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

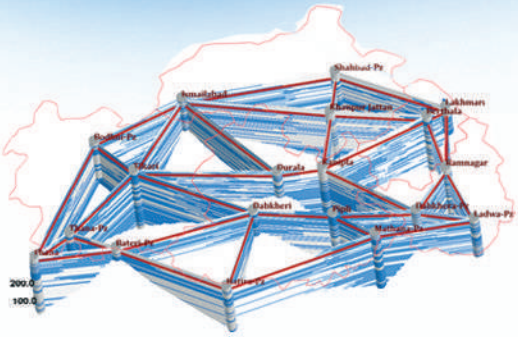
AQUIFER MAPPING AND MANAGEMENT PLAN

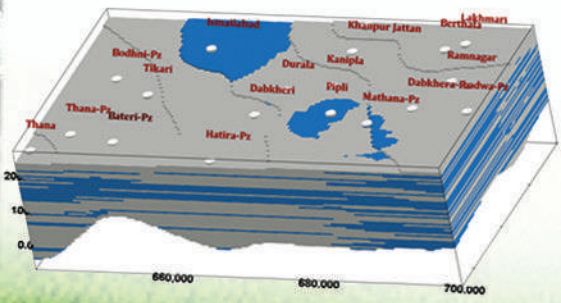
Kurukshetra District, Haryana

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING & MANAGEMENT PLAN





KURUKSHETRA DISTRICT HARYANA

Central Ground Water Board, NWR Chandigarh
Ministry of Water Resources, River Development and Ganga Rejuvenation
Government of India
2016

AQUIFER MAPPING

&

MANAGEMENT PLAN

KURUKSHETRA DISTRICT

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AQUIFER MAPPING AND MANAGEMENT PLAN

KURUKHETRA DISTRICT

(1682.53 Sq Km)

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1. INTRODUCTION

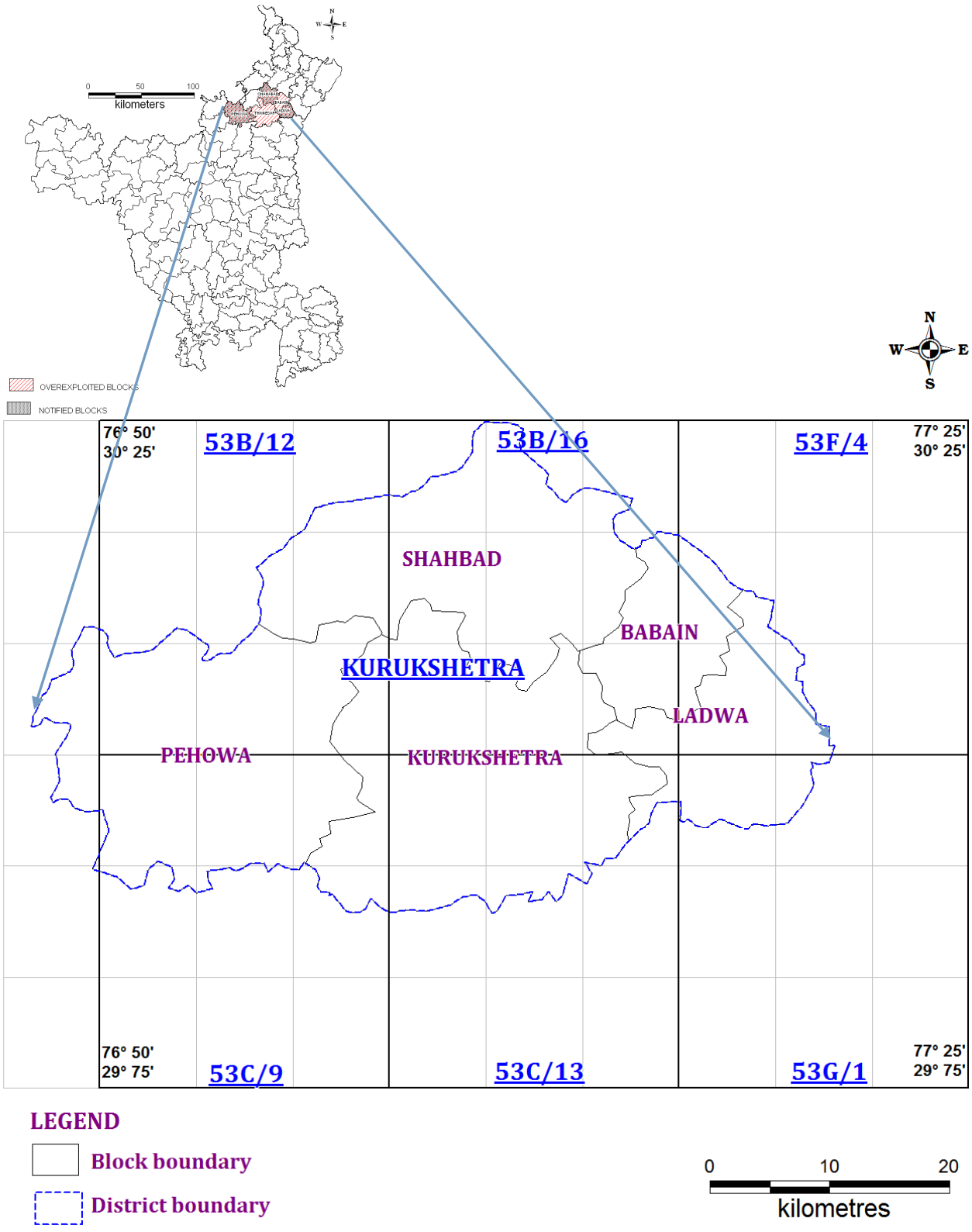
1.1 GENERAL

Kurukshetra district falls in the north-east part of the Haryana State and bounded by North latitudes 29°53'00" and 30°15'02" and East longitudes 76°26'27" and 77°07'57". The area of the district is 1682.53 Sq Km. The district is bordered by Karnal district in the south and south eastern, Kaithal district in the south western and Ambala district in the north. The district is also bordered by Patiala district of Punjab State in the north-west. It has six blocks (Ladwa, Pehowa, Shahabad, Thanesar, Babain and Ismailabad) and are shown in fig 4.1. Ismailabad block has been recently created from Pehowa, Shahabad & Thanesar blocks. The total population of the district as per 2011 census is 964231. The eastern parts of the district falls in the Upper Yamuna Basin and western parts falls in Ghaggar basin. Irrigation is done by surface as well as ground water.

The normal annual rainfall of the district is 582 mm which is unevenly distributed over the area. In general, rainfall in the district increases from southwest to northeast. The area represents almost flat alluvial plain without any conspicuous topographical features. The average elevation of the plain varies from 274 to 241 m above mean sea level. The general slope of the land is from north-east to south-west wards. The only river Markanda flows in the north-western part of the district originates in Nahan hills & flows in south western direction. Chautang, Khad and Omla nalas are of local drains. The entire district is covered by tropical arid brown soils. In general these soils are deep and imperfectly drained. The permeability of these soils is low to moderate, mildly alkaline to strongly alkaline. Out of 1,51,000 ha net irrigated area, 28000 ha is irrigated by canal and 1,23,000 ha is irrigated by ground water (81%). Paddy constitutes main kharif crop whereas the wheat is the main Rabi crop.

Kurukshetra is the starting point of a great pilgrimage for millions of Hindus from all over the country who visit the land of Kurukshetra, the venue of the Mahabharata war and the birth place of the Bhagvad Gita, for its holy places. Mythologically, the name Kurukshetra applies to a circuit of about 80 miles (128 kilometres) which includes a large number of holy places, temples and tanks, connected with the ancient Indian traditions and the Mahabharata war. It is also known as Brahmakshetra, the field of Brahma, the Creator. Hindu people from all parts of India gather at the Kurukshetra tanks on the occasion of the solar eclipse.

Fig 1: Base Map of Kurukshetra District



2. DATA COLLECTION AND GENERATION

2.1 Tube well Logs and Geophysical Data

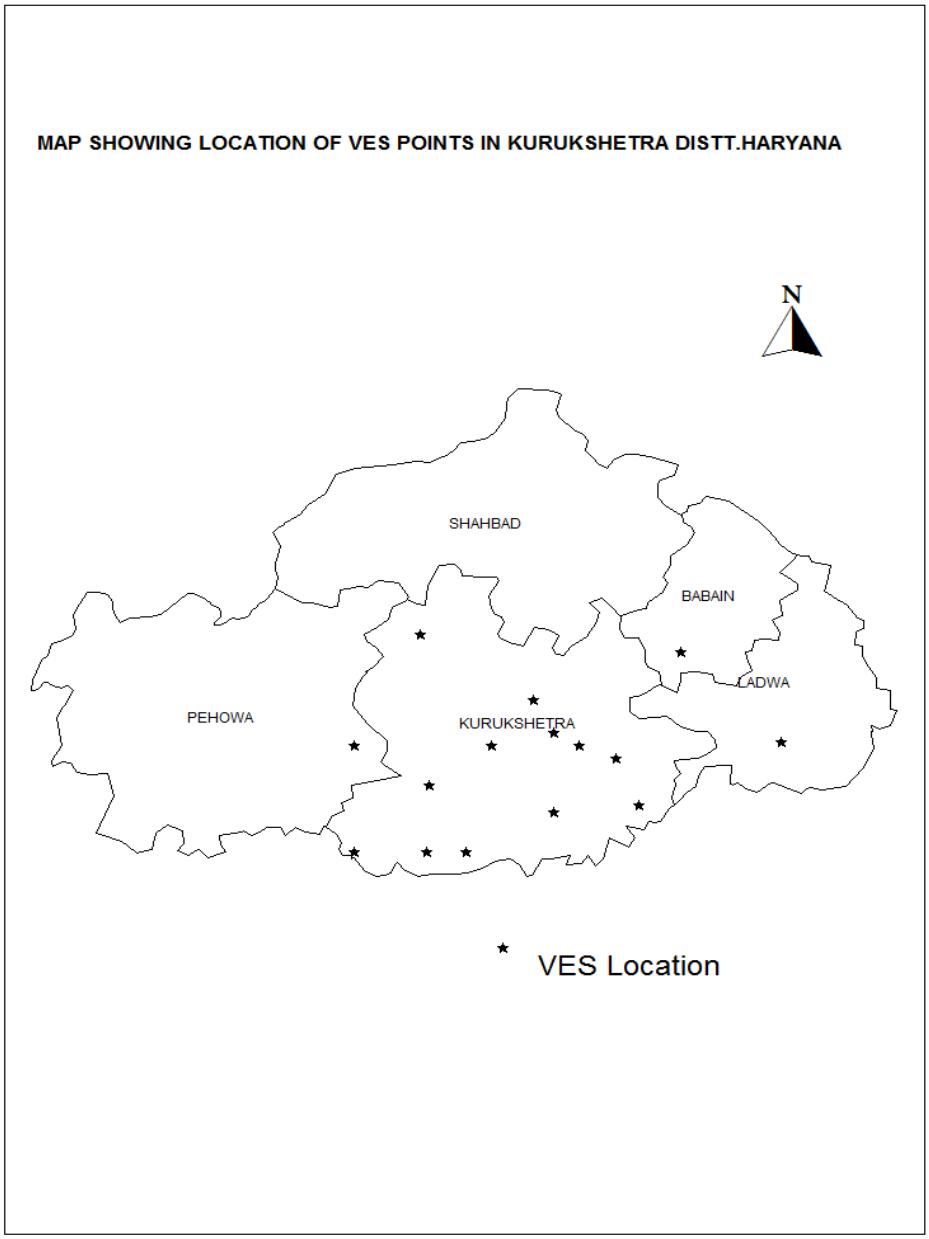
The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB, Public Health and Engineering Department (PHED) and private wells have been collected and those supported electrical logs have been validated for aquifer map preparation. Deeper well data of CGWB is available. 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 Kurukshetra district

S. No.	Source	No. of wells	Depth	
			<200m	>200m
1	CGWB	17	3	14
2	Private	11	11	0
3	PHED	33	33	0

Geophysical investigation has been carried out in the area and locations of VES are shown in figure 2.

Geophysical Studies



2.2 SPATIAL DATA DISTRIBUTION

The data of CGWB (Fig 2) and all the wells from PHED and Private in the area are plotted on the map of 1:50000 scale with 5'X5'grid (9km x 9km) and is shown in Fig 3 & 4 respectively. The exploration data shows that majority of tube wells falls in the Ist Aquifer and IInd Aquifer. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation.

Fig 2: Location of CGWB Wells

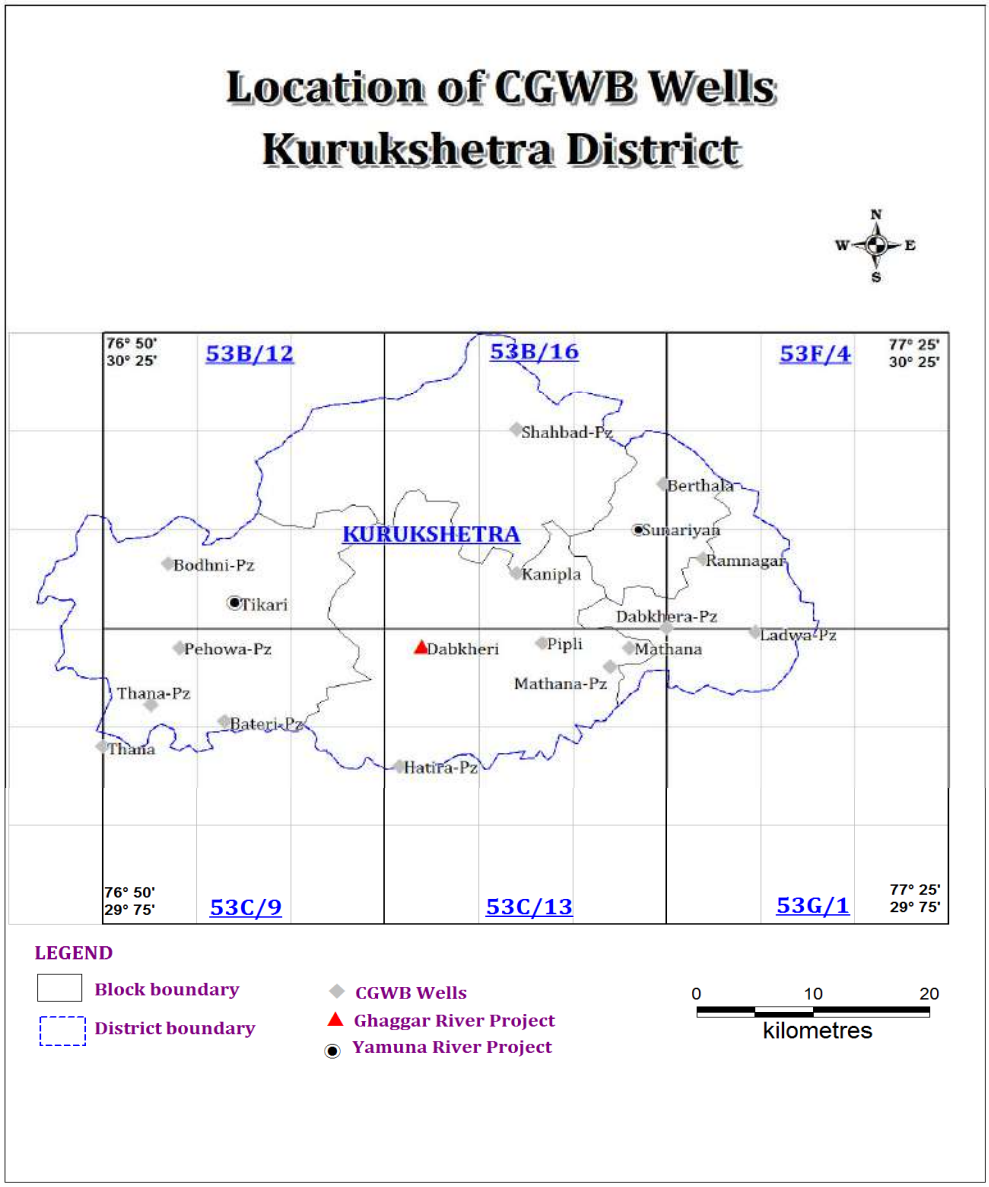


Fig 3: Location of PHED Wells

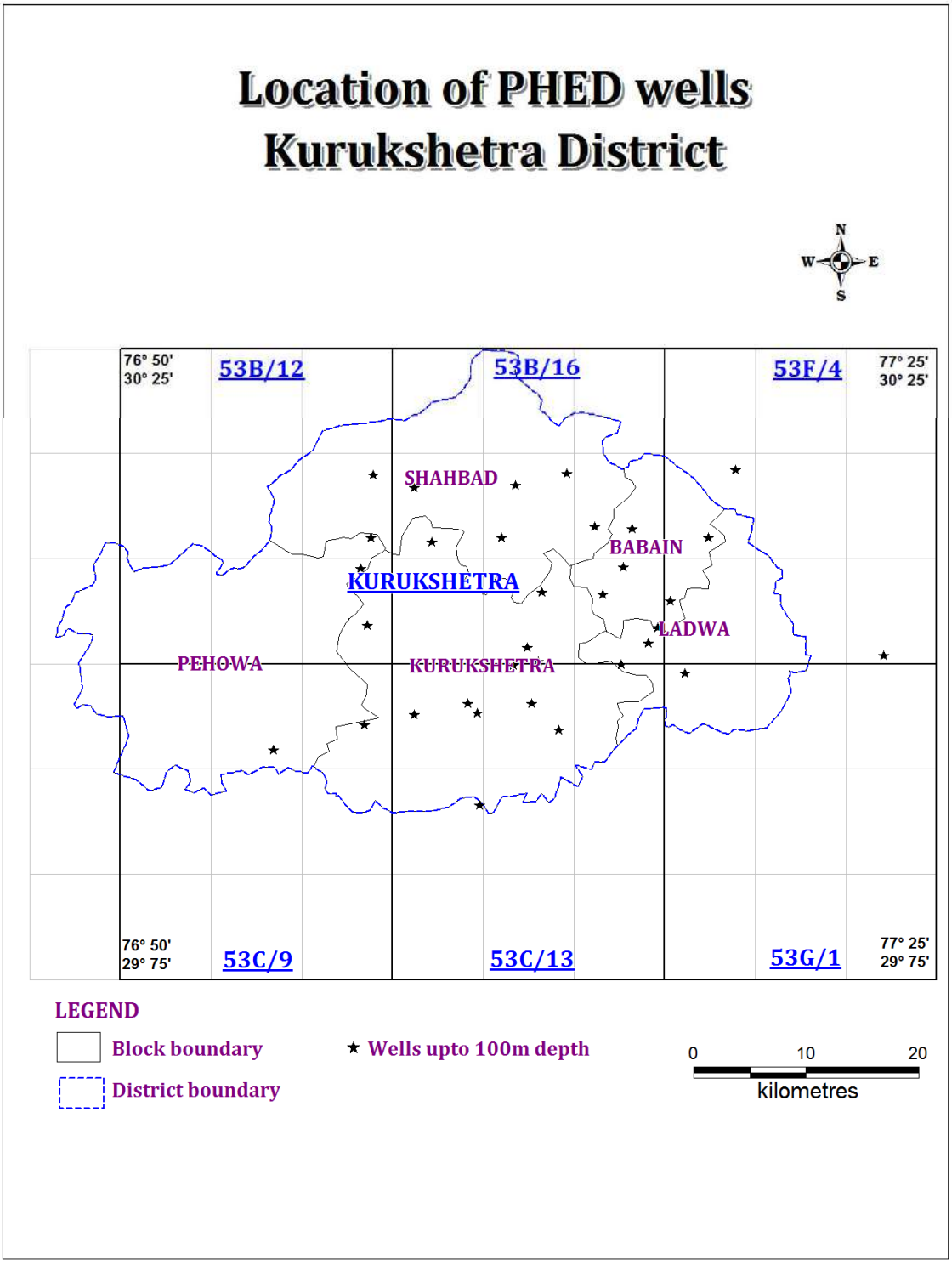
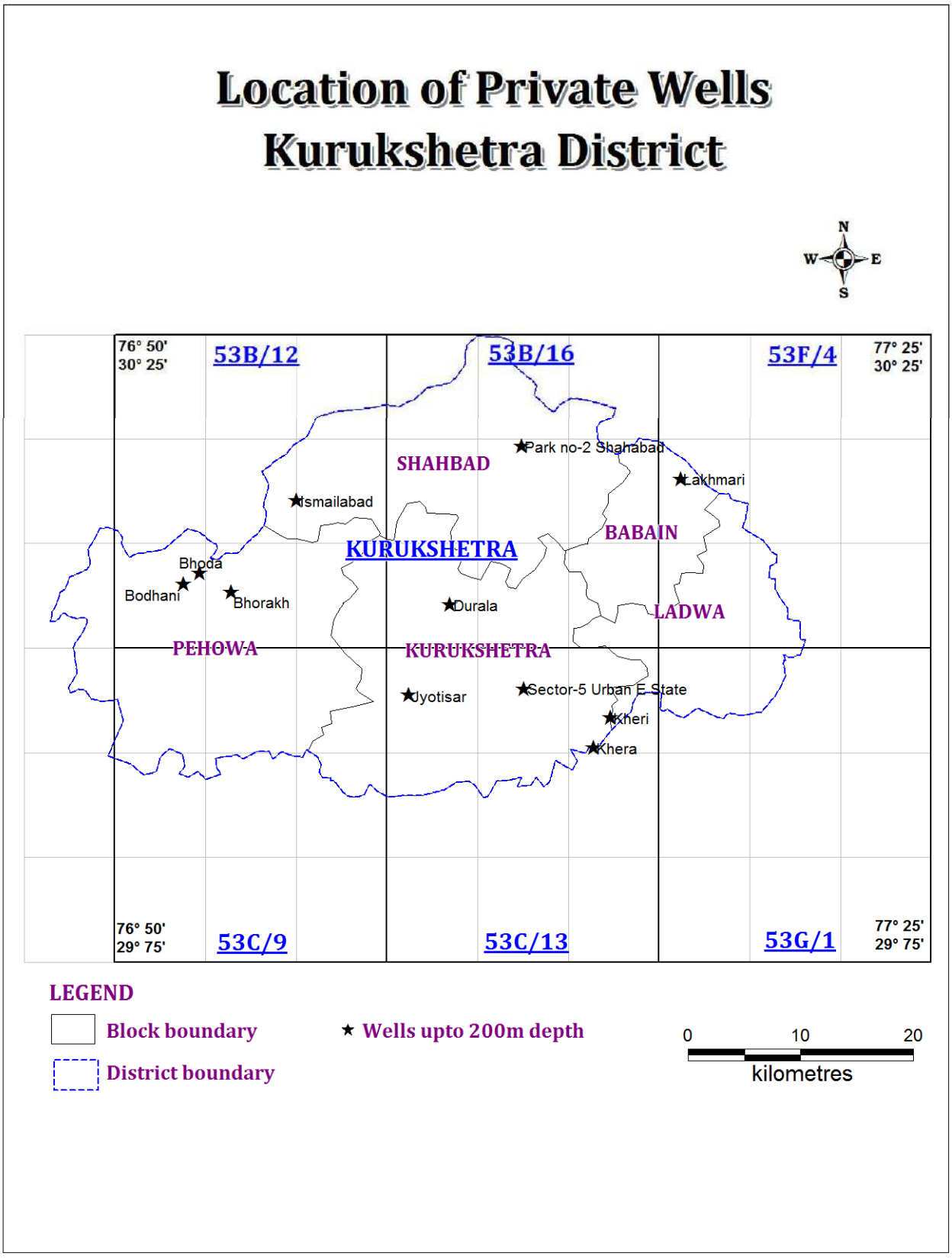


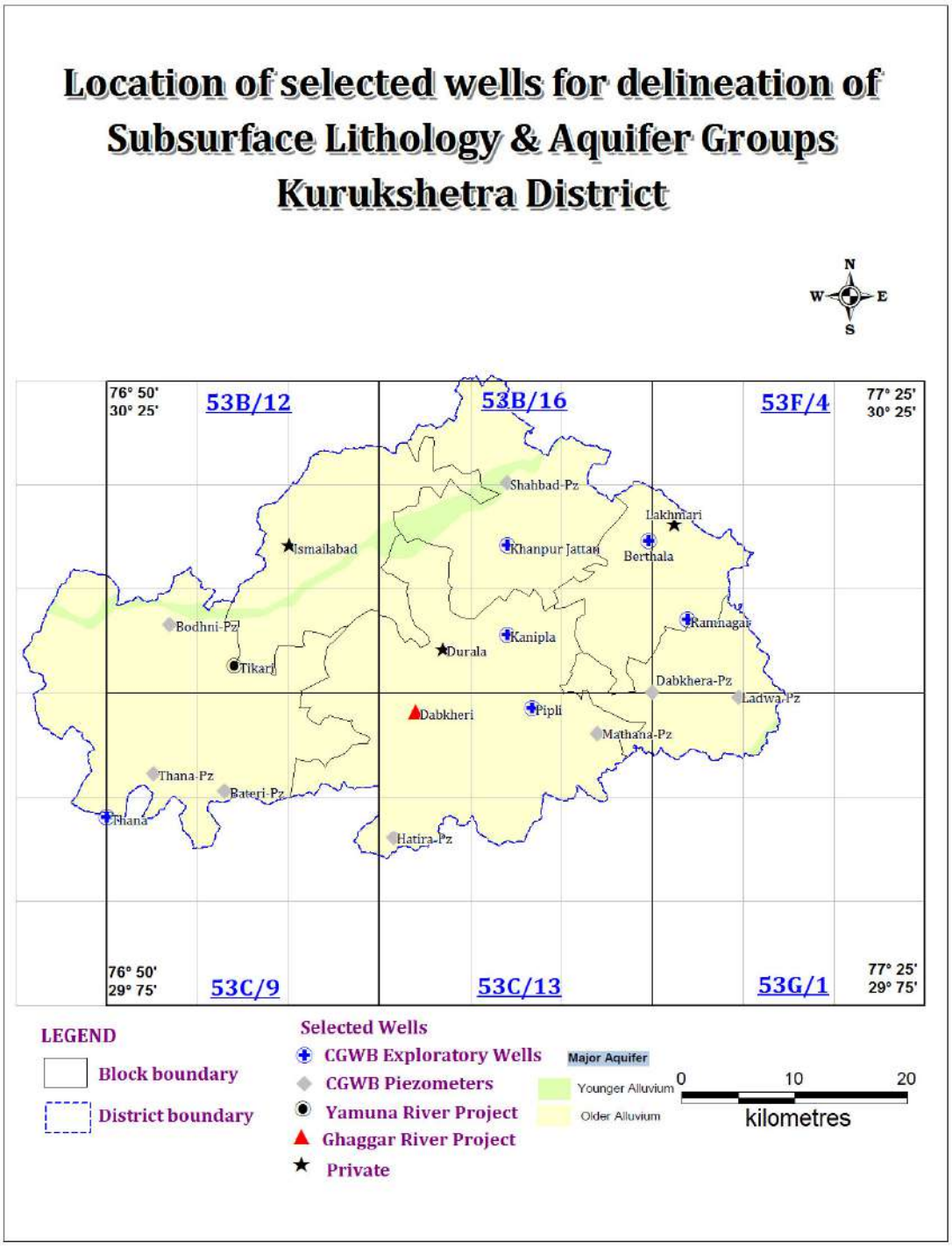
Fig 4: Location of Private Wells



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 -5.

Fig 5: Validated Exploration Data of Kurukshetra District



The topographic elevation values have been plotted to prepare the elevation contour map and is in fig 6. The locations of validated wells are plotted and litholog is shown in fig 7.

Fig 6: Elevation Contour Map-Kurukshetra District

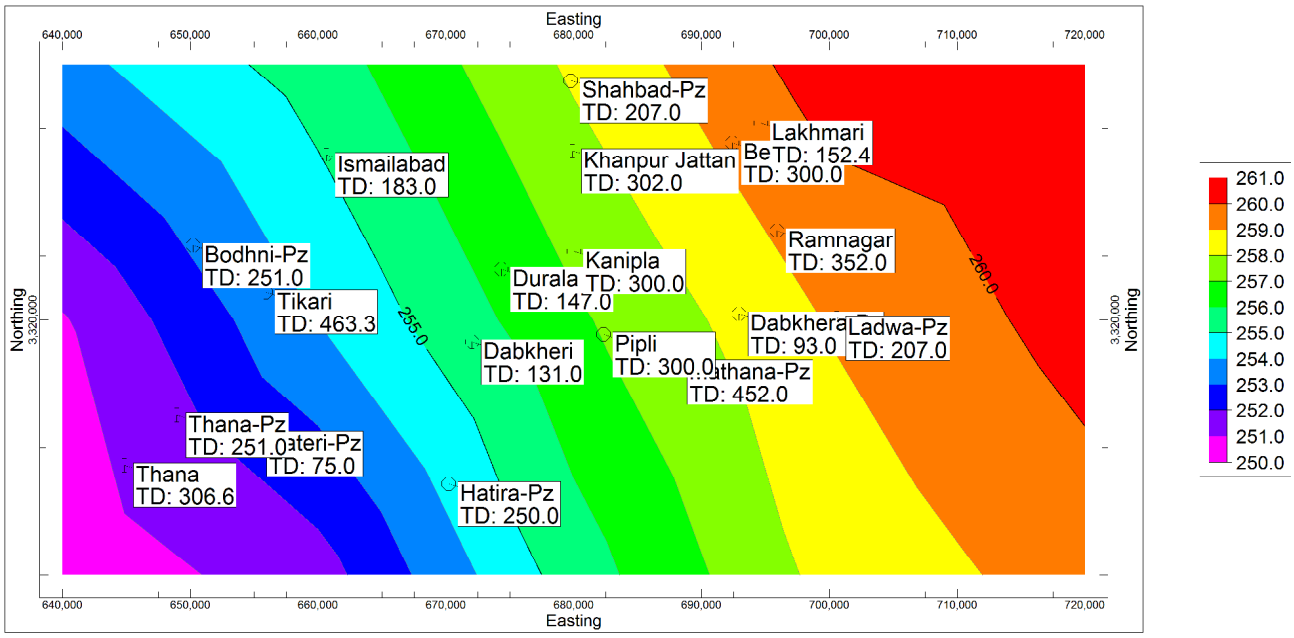
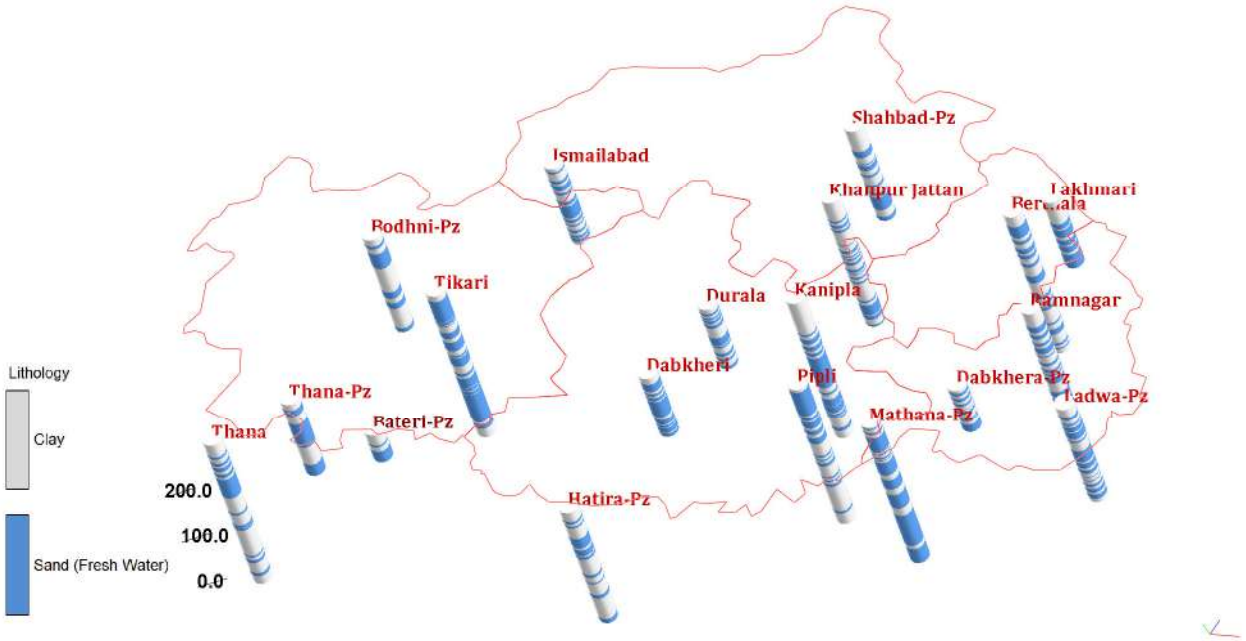


Fig 7: 3Dimension location of validated Exploratory Wells with litholog



Summarized details of the validated and optimized wells are given in table 4.2.

Table 2: 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	
Shahbad	53B/12	2C	-	-	1	-	Ismailabad (183m)
	53B/16	1A	-	-	-	-	-
		2A	-	-	-	-	-
		1B	-	1	-	-	Shahbad-Pz (207m)
		2B	-	1	-	-	Khanpur Jattan (302m)
Babain	53B/16	2C		1	-	-	Berthala (300m)
	53F/4	2A	-	-	1	-	Lakhmari (152m)
Pehowa	53B/12	3A	-	1	-	-	Bodhni-Pz (251m)
		3B	1	-	-	-	Tikari (463.3m)
		3C	-	-	-	-	-
	53C/9	1A	-	1	-	-	Thana-Pz (251m)
		1B	-	-	-	1	Bateri-Pz (75m)
		1C	-	-	-	-	-
Kurukshetra	53B/16	3A	-	-	1	-	Durala (147m)
		3B	-	1	-	-	Kanipla (300m)
	53C/13	1A	-	-	1	-	Dabkheri (131m)
		2A	-	1	-	-	Hatira-Pz (250m)
		1B	-	1	-	-	Pipli (300m)
		1C	1	-	-	-	Mathana-Pz (452m)
Ladwa	53B/16	3C	-	-	-	1	Dabkhera-Pz (93m)
	53F/4	3A	1	-	-	-	Ramnagar (352m)
	53G/1	1A	-	1	-	-	Ladwa-Pz (207m)

3. HYDROGEOLOGY

3.1 PREVIOUS WORK

The area belongs to Upper Yamuna and Ghaggar Basins and occupied by geological formations of Quaternary age comprising of Recent alluvial deposits of Indus alluvial plains. Ground water at shallow depth occur under unconfined to semi confined condition and confined conditions in deeper aquifers.

Central Ground Water Board has drilled 05 exploratory wells and 35 piezometers through in-house and 09 PZs through outsourced by M/s WAPCOS Ltd. to delineate and determine the potential aquifer zones, evaluation of aquifer characteristics etc. The drilling has been done to a maximum depth of about 463 m and revealed the presence of 3 to 9 prominent permeable granular zones with aggregate thickness varying from 31 to 203 m. The granular zone consists of fine to coarse sand, occasional gravel and pebble.

Further, the study of exploratory boreholes drilled in the district revealed the presence of three distinct aquifer groups up to the maximum drilled depth of 450 m. The first aquifer groups forms the water table aquifer and occurs down to 115 m below ground level. The second aquifer occurs in the depth range of 65 to 283 m depth which behaves as semi-confined to confined and consisting of individual sand and clay layers. The third one exist between 197 and 346 m depth and occurs in confined condition and consisting of thin sand layers alternating with thicker clay layer. The thickness of the alluvium is presumed to be more because bedrock has not been encountered up to 450 m depth in the district. Overall flow of ground water is towards south-west direction.

The aquifer parameters were also determined during the ground water exploration work. The discharge of 5 exploratory wells constructed varies from 1374 to 4140 lpm for a draw-down of 3 to 6m. The transmissivity value ranges from 830 to 2424m^2/day. The storage coefficient values ranges from 1.38x10-3 to 6.6x10-4. In the eastern part of the district which falls in the Upper Yamuna Basin, the aquifer parameters are as follows (Table 3).

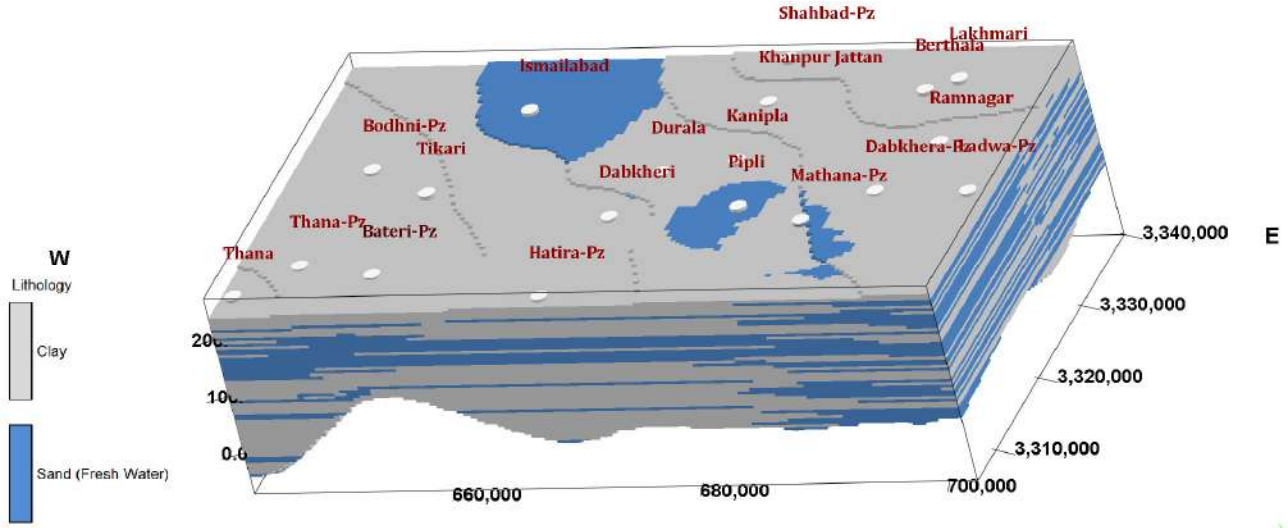
Table 3: Aquifer parameters

Aquifer Group	Average Transmissivity (m^2/day)	'K' (Lateral)	Storativity
Unconfined	2,200	24	0.12
Semi-confined	700	7.2	1x10-3
Confined	525	7.1	4.5x10-4

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. The 2D lithology map and 3D lithological fence diagram has been prepared using the lithology model and are shown in fig 8 & 9 respectively.

Fig 8: 3-Dimension Lithological Model of Kurukshetra District



The major aquifer system of the Kurukshetra district is alluvial deposit having older and younger alluvium which mainly comprised of sand, silt and clay. The major lithological formations are sand & clay and silt is found admixed with sand and clay. The top surface layer and soil is mainly silty clay. There is inter-layering of sand and clay with thick clay at Hatira towards south and thin clay at Shahbad towards north. Thin inter layering of clay with sand can be seen clearly at site Mathana which drilled depth is 452m bgl. The lithology along W-E direction shows the variation in lithology thickness i.e. thin clay layers inter bedded with sand except at location Pipli where thick clay layers were identified at depths below 125m. There is thin inter-layering of sand and clay towards NE and thick inter-layering of sand and clay towards SW. the maximum thickness of sand horizon is 66.5m at site Mathana and clay horizon is 67m at site Kanipla. The 3D lithological fence will represent the much more clear representation of sub-surface lithology in space.

3.2.1 Ground Water Exploration

Ground water exploration was carried out in Kurukshetra district under NAQUIM. A well field was constructed at Khanpur Jattan, tapping Aquifer-I, Aquifer-II and Aquifer –III. At Challaon, tube well was constructed tapping Aquifer-I, whereas at Kanepla, Aquifer-III was tapped. At Bir Pipli exploratory well was constructed tapping Aquifer –I & II. Aquifer parameters of exploratory wells are given in Table 4.

Table 4: Aquifer Parameters of Exploratory wells in Kurukshetra district

S.No	Location	Block	Zone tapped (m bgl)	SWL mbgl	Discharge (lpm)	Drawdown (m)	APT Duration hrs	Specific Capacity lpm/mt	Transmissivity m^2/day	Storativity
1	Khanpur Jattan-I	Shahabad	60-68	46.35 July, 2016	775	3.97	6 .5	197	2200	NA (Sy = 12%)
2	Khanpur Jattan-II	Shahabad	153-159, 172-175, 186-189	42.78 June, 2016	1148	5.32	10	215.78	1400	4.4x10-5
3	Khanpur Jattan-III	Shahabad	228-240, 251-257	43.38 July, 2016	1325	3.22	7.8	411.49	1700	1.5x10-4
4	Challaon	Pehowa	74-80, 86-95, 107-109	23.00	350	0.5	2	700	-	- (No OW)
5	Bir Pipli	Kurukshetra	166-172, 204-207, 213-218, 272-276	31.00	1323	4.45	7	297	-	- (No OW)
6	Kanepla	Thanesar	215-225, 278-281	37.10	1325	5.15	6	257.3	1740	- (No OW)

3.2.2 Change of Water level in different aquifers during Pumping Test

Interconnection of aquifers in term of vertical water flow from one aquifer to other is the most obvious query raised by the ground water stakeholders. The well field pumping tests and intensive water level monitoring of all the six wells (EW+OW) helps to understand the aquifer to aquifer relationship. Site plan of the well field is given in Plate I.

Observations During Pumping Test of Aquifer II

While planning Aquifer Performance Test of EW tapping Aquifer II (200m) at Khanpur Jatta site, all the wells in the well field tapping Aquifer I, II & III along with Observation Well were therefore, monitored to understand the hydraulic connectivity between the under lying (Aq-III)

and overlying aquifer-I. The aquifer –II is the most prolific with total isopack thickness of 41 meter sand zones tapped by EW (Aq II) between 130-189 mbgl. The actually measured water level data are as follows in the table-:

Time since pumping (hrs)	**Aquifer I** (2 zones between 48-68m)		**Aquifer II** (pumping condition) 5 zones between 130-189m		**Aquifer III** (4 zones between 217-273 m)	
	EW	**OW**	**EW**	**OW**	**EW**	**OW**
	Depth to Water level (mbgl) [13.05.2016]					
Initial level		41.55		42.78		39.88
1	42.98	42.75	46.58	43.31	40.20	40.78
2	42.98	42.75	46.88	43.49	40.20	40.78
3	42.98	42.75	46.91	43.68	40.20	40.78
4	42.98	42.75	46.95	43.70	40.20	40.78
5	42.98	42.75	47.01	43.84	40.17	40.78
6	43.17	43.05	47.03	43.93	40.17	40.77
7	43.17	43.00	47.10	43.93	40.17	40.77
8	43.17	42.80	47.09	43.90	40.17	40.77
9	43.17	42.80	47.17	43.80	40.17	40.77
10	43.17	42.80	47.17	43.80	40.17	40.77

The difference in the initial water level/ piezometric head is different indicating that hydraulically three aquifers are distinctