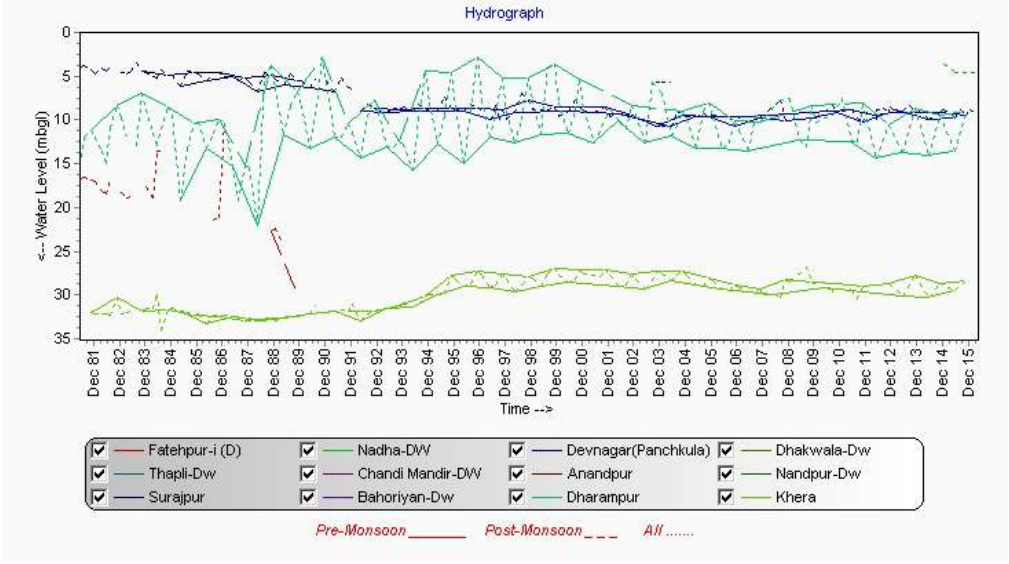
Block	Type of Rock Formation	Total Geographical Area (ha)	Total Assessment Area (Ha)	Net Ground Water Availability (Dynamic Ground Water Resources) (As on 31st March 2011) (in ham)	Fresh In-Storage Ground Water Resources (Aquifer I)(in ham)	Total Groundwater Resources AQUIFER-I(in ham)	Total Availability of Ground Water Resources upto 300m (in ham)	Total Availability of Ground Water Resources upto 300m (in bcm)
				1	2	5=(1+2)	6=5	7
					Based on Aquifer Mapping			
Barwala	Alluvium	18401	18401	6933	64773	71706	71706	0.717
Pinjore	Alluvium	21760	10660	4246	58746	62992	62992	0.630
Raipur Rani	Alluvium	13698	10498	3375	37513	40888	40888	0.409
Dist. Total (ham)		53859	39559	**14554**	**161032**	**175586**	**175586**	**1.756**
Dist. Total (bcm)				**0.146**	**1.610**	**1.756**	**1.756**	

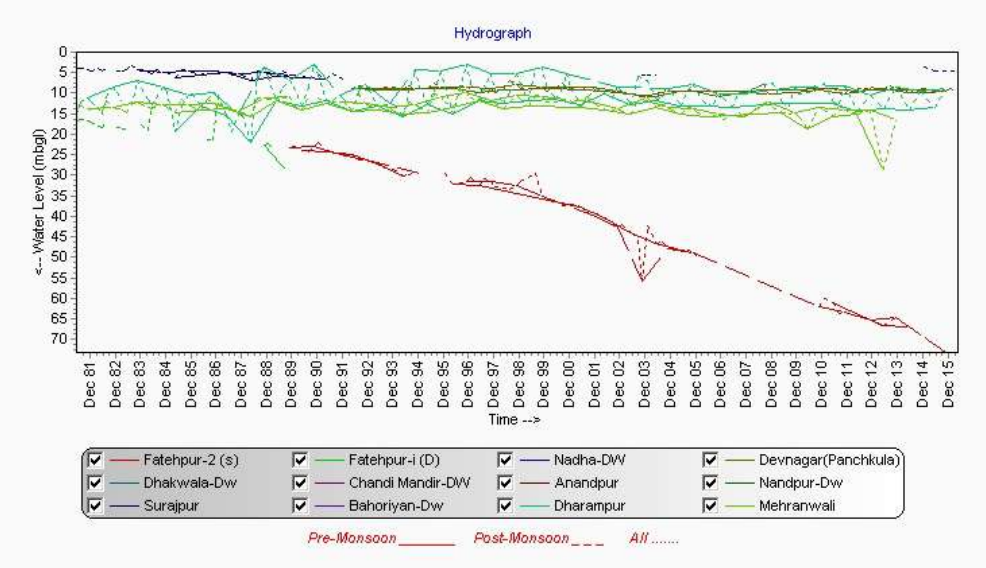
5. GROUND WATER RELATED ISSUES

The district is having variation of geology and geomorphology like highly and moderately dissected hills, active flood plain and alluvial plains which lead to its high recharge sources and potential, resulting in no major ground water related issues. But as the time is progressing the population is growing and their dependency on ground water is also growing leading to its high consumption as compared to its recharge as well as some quality issues are also raising at sporadic locations (fig17). As the area is a good recharge zone but there is nothing done to increase the residence time of the ground water in the aquifer.

Fig 17: Hydrographs of various sites in Panchkula district.







5.1 GROUND WATER IRRIGATION SCENARIO

As per the data available from minor irrigation census 2006-07 the detailed number of shallow, deep, tube wells, lined, unlined water distribution system, land holdings of wells are given below in table 9, 10 and shown in fig 18.

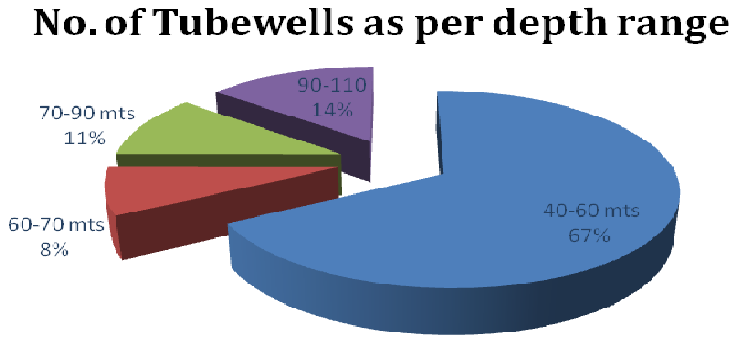
Table 9: Distribution of Tube wells According to Owner's Holding Size

Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Public	Group of Farmers	Total
0	83	411	127	163	1150	1934

Table 10: Type of Ground water distribution device

Open Water Channel		
Lined/pucca	Unlined/kutcha	Total
1156	778	1934

Fig 18: Irrigation tubewells as per depth range.



6. AQUIFER MANAGEMENT PLAN

Another focus has been given to minimize the gross draft by enhancing ground water use efficiency in irrigation system after replacing the water distribution system from unlined/kutcha channel to Under Ground Pipeline System (UGPS) for the whole Panchkula district.

6.1 SCOPE OF IMPLEMENTATION

This plan is focusing on the technical aspects of the ground water recharge through various meansso that various implementing agencies may get the appropriate technical guidelines. The existing/ongoing schemes of the central or state govt. like MANERGA, IWSP, PMKSY (Prime Minister Krishi Sinchai Yojna), NABARD funded schemes, Urban Development schemes, departmentally funded projects etc. may be benefitted from the recharge plan by incorporating the input in the operational guidelines/ design and for locating the specific sites.

Agriculture University, Engineering Collages, Academic and Research Institution, NGO may also take up the pilot or demonstrative projects in the blocks suitable to them to plan at local level as per local conditions. Artificial recharge plan for urban areas, rural areas through recharge pits is given in Table 11, 12 & 13.

Table: 11

Artificial Recharge in Urban Area

Block	Total Households	No of Houses taken for Artificial Recharge (10% of total households	Total No of AR Structures (one structure for 10 house holds)	Annual Rainfall runoff Available for recharge (MCM) (No of households x avg rooftop area(200 sqm) x runoff coefficient (80%) x rainfall, 960mm)
PINJORE	68218	6822	6822	1.048
BARWALA	942	94.2	94	0.012
RAIPUR RANI	1793	179	179	0.041
		TOTAL	7095	1.101

Table:12

ARTIFICIAL RECHARGE IN RURAL AREA

Block	Total Households	No of Houses taken for Artificial Recharge (10% of total households	Total No of AR Structures (one structure for 10 house holds)	Annual Rainfall runoff Available for recharge (MCM) (No of households x avg rooftop area(150 sqm) x runoff coefficient (80%) x rainfall, 960mm)
PINJORE	20133	2013	2013	0.232
BARWALA	13104	1310	1310	0.122
RAIPUR RANI	8978	898	898	0.153
		TOTAL	4222	0.507

Table:13

Artificial Recharge Through Recharge Pits in Farm

Block	Total Geographical Area (in Hectares)	10%of village area taken for farm recharge(sq m)	Total number of recharge pits (1 recharge pit / hector) for 10% area	Annual recharge (MCM)= (Area*Runoff 15%*Rainfall 777 mm/1000000)
PINJORE	17024	17024000	1702	2.45
BARWALA	17368	17368000	1737	2.02
RAIPUR RANI	12813	12813000	1281	2.73
		TOTAL	4721	7.21

6.2 POTENTIAL OF ENHANCING THE GROUND WATER USE EFFICIENCY

The micro level transformation in the ground water management have vast impact potential to counter extensive ground water depletion faced by the state of Haryana, particularly in overexploited blocks.

There are around 778 (out of 1934) tubewells (40.22%) operated by farmers for irrigation through unlined/Katcha open channel system in Panchkula district where water from the tubewell is discharge to the agricultural field. In this process huge (upto 20 %) quantity of ground water is wasted in soil moisture and evaporation losses.

Around 67% of the tube wells are of shallow depth (40- 60m) and remaining are deeper (60-110 m) depth. Thus majority of wells are tapping Aquifer group-1 which is under stress due to overexploitation.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in Panchkula district is estimated at 88.62 MCM. It is expected that around 25% of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby draft will be reduced up to 107.61 MCM assuming there is no crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in the area. The measure if implemented will bring down the stage of ground water development from 80% to 68%. The category of the blocks will also improve drastically resulting in boosting of agriculture and industrial development which may be otherwise not sustainable for future.

The tubewells also consume enormous electricity which is subsidized and government incurs significant revenue on this account. The measures therefore will result in saving of energy and money. Pollution impact will be reduced whenever diesel engines are used by the farmers. The environmental and ecological condition in the irrigated land will improve. Unwanted weed growth will also be controlled inside the farm land. This will also be useful in the waterlogged/ shallow water table areas as the seepage losses in these areas also aggravate the water logging. **Government should make/launch a mission mode program for installing the underground pipe lines instead of having *katcha* channel in the entire Haryana**. Heavy ground water overdraft can be reduced by these efforts. This will ensure **more crop per drop**. Reduction in stage of development after construction of Pacca channels in irrigated land is given in table-14.

Table: 14 Reduction in stage of development after construction of Pacca channels in irrigated land

District	Net Annual Ground Water Availability (mcm)	Total Draft (present) (mcm)	Gross Irrigation Draft (present) (mcm)	Gross Ground Water Draft for Domestic and industrial supply (mcm)	Percentage of unlined channel	Wastage through unlined channel, (mcm) (Col 3 X Col5 X 0.25#)	Potential of Reduced irrigation overdraft (Col3-col6) (mcm)	Gross draft after saving of water (mcm) (Col 7+Col4)	Present Stage of Development (%)	Stage of development afterwards (Col 8/Col1)X100) (%)	Reduction in stage of development after constructing pucca channel (Col9-Col10) (%)
	1	2	3	4	5	6	7	8	9	10	11
Barwala	**69.33**	58.27	52.42	5.85	**40.22**	**5.27**	**47.15**	**53.00**	**84**	**76.44**	**7.60**
Pinjore	**42.46**	24.61	10.21	14.4	**40.22**	**1.03**	**9.18**	**23.58**	58	**55.54**	**2.42**
Raipur Rani	**33.75**	33.64	25.99	7.65	**40.22**	**2.61**	**23.38**	**31.03**	100	**91.93**	**7.74**

6.3 WATER SAVING POTENTIAL FROM CROP DIVERSIFICATION – CHANGE PADDY TO MAIZE/SOYABEAN:

As the requirement of water for paddy is much high therefore by changing paddy to maize/soyabean will help in saving of water. For estimating the water saving by crop diversification it is assumed that one mcm of water will be saved in case of maize or soyabean planted in one sq km of land. In case of pulses even higher amount of ground water can be saved.

Scope of quantitative impact on stage of development after applying various management strategies is given in Table 15.

Table 15: Scope of Quantitative Impact on Stage of Development after applying various management strategies

Block	Net Ground Water Availability (mcm)	Total Draft (mcm)	Present Stage of draft (SOD) (%) As per 2013	Reduction in draft by different water saving method			SOD afterwards (%)
				Replace water courses by UG Pipes (mcm)	Adopt Artificial recharge (mcm)	Total (mcm) (2+3)	
			1	2	3	*4*	
Barwala	69.33	58.27	84	5.27	2.15	7.42	**73**
Pinjore	42.46	24.61	58	1.03	3.73	4.76	**47**
Raipur Rani	33.75	33.64	100	2.61	2.92	5.53	**84**
Total	**145.53**	**116.52**	**80**	**8.91**	**8.8**	**17.71**	**68**

7.BLOCK WISE AQUIFER MAPS

AND

MANAGEMENT PLAN

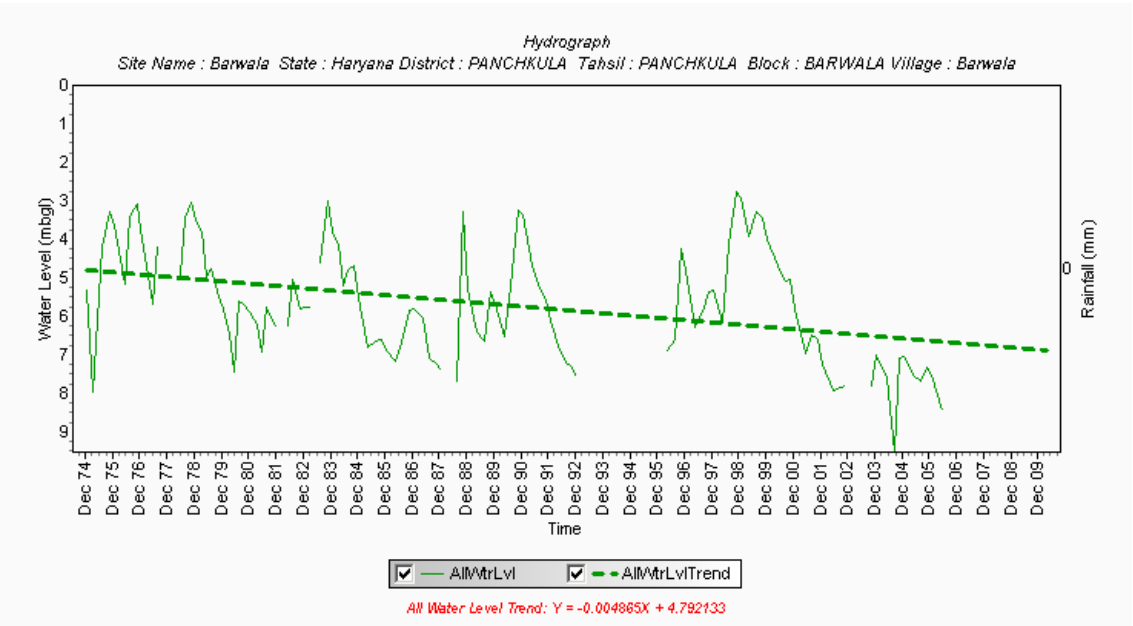
i. Barwala Block (184 sq km)

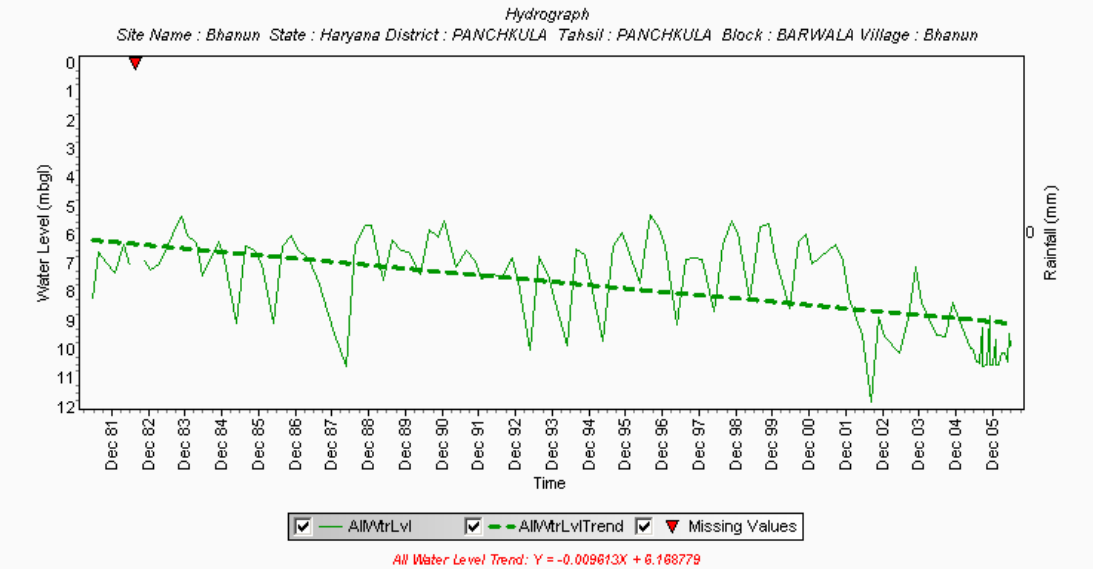
Population (2011)	Rural-72373 Urban-4934 Total-77307
Rainfall	Monsoon -688.2mm Non Monsoon-88.6mm
Average Annual Rainfall	776.8mm
Agriculture and Irrigation	Major Crops- Wheat, Rice & Maize Other crops-Bajra, Rapeseed & Mustard, Sugarcane, Potatoes Net Area Sown-98.58sqkm Total Irrigated Area-72sqkm
Water Bodies	**118** nos.

Ground Water Resource Availability: Ground Water Resources available as a single aquifer system in the block up to a depth of 300m. Block is categorized as Safe as per Dynamic Ground Water Resource assessment (31.3.2013).

Ground water Extraction: Information regarding the abstraction from deeper part of the aquifer is not available, but there are drinking water supply tapping combined aquifer therefore, aquifer could not be assessed separately.

Water level Behavior(2015): Pre Monsoon-8.4-18.2mbgl&Post Monsoon-3.9-34.8mbgl

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Site Name : Bhanun State : Haryana District : PANCHKULA Tahsil : PANCHKULA Block : BARWALA Village : Bhanun
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
AllWtrLvlTrend
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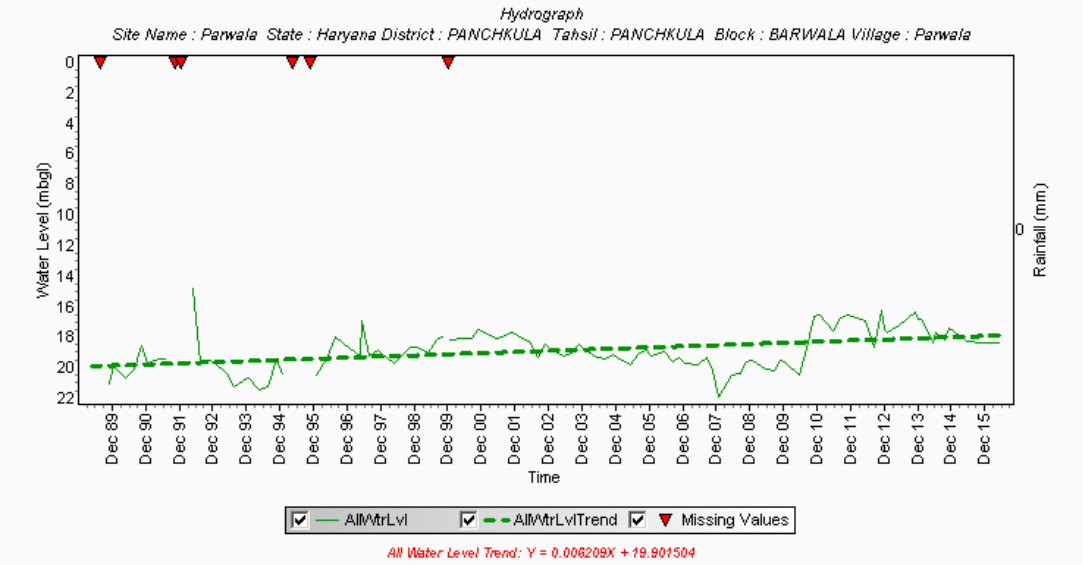
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Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
AllWtrLvlTrend
Missing Values
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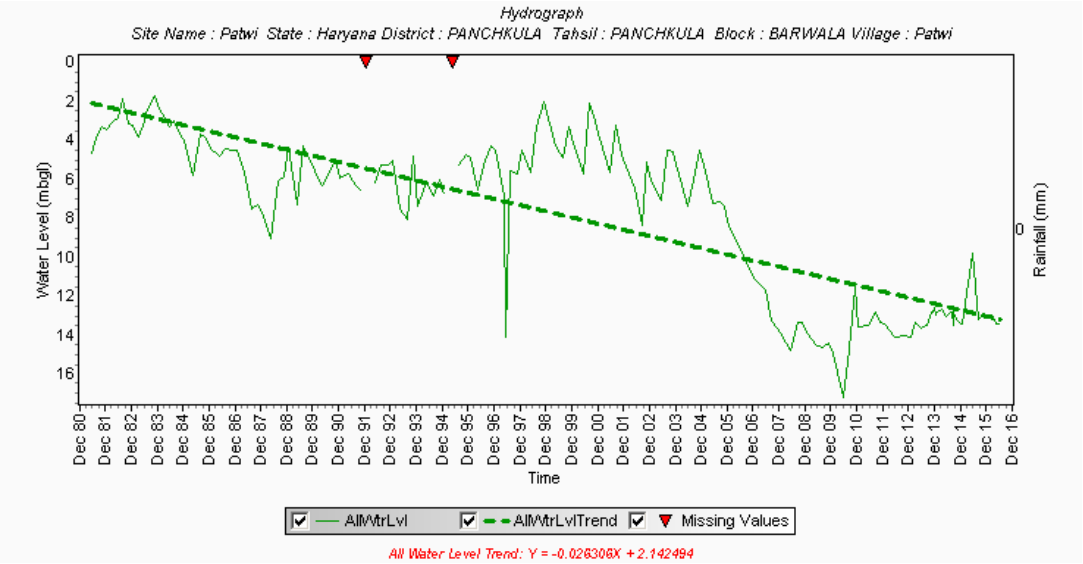

Hydrograph
Site Name : Patwi State : Haryana District : PANCHKULA Tahsil : PANCHKULA Block : BARWALA Village : Patwi
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
AllWtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.026306X + 2.142494

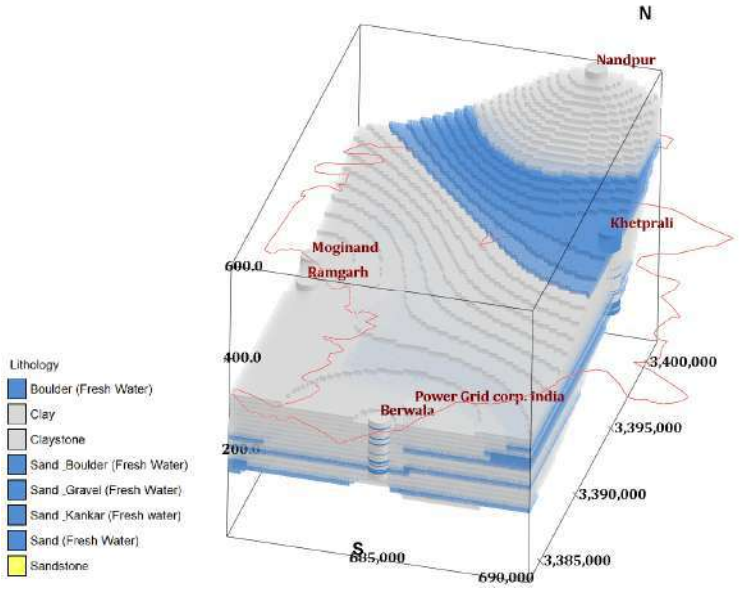
Aquifer Disposition: Single Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (13-270m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	48.89	-	12	NA

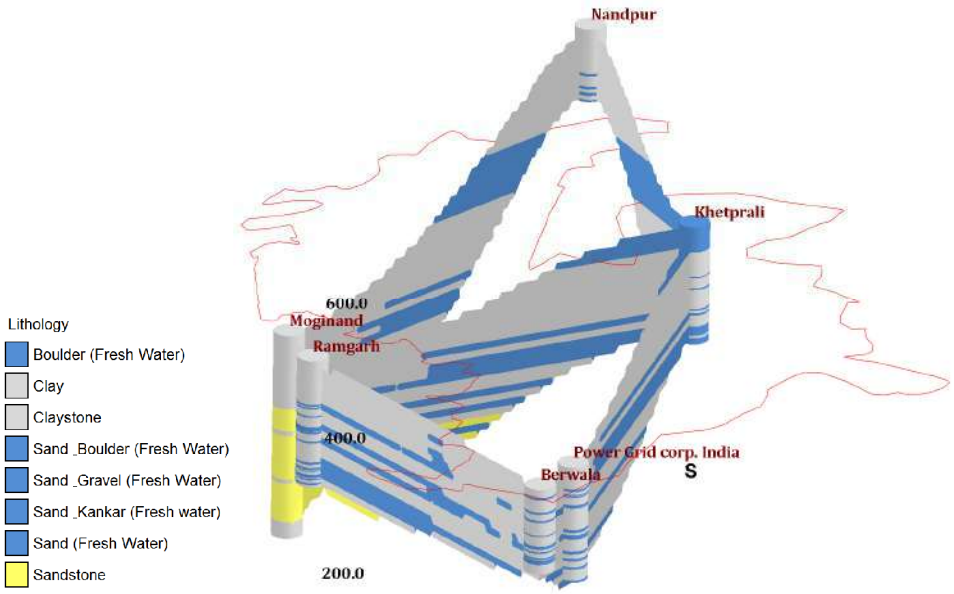
Aquifer comprises of freshwater only and the main aquifer formations are mixture of Boulders, gravels, kankar and sand.

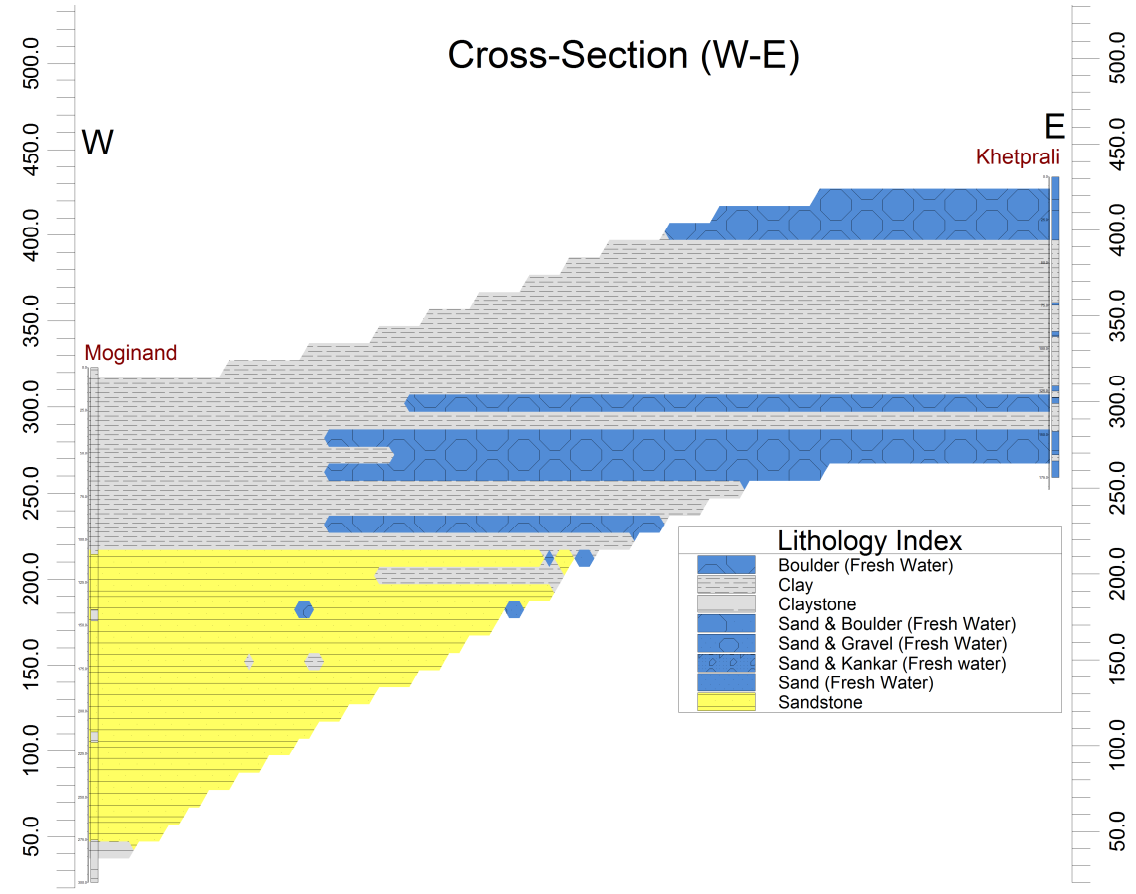
The non-aquifer material comprises of clay and claystone.

3D Lithology model



3D Lithology Fence




Cross-Section (W-E)
W
E
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Moginand
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400.0
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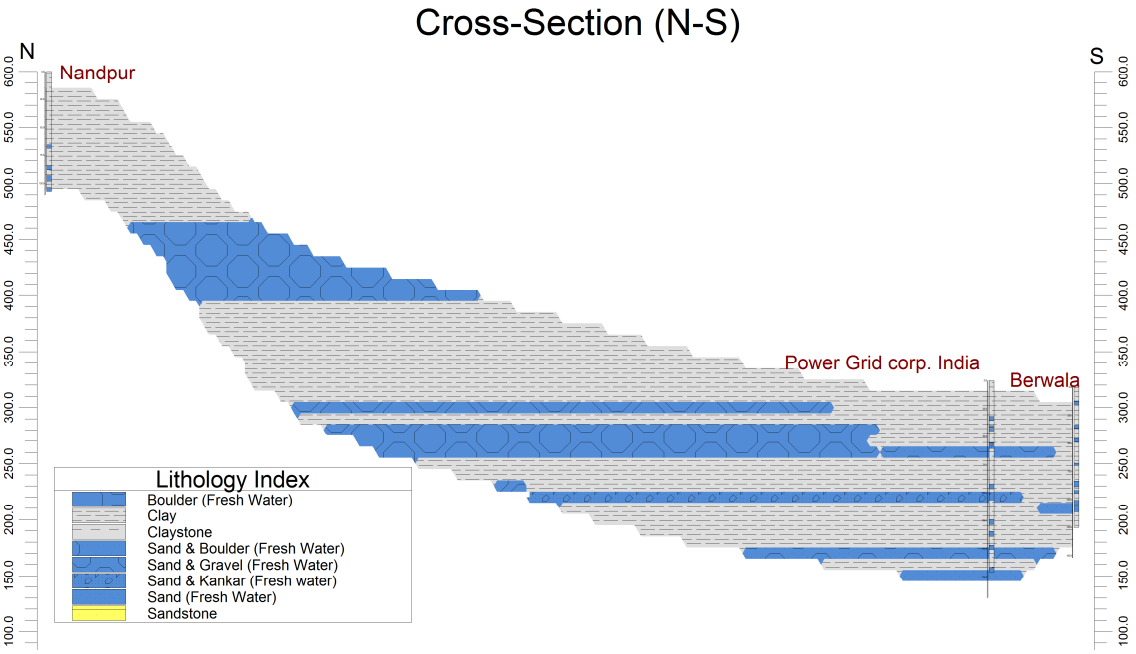
100.0
50.0
Lithology Index
Boulder (Fresh Water)
Clay
Claystone
Sand & Boulder (Fresh Water)
Sand & Gravel (Fresh Water)
Sand & Kankar (Fresh water)
Sand (Fresh Water)
Sandstone


Cross-Section (N-S)
N
S
Nandpur
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Berwala
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500.0
450.0
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250.0
200.0
150.0
100.0
Lithology Index
Boulder (Fresh Water)
Clay
Claystone
Sand & Boulder (Fresh Water)
Sand & Gravel (Fresh Water)
Sand & Kankar (Fresh water)
Sand (Fresh Water)
Sandstone

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	69.33
	In-storage Aquifer I	647.73
	Total	717.66
Ground Water Extraction (mcm)	Irrigation (2013)	52.42
	Domestic & Industrial (2013)	5.85
Future Demand for domestic & Industrial sector (2025) (in mcm)		1.51
Chemical Quality of ground water		Potable for drinking and irrigation (Details in ANNEXURE II)
Other issues		NA

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (13m) is 0 mcm. (based on the limited litholog data)
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 5.27mcm volume of water wastage
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

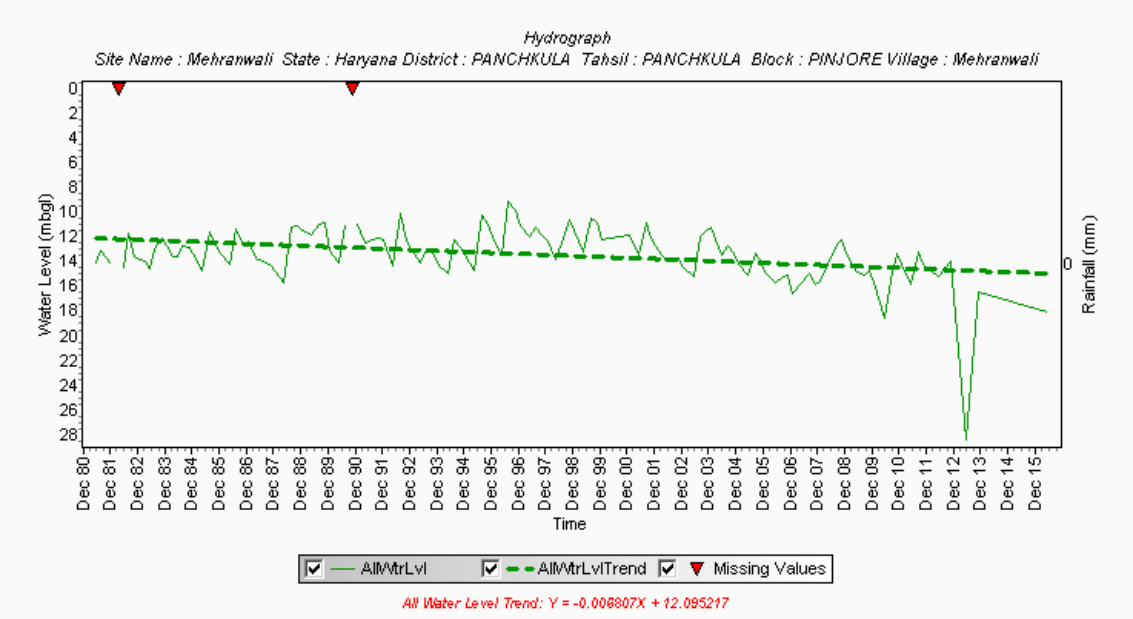
ii. PINJORE BLOCK (217.6 sq km)

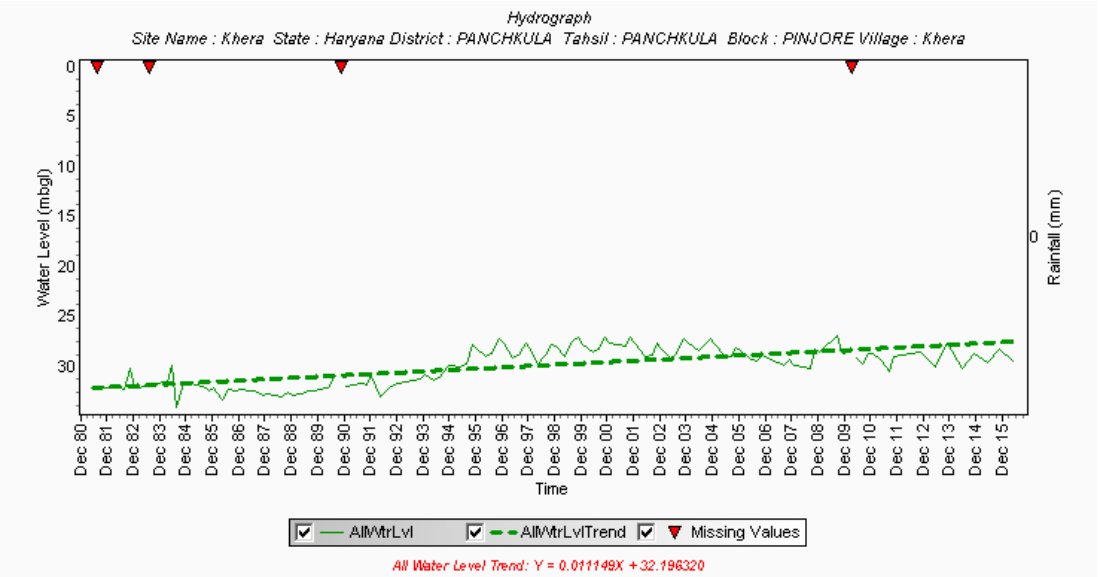
Population (2011)	Rural-104275
	Urban-19746
	Total-124021
Rainfall	Monsoon -805.60mm
	Non Monsoon-154.40mm
Average Annual Rainfall	960mm
Agriculture and Irrigation	Major Crops- Wheat, Rice & Maize
	Other crops-Bajra, Rapeseed & Mustard, Sugarcane, Potatoes
	Net Area Sown-71.03sqkm
	Total Irrigated Area-21.94sqkm
Water Bodies	268 nos.

Ground Water Resource Availability: Ground Water Resources available as a single aquifer system in the block up to a depth of 300m. Block is categorized as Safe as per Dynamic Ground Water Resource assessment (31.3.2013).

Ground water Extraction: Information regarding the abstraction from deeper part of the aquifer is not available, but there are drinking water supply tapping combined aquifer therefore, aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-4.6-29.5 bgl &Post Monsoon-6-28.3mbgl

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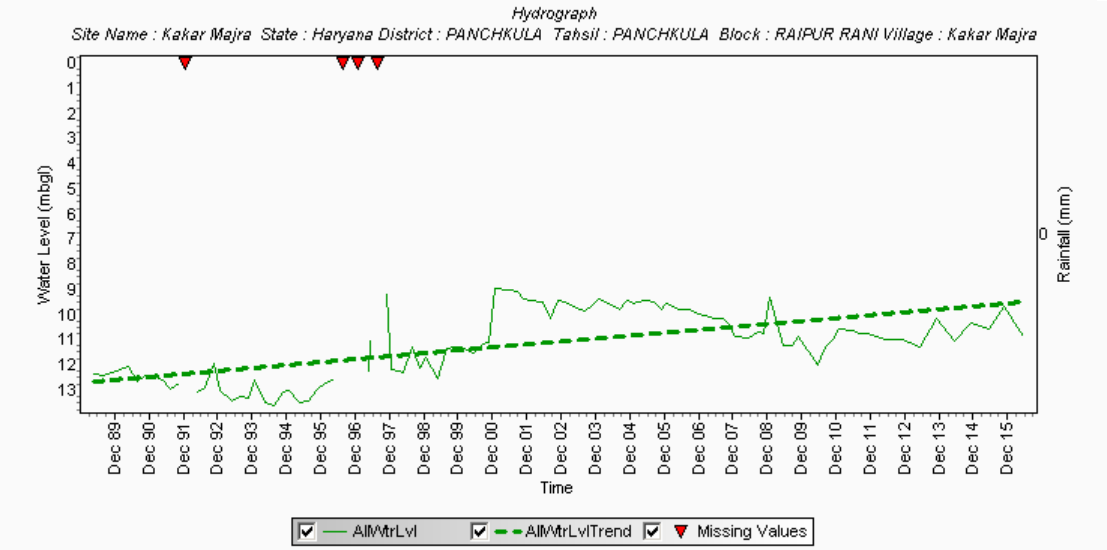
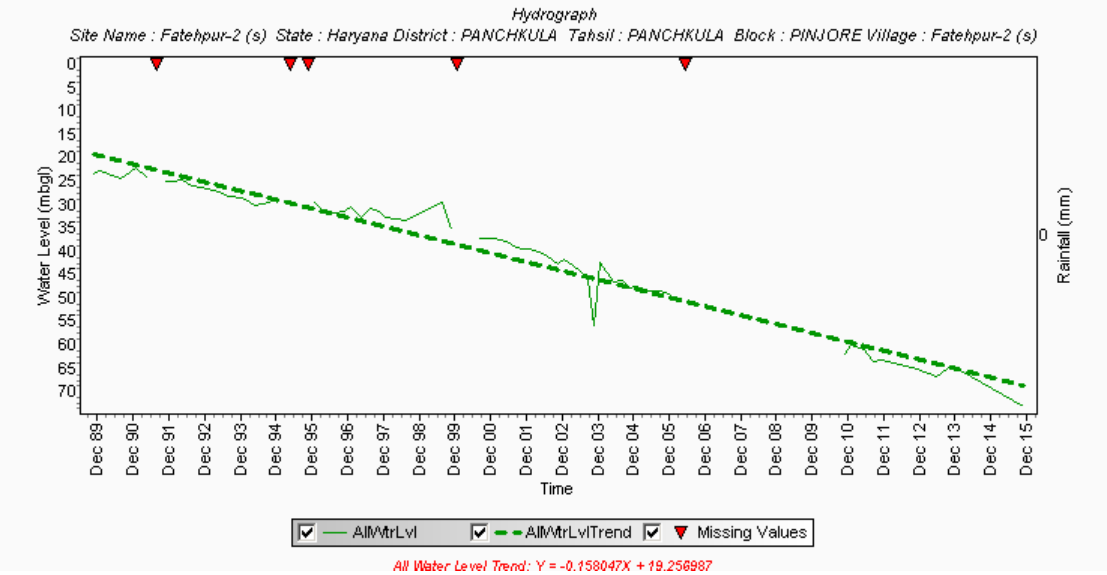
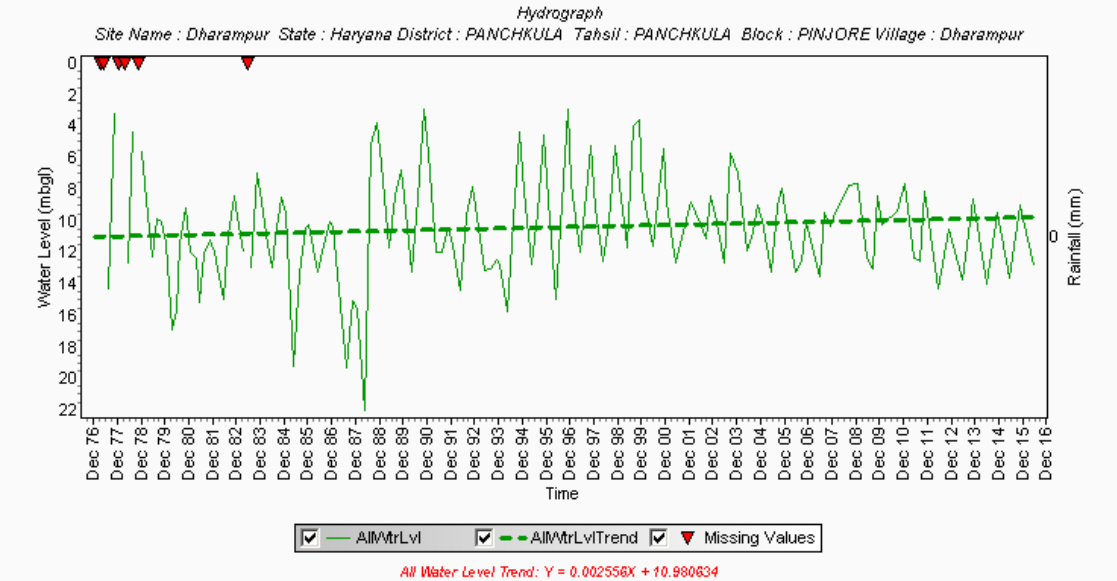
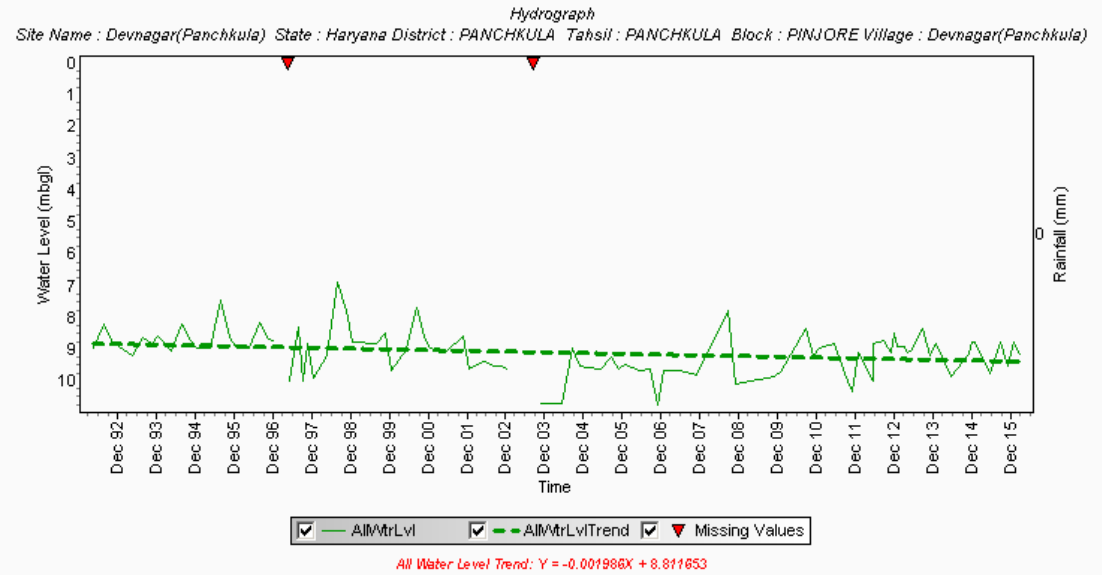
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
Missing Values
All Water Level Trend: Y = 0.011149X + 32.196320


Hydrograph
Site Name : Kakar Majra State : Haryana District : PANCHKULA Tahsil : PANCHKULA Block : RAIPUR RANI Village : Kakar Majra
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
Missing Values
All Water Level Trend: Y = 0.009694X + 12.632066


Hydrograph
Site Name : Fatehpur-2 (s) State : Haryana District : PANCHKULA Tahsil : PANCHKULA Block : PINJORE Village : Fatehpur-2 (s)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.158047X + 19.256987





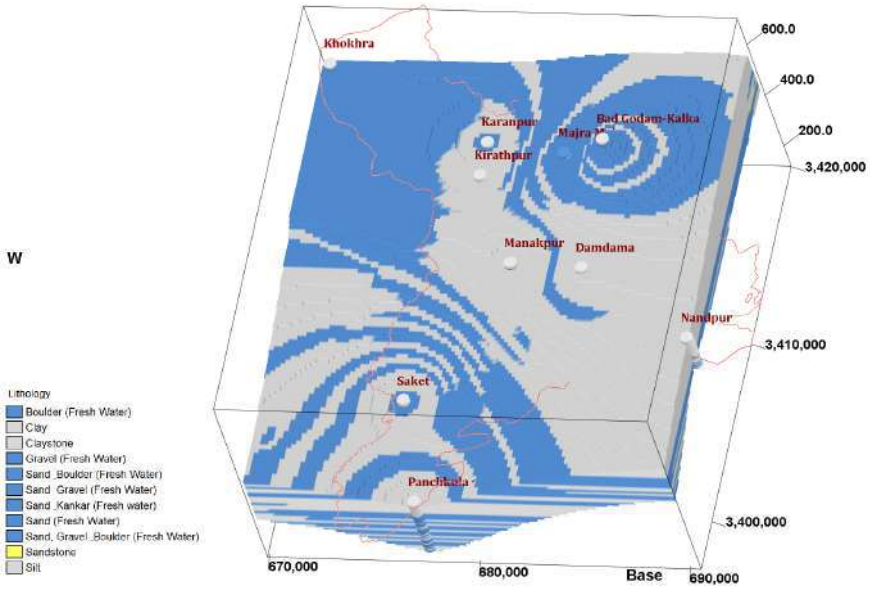
Aquifer Disposition: Single Aquifer System

Aquifer comprises of freshwater only and the main aquifer formations are mixture of Boulders, gravels, kankar and sand.

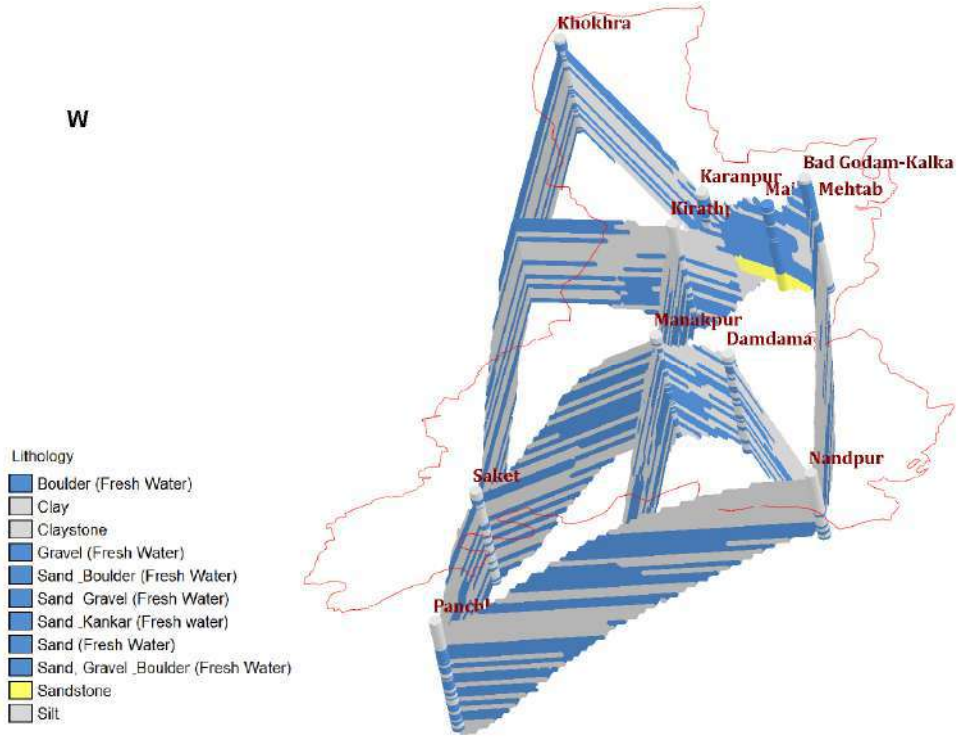
The non-aquifer material comprises of clay and claystone.

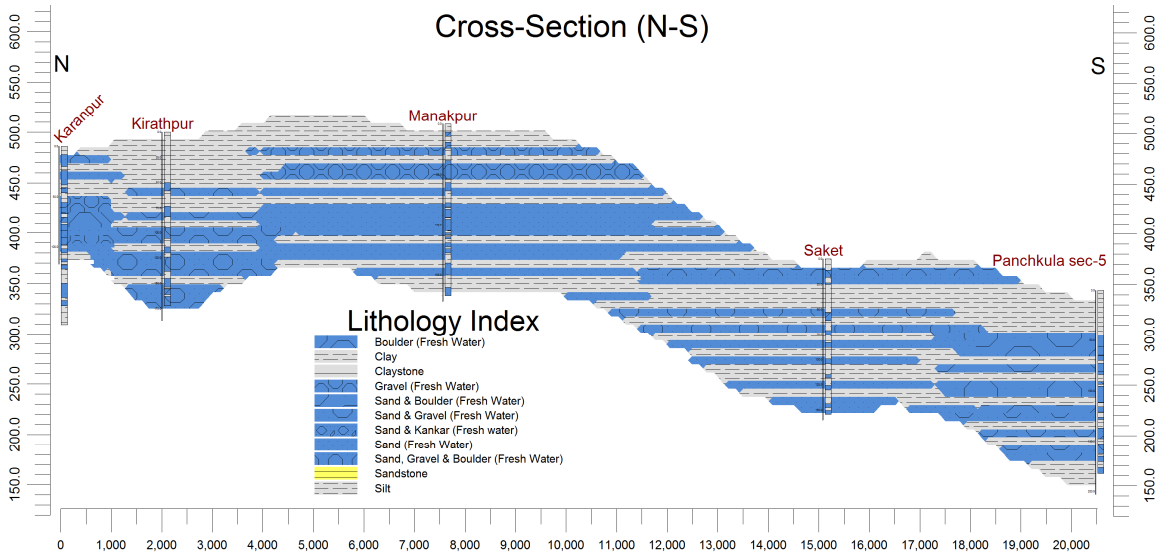
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (17-182m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	76.54	366-2249	12	NA

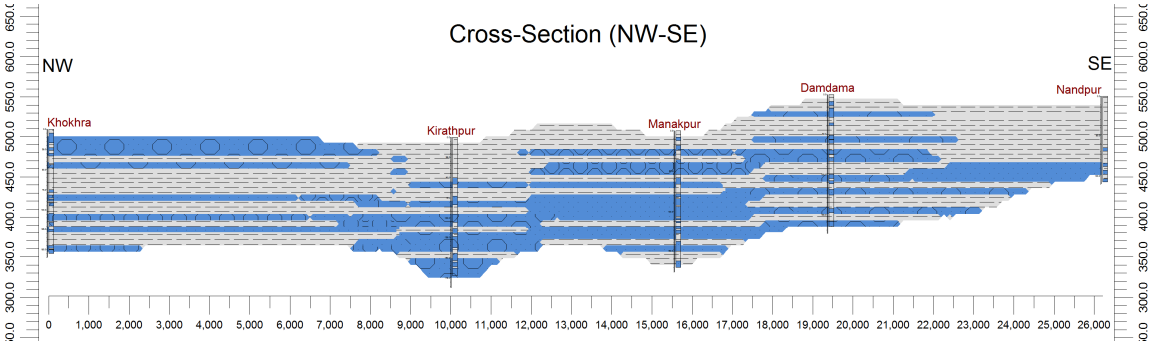
3D Lithology model

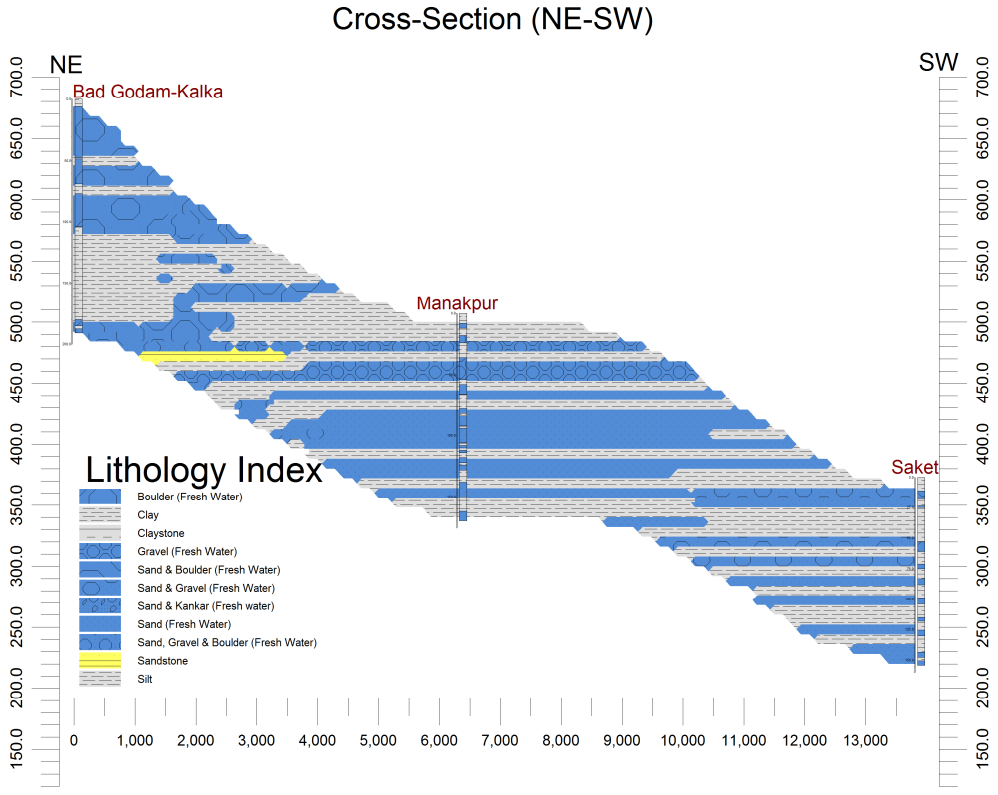


3D Lithology Fence




Cross-Section (N-S)
N
S
Karanpur
Kirathpur
Manakpur
Saket
Panchkula sec-5
Lithology Index
Boulder (Fresh Water)
Clay
Claystone
Gravel (Fresh Water)
Sand & Boulder (Fresh Water)
Sand & Gravel (Fresh Water)
Sand & Kankar (Fresh water)
Sand (Fresh Water)
Sand, Gravel & Boulder (Fresh Water)
Sandstone
Silt


Cross-Section (NW-SE)
NW
SE
Khokhra
Kirathpur
Manakpur
Damdama
Nandpur


Cross-Section (NE-SW)
NE
SW
Bad Godam-Kalka
Manakpur
Saket
Lithology Index
Boulder (Fresh Water)
Clay
Claystone
Gravel (Fresh Water)
Sand & Boulder (Fresh Water)
Sand & Gravel (Fresh Water)
Sand & Kankar (Fresh water)
Sand (Fresh Water)
Sand, Gravel & Boulder (Fresh Water)
Sandstone
Silt

Ground Water Resource, Extraction, Contamination and other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	42.46
	In-storage Aquifer I	587.46
	Total	629.92
Ground Water Extraction (mcm)	Irrigation (2013)	10.21
	Domestic & Industrial (2013)	14.40
Future Demand for domestic & Industrial sector (2025) (in mcm)		1.05
Chemical Quality of ground water		Potable for drinking and irrigation (Details in ANNEXURE II)
Other issues		NA

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (17m) is 0 mcm. (based on the limited litholog data)
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 1.03mcm volume of water wastage
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

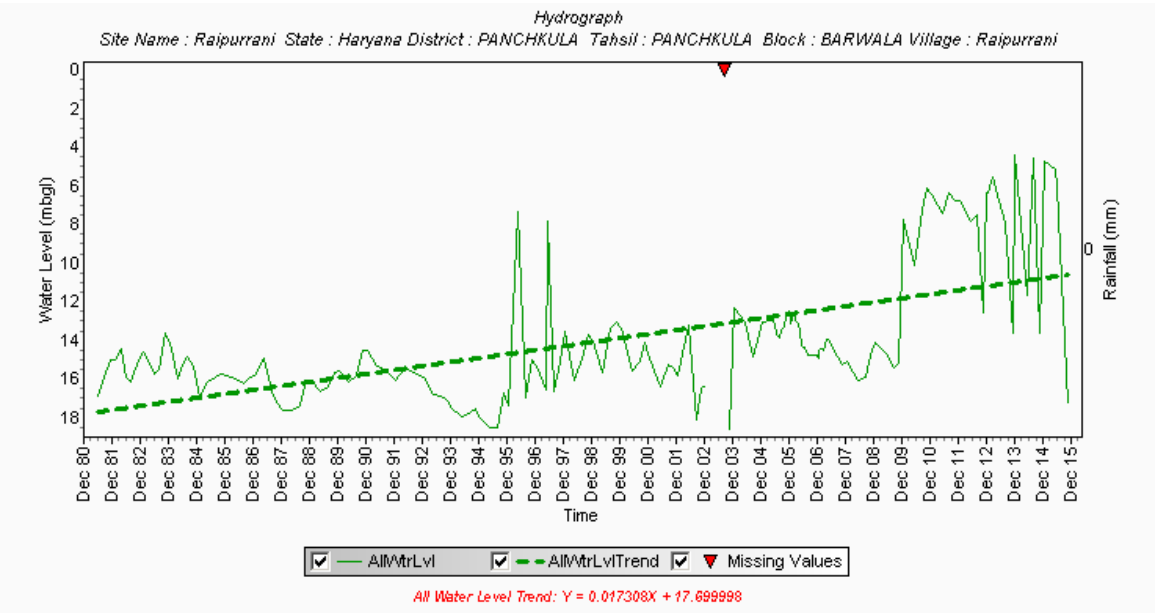
iii. Raipur Rani Block (136.98 sq km)

Population (2011)	Rural-50085 Urban-9028 Total-59113
Rainfall 2014	Monsoon -1222.4mm Non Monsoon-199.8mm
Average Annual Rainfall	1422.2mm
Agriculture and Irrigation	Major Crops- Wheat, Rice & Maize Other crops-Bajra, Rapeseed & Mustard, Sugarcane, Potatoes Net Area Sown-78.58sqkm Total Irrigated Area-49.04sqkm
Water Bodies	**96** nos.

Ground Water Resource Availability: Ground Water Resources available as a single aquifer system in the block up to a depth of 300m. Block is categorized as Safe as per Dynamic Ground Water Resource assessment (31.3.2013).

Ground water Extraction: Information regarding the abstraction from deeper part of the aquifer is not available, but there are drinking water supply tapping combined aquifer therefore, aquifer could not be assessed separately.

Water level Behavior(2015): Pre Monsoon-5.1-24.1mbgl&Post Monsoon-3.0-23.2mbgl



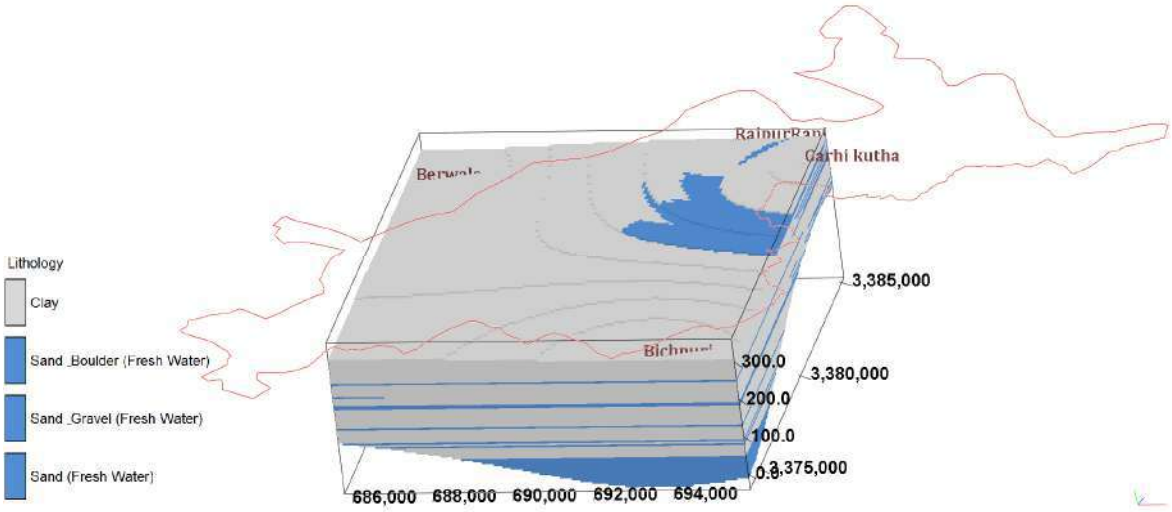
Aquifer Disposition: Single Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (11-187m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	49.63	-	12	NA

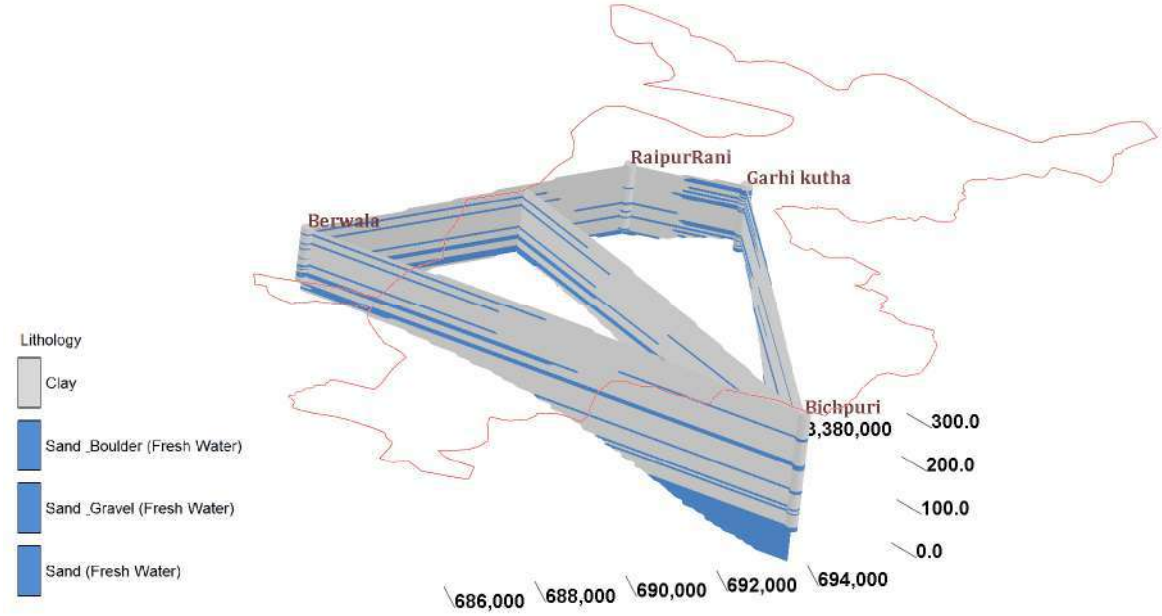
Aquifer comprises of freshwater only and the main aquifer formations are mixture of Boulders, gravels, kankar and sand.

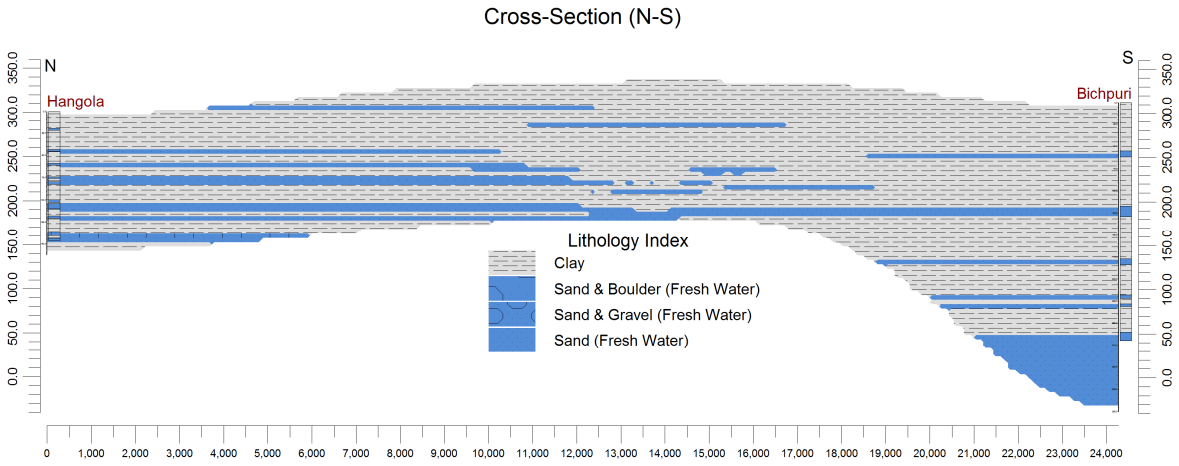
The non-aquifer material comprises of clay.

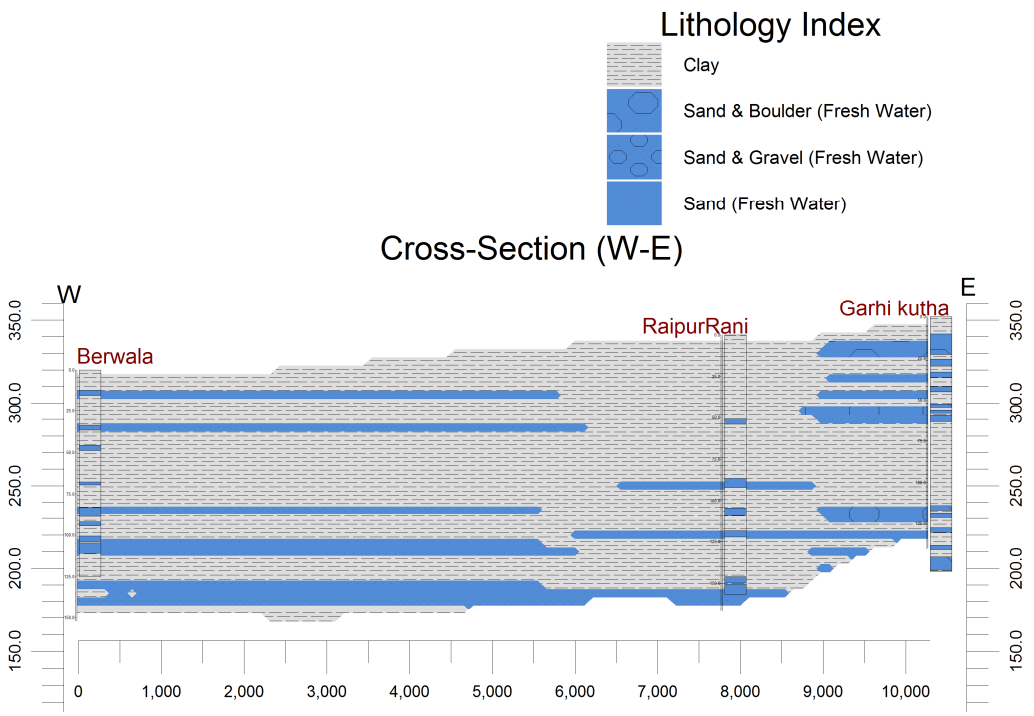
3D Lithology model



3D Lithology Fence




Cross-Section (N-S)
N
S
Hangola
Bichpuri
Lithology Index
Clay
Sand & Boulder (Fresh Water)
Sand & Gravel (Fresh Water)
Sand (Fresh Water)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
21,000
22,000
23,000
24,000


Lithology Index
Clay
Sand & Boulder (Fresh Water)
Sand & Gravel (Fresh Water)
Sand (Fresh Water)
Cross-Section (W-E)
W
E
Berwala
RaipurRani
Garhi kutha
150.0
200.0
250.0
300.0
350.0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	33.75
	In-storage Aquifer I	375.13
	Total	408.88
Ground Water Extraction (mcm)	Irrigation (2013)	25.99
	Domestic & Industrial (2013)	7.65
Future Demand for domestic & Industrial sector (2025) (in mcm)		1.21
Chemical Quality of ground water		Potable for drinking and irrigation (Details in ANNEXURE II)
Other issues		Declining water level trend (38.1–39.9cm/yr)

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (11m) is 62.99 mcm.
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 2.61 mcm volume of water wastage
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

9. CONCLUSIONS

- Panchkula district is located in Northern part of the State and lies between 30° 26'- 30° 55' North latitudes and 76° 46'- 77° 10' East longitudes. Total geographical area of the district is 898 sq. km.
- The district is mainly drained by the river Ghaggar and its tributaries. Siwalik hill ranges occupy the Northern and North-Eastern fringe of Panchkula district and attain the height up to 950m above mean sea level
- A dissected rolling plain in the Northern parts of district is a transitional tract between Siwaliks hills and alluvial plains.
- Geophysical investigation shows there three to four geo-electrical layers. It has been found that the resistivity of the top layer is within 650 ohm-m with varying thickness 1.15 to 8.84m. Productive zones are sand with pebble and gravel layers. In general the resistivity more than 200 ohm m corresponds to boulder formation.
- The depth to water level ranges from 4.6m bgl at Nadha to 29.52m bgl at Khera during pre-monsoon and 3.02m bgl to 34.75m bgl during post-monsoon.
- The ground water is alkaline in nature and potable for drinking and irrigation purposes. Majority of the samples are within the permissible limit of BIS (2012). Iron concentration more than the permissible limit is found at only one site Patwi having a value of 0.6369mg/l.
- The ground water exploration in the district reveals that clay group of formations dominates over the sand group in the district area. The ground water occurs in pore-spaces of alluvial formation including Kandi belt stretching to Siwalik foothills under water table and in semi-confined conditions. These aquifers consist of sand, silt, gravels and kankar associated with clay and form highly potential aquifers.
- According to the present NAQUIM study, it has been found that there is a large variability in the aquifer system; it varies from sandstone/clay in north-east to sandstone/conglomerate to boulder/gravels to alluvial deposits towards south-west.
- As per Ground water resource estimation as on March 2013, the stage of ground water development ranges between 58% (block-Pinjore) to 100% (block-Raipur Rani). Morni block has not been assessed being completer hilly area.

- Out of 3 assessed blocks, one is semi-critical (Raipur Rani) and two are safe (Barwala & Pinjore).
- The net ground water availability is 145.53 mcm, and existing gross ground water draft for all uses is 116.52 mcm and net ground water availability for future irrigation development is 3.77mcm. The stage of ground water development in the district is 80%.
- The district is belongs to single aquifer system upto a depth of 300m. Dynamic & In- storage ground water resources has also been carried for the same.
- Dynamic ground water resources of the district are 0.146 bcm and fresh in storage ground water resources of Ambala district are 1.61 bcm. Thus total Ground water resources of Aquifer are 1.756bcm.
- There is not an overdraft in the district but it is suggested that proposed artificial recharge measures and conserving ground water through laying of underground water pipe line will save 8.8 & 8.91 mcm of ground water respectively.
- There are around 778 (out of 1934) tubewells (40%) operated by farmers for irrigation through unlined/Katcha open channel system in Panchkula district where water from the tubewell is discharge to the agricultural field. In this process, huge (upto 25%) quantity of ground water is wasted in soil moisture and evaporation losses.
- Around 86% of the tube wells are of in depth range of up to 70 meters and remaining are deeper (70-110 m) depth in the district. Thus majority of wells are tapping Aquifer group-I which is under stress due to overexploitation.
- Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in Panchkula district is estimated at 88.62 MCM. It is expected that around 25% of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby draft will be reduced to the tune of 22.15 MCM assuming there is no crop diversification by the farmers.
- In addition to that by adopting artificial recharge to ground water 8.8 MCM of overdraft can be reduced
- By adopting all the measures stage of development in the district can be reduced to 68% from the present 80%.

ANNEXURE I: Depth to water level of GWOW (2015)

S. No.	Location	Latitude	Longitude	Water Level		Fluctuation
				May	Nov	
1	Batour	30°33'10'' N	76°56'59'' E	-	6.93	-
2	Bunga At Dabkhori-DW	30°37'40'' N	76°56'59'' E	-	34.75	-
3	Devnagar	30°41'48'' N	76°52'24'' E	9.77	9.52	0.25
4	Dharampur	30°48'40'' N	76°55'10'' E	13.60	8.94	4.66
5	Golpura-DW	30°30'18'' N	76°59'10'' E	-	3.02	-
6	Hangola	30°31'58'' N	77°01'52'' E	8.25	5.49	2.76
7	Jaspur-DW	30°29'00'' N	76°57'00'' E	15.50	-	-
8	Jaspur-Pz	30°28'47'' N	76°57'07'' E	18.30	-	-
9	Jaswant Garh-DW	30°38'17'' N	76°56'32'' E	-	3.89	-
10	Kakar Majra	30°29'30'' N	77°01'30'' E	10.56	9.64	0.92
11	Khera	30°49'30'' N	76°52'40'' E	29.52	28.30	1.22
12	Kheri-DW	30°33'56'' N	76°59'51'' E	10.20	10.82	-0.62
13	Kona	30°53'27'' N	76°49'56'' E	-	6.00	-
14	Kundi-DW	30°39'53'' N	76°51'06'' E	-	18.90	-
15	Maranwala	30°53'29'' N	76°49'44'' E	-	20.50	-
16	Mauli-DW	30°31'43'' N	76°58'36'' E	-	23.15	-
17	Nadha-DW	30°41'00'' N	76°54'00'' E	4.60	-	-
18	Parwala	30°38'30'' N	77°00'30'' E	18.22	18.30	-0.08
19	Patwi	30°28'10'' N	76°56'20'' E	9.83	12.95	-3.12
20	Raipur Rani-Pz	30°35'00'' N	77°01'00'' E	6.13	-	-
21	Raipurrani	30°35'15'' N	77°01'20'' E	5.13	-	-
22	Ram Nagar-DW	30°51'00'' N	76°52'00'' E	18.00	-	-
23	Ramgarh-DW	30°39'00'' N	76°53'00'' E	12.71	-	-
24	Rampur-DW	30°36'11'' N	77°02'52'' E	-	7.14	-
25	Shahjahan Pur-DW	30°32'39'' N	77°02'49'' E	-	20.01	-
26	Toka-DW	30°37'00'' N	76°58'00'' E	8.37	-	-

ANNEXURE II: Results of chemical analysis of water samples from NHS in Haryana (2015)

S. No	Location	Block	pH	EC in µS/cm at 25°C	CO3	HCO3	Cl	SO4	NO3	F	PO4	Ca	Mg	Na	K	SiO2	T.H as CaCO3	As	Fe
					(----------mg/l----------)														
1	Patwi	Raipur Rani	**8.75**	1595	59	309	139	192	**67**	BDL	0.03	17	35	285	1	16	186	BDL	**0.6369**
2	Chandi mandir	Pinjore	8.35	625	23	36	73	52	**143**	0.2	0.02	45	25	58	3.1	19	216	BDL	0.1594
3	Abdullapur	Pinjore	8.35	405	23	59	52	12	**49**	0.09	0.02	37	15	26	4.2	20	155	BDL	BDL
4	Dharampur	Pinjore	7.8	650	Nil	250	49	15	**55**	0.06	0.02	70	25	26	1.2	25	278	BDL	0.1122
5	Khera	Pinjore	7.9	545	Nil	214	42	BDL	44	0.24	0.03	50	15	40	1.3	25	186	BDL	0.0023
6	Garidan	Pinjore	8.2	308	Nil	178	10	BDL	16	BDL	0.03	50	2.5	19	0.9	26	134	0.001	0.068
7	Kona	Pinjore	8.45	328	47	24	31	5	33	0.07	0.03	33	7.5	28	1.4	20	113	0.001	0.0858
8	Mahranwali	Pinjore	8.3	300	35	95	14	BDL	13	0.1	0.02	37	10	16	1.7	19	134	BDL	BDL
9	Devinagar	Pinjore	8.6	330	12	143	10	24	9.2	BDL	0.03	21	13	38	2.6	19	103	BDL	BDL
10	Fatehpur	Pinjore	8.21	265	Nil	143	6.9	BDL	5.1	0.16	0.02	29	5	18	2	19	93	BDL	BDL
11	Raipur Rani	Raipur Rani	7.95	495	Nil	250	14	8	38	0	0.03	37	23	36	2.2	20	186	BDL	0.1183
12	Hangola	Raipur Rani	8.35	605	35	107	49	12	**90**	0.21	0.02	37	10	77	1.4	15	134	BDL	BDL
13	Batwal	Barwala	8.15	810	Nil	452	35	9	25	0.43	0.03	54	33	84	3.4	20	268	BDL	BDL
14	Kheri	Barwala	7.95	1040	Nil	297	118	12	**136**	0.07	0.03	45	30	136	2.7	21	237	BDL	BDL
15	Golpur	Raipur Rani	**8.95**	1710	Nil	512	139	115	**196**	0.22	0.02	23	34	325	3.5	22	196	BDL	BDL
16	Jaspur	Raipur Rani	8.23	800	Nil	393	42	BDL	**90**	0.25	0.02	37	19	130	2.2	20	170	BDL	BDL
17	Kakkar Majra	Raipur Rani	7.89	**2500**	Nil	393	361	205	**305**	0.72	0.05	103	**113**	265	2.5	26	722	BDL	BDL
18	Bataour	Barwala	**8.81**	535	59	250	6.9	BDL	3.6	0.61	0.02	12	28	82	2.3	18	144	BDL	BDL

The values more than the permissible limits (BIS Standard 2012) are shown in red colour

ANNEXURE III: Lithological data of optimized wells

Well Name	Zones (m bgl)		Lithology	Thickness (m)
	From	To		
Khokhra	0	5	Clay	5
	5	17	Sand & Gravel	12
	17	23	Clay	6
	23	26	Sand & Gravel	3
	26	30	Clay	4
	30	33	Sand & Gravel	3
	33	44	Clay	11
	44	48	Sand & Gravel	4
	48	75	Clay	27
	75	78	Sand	3
	78	81.5	Clay	3.5
	81.5	85	Sand & Gravel	3.5
	85	86.5	Clay	1.5
	86.5	89	Sand	2.5
	89	91	Clay	2
	91	94.8	Sand, Gravel & Boulder	3.8
	94.8	104	Clay	9.2
	104	114	Sand, Gravel & Boulder	10
	114	115.5	Clay	1.5
	115.5	119.8	Sand & Gravel	4.3
	119.8	125	Clay	5.2
	125	128	Sand	3
	128	145	Clay	17
	145	148.5	Sand	3.5
	148.5	150.4	Clay	1.9
	150.4	155	Sand, Gravel & Boulder	4.6
Kirathpur	0	50	Clay	50
	50	58	Sand & Gravel	8
	58	73	Clay	15
	73	83.5	Sand & Gravel	10.5
	83.5	95	Clay	11.5
	95	105.5	Sand & Gravel	10.5
	105.5	114	Clay	8.5
	114	120	Sand & Gravel	6
	120	124	Clay	4
	124	138	Sand & Gravel	14
	138	145	Clay	7
	145	153.5	Sand & Gravel	8.5
	153.5	155.5	Clay	2

	155.5	161	Sand & Gravel	5.5
	161	163	Clay	2
	163	172	Sand & Gravel	9
Manakpur	0	8	Clay	8
	8	12	Boulder	4
	12	18	Clay	6
	18	24	Gravel	6
	24	36	Clay	12
	36	54	Gravel	18
	54	58	Clay	4
	58	66	Sand	8
	66	78	Clay	12
	78	82	Sand	4
	82	84	Clay	2
	84	92	Sand	8
	92	94	Clay	2
	94	106	Sand	12
	106	108	Clay	2
	108	110	Sand	2
	110	112	Clay	2
	112	114	Sand	2
	114	118	Clay	4
	118	122	Sand	4
	122	124	Clay	2
	124	128	Sand	4
	128	138	Clay	10
	138	150	Sand	12
	150	162	Clay	12
	162	170	Sand	8
Nandpur	0	65	Clay	65
	65	69	Sand	4
	69	84	Clay	15
	84	88	Sand	4
	88	93	Clay	5
	93	98	Sand	5
	98	103.5	Clay	5.5
	103.5	107	Sand	3.5
Power Grid corp. India	0	32	Clay	32
	32	35.6	Sand	3.6
	35.6	40	Clay	4.4
	40	41.6	Sand	1.6
	41.6	42.4	Clay	0.8
	42.4	44.8	Sand	2.4
	44.8	55.2	Clay	10.4
	55.2	60.4	Sand & Gravel	5.2

	60.4	92	Clay	31.6
	92	96.4	Sand	4.4
	96.4	99.6	Clay	3.2
	99.6	106.6	Sand & Kankar	7
	106.6	124	Clay	17.4
	124	128.4	Sand	4.4
	128.4	134.4	Clay	6
	134.4	138.8	Sand	4.4
	138.8	146.8	Clay	8
	146.8	150.8	Sand & Gravel	4
	150.8	166.4	Clay	15.6
	166.4	170.4	Sand	4
Moginand	0	108.5	Clay	108.5
	108.5	141	Sandstone	32.5
	141	147.5	Claystone	6.5
	147.5	212	Sandstone	64.5
	212	218	Claystone	6
	218	275	Sandstone	57
	275	355	Claystone	80
Khetprali	0	37	Boulder	37
	37	73	Clay	36
	73	74.75	Sand	1.75
	74.75	90	Clay	15.25
	90	93	Boulder	3
	93	122	Clay	29
	122	125	Boulder	3
	125	128.75	Clay	3.75
	128.75	132	Boulder	3.25
	132	148	Clay	16
	148	162	Boulder	14
	162	165.5	Clay	3.5
	165.5	175	Boulder	9.5
Garhi kutha	0	10.4	Clay	10.4
	10.4	22.6	Sand & Boulder	12.2
	22.6	25.5	Clay	2.9
	25.5	29.7	Sand & Boulder	4.2
	29.7	33.2	Clay	3.5
	33.2	36.4	Sand	3.2
	36.4	42	Clay	5.6
	42	45	Sand	3
	45	52.4	Clay	7.4
	52.4	55	Sand & Boulder	2.6
	55	56.7	Clay	1.7
	56.7	58.3	Sand & Boulder	1.6
	58.3	59.5	Clay	1.2

	59.5	63.4	Sand	3.9
	63.4	114	Clay	50.6
	114	117.4	Sand & Boulder	3.4
	117.4	119	Clay	1.6
	119	121.5	Sand & Boulder	2.5
	121.5	127.6	Clay	6.1
	127.6	130.5	Sand	2.9
	130.5	138.2	Clay	7.7
	138.2	140.7	Sand	2.5
	140.7	145.1	Clay	4.4
	145.1	153	Sand & Boulder	7.9
	153	153.92	Clay	0.92
RaipurRani	0	50.8	Clay	50.8
	50.8	54	Sand	3.2
	54	86.5	Clay	32.5
	86.5	92	Sand	5.5
	92	105	Clay	13
	105	109.3	Sand	4.3
	109.3	118.5	Clay	9.2
	118.5	122.3	Sand	3.8
	122.3	146	Clay	23.7
	146	149.8	Sand	3.8
	149.8	150.7	Clay	0.9
	150.7	156.5	Sand	5.8
BERWALA	0	12.2	Clay	12.2
	12.2	15.2	Sand	3
	15.2	33.5	Clay	18.3
	33.5	36.6	Sand	3.1
	36.6	45.7	Clay	9.1
	45.7	48.8	Sand	3.1
	48.8	67.7	Clay	18.9
	67.7	69.5	Sand	1.8
	69.5	83.5	Clay	14
	83.5	88.7	Sand	5.2
	88.7	92.1	Clay	3.4
	92.1	94.5	Sand	2.4
	94.5	100.6	Clay	6.1
	100.6	104	Sand	3.4
	104	104.9	Clay	0.9
	104.9	111	Sand	6.1
	111	125	Clay	14
Bichpuri	0	55	Clay	55
	55	62	Sand	7
	62	117	Clay	55
	117	129	Sand	12

	129	177	Clay	48
	177	184	Sand	7
	184	218	Clay	34
	218	222	Sand	4
	222	228	Clay	6
	228	231	Sand	3
	231	260	Clay	29
	260	270	Sand	10
Saket	0	11	Clay	11
	11	18	Sand & Gravel	7
	18	23.5	Clay	5.5
	23.5	25	Sand	1.5
	25	53	Clay	28
	53	61	Sand & Gravel	8
	61	71	Clay	10
	71	75	Sand & Gravel	4
	75	83	Clay	8
	83	88	Sand	5
	88	99.5	Clay	11.5
	99.5	104	Sand	4.5
	104	115	Clay	11
	115	118	Sand	3
	118	125.5	Clay	7.5
	125.5	130	Sand	4.5
	130	143.5	Clay	13.5
	143.5	147.5	Sand	4
	147.5	150.5	Clay	3
	150.5	154	Sand	3.5
Damdama	0	8.6	Clay	8.6
	8.6	13.4	Sand & Gravel	4.8
	13.4	16.6	Clay	3.2
	16.6	29.4	Sand & Boulder	12.8
	29.4	36.2	Clay	6.8
	36.2	39.4	Sand & Gravel	3.2
	39.4	51.4	Clay	12
	51.4	56.6	Sand & Boulder	5.2
	56.6	57.4	Clay	0.8
	57.4	61.4	Sand & Boulder	4
	61.4	69.6	Clay	8.2
	69.6	75.4	Sand & Gravel	5.8
	75.4	79.2	Clay	3.8
	79.2	83.6	Sand & Gravel	4.4
	83.6	99.8	Clay	16.2
	99.8	105.2	Sand & Gravel	5.4
	105.2	107.8	Clay	2.6

	107.8	111.4	Sand & Gravel	3.6
	111.4	118.6	Clay	7.2
	118.6	125.4	Sand & Gravel	6.8
	125.4	142.2	Clay	16.8
	142.2	147.2	Sand & Gravel	5
	147.2	157.6	Clay	10.4
	157.6	164.6	Sand & Gravel	7
Majra Mehtab	0	8	Boulder	8
	8	10	Clay	2
	10	12	Boulder	2
	12	14	Gravel	2
	14	30	Boulder	16
	30	32	Clay	2
	32	52	Boulder	20
	52	53	Clay	1
	53	57	Boulder	4
	57	58	Silt	1
	58	112	Boulder	54
	112	141	Sandstone	29
Karanpur	0	8	Clay	8
	8	20	Sand & Gravel	12
	20	24	Clay	4
	24	38	Sand	14
	38	40.5	Silt	2.5
	40.5	46	Gravel	5.5
	46	55.5	Silt	9.5
	55.5	66.5	Gravel	11
	66.5	70	Silt	3.5
	70	75	Boulder	5
	75	77	Silt	2
	77	84	Boulder	7
	84	91	Sand	7
	91	98	Gravel	7
	98	102	Clay	4
	102	106	Sand	4
	106	112	Clay	6
	112	115	Sand	3
	115	118	Clay	3
	118	122	Sand	4
	122	136	Clay	14
	136	150	Sand	14
	150	153	Silt	3
	153	158	Sand	5
	158	177	Clay	19
Bad	0	6	Clay	6

Godam-Kalka	6	47.6	Sand & Boulder	41.6
	47.6	48.4	Clay	0.8
	48.4	68.4	Sand & Boulder	20
	68.4	76.4	Clay	8
	76.4	104	Sand & Boulder	27.6
	104	180	Clay	76
	180	185.2	Sand & Boulder	5.2
	185.2	187.6	Clay	2.4
	187.6	190.8	Sand & Boulder	3.2
Panchkula sector-5	0	44.2	Clay	44.2
	44.2	64.6	Sand & Boulder	20.4
	64.6	65	Clay	0.4
	65	69.8	Sand & Boulder	4.8
	69.8	72.6	Clay	2.8
	72.6	83.8	Sand & Boulder	11.2
	83.8	91	Clay	7.2
	91	93.6	Sand & Gravel	2.6
	93.6	95.4	Clay	1.8
	95.4	111.2	Sand & Boulder	15.8
	111.2	115.8	Clay	4.6
	115.8	120.8	Sand & Boulder	5
	120.8	125.8	Clay	5
	125.8	128.2	Sand & Gravel	2.4
	128.2	136.6	Clay	8.4
	136.6	147.4	Sand & Gravel	10.8
	147.4	152.6	Clay	5.2
	152.6	162.6	Sand & Gravel	10
	162.6	165	Clay	2.4
	165	170.2	Sand & Boulder	5.2
	170.2	176.2	Clay	6
	176.2	182.2	Sand & Boulder	6
Ramgarh	0	64.2	Clay	64.2
	64.2	67	Sand	2.8
	67	68.6	Clay	1.6
	68.6	71.4	Sand	2.8
	71.4	81	Clay	9.6
	81	83.4	Sand	2.4
	83.4	97.4	Clay	14
	97.4	105	Boulder	7.6
	105	105.4	Clay	0.4
	105.4	108.2	Boulder	2.8
	108.2	119	Clay	10.8
	119	121.8	Sand & Boulder	2.8
	121.8	149.8	Clay	28

	149.8	153.4	Sand & Gravel	3.6
	153.4	157.8	Clay	4.4
	157.8	161	Sand & Boulder	3.2
	161	162.2	Clay	1.2
	162.2	163.4	Sand	1.2
	163.4	168.2	Clay	4.8
	168.2	172.6	Sand & Boulder	4.4
	172.6	173.8	Clay	1.2
	173.8	175.8	Sand & Gravel	2
	175.8	180.2	Clay	4.4
	180.2	183.2	Sand & Gravel	3
	183.2	187	Clay	3.8
Hangola	0	20	Clay	20
	20	22	Sand	2
	22	43.5	Clay	21.5
	43.5	45.4	Sand	1.9
	45.4	59	Clay	13.6
	59	61	Sand	2
	61	74	Clay	13
	74	76	Sand	2
	76	79.5	Clay	3.5
	79.5	82.6	Sand	3.1
	82.6	100	Clay	17.4
	100	102.6	Sand	2.6
	102.6	104	Clay	1.4
	104	110	Sand	6
	110	118	Clay	8
	118	120.6	Sand	2.6
	120.6	136.7	Clay	16.1
	136.7	140.6	Sand & Gravel	3.9
	140.6	144.1	Clay	3.5
	144.1	146.6	Sand	2.5

Water Level Monitoring

Validation of data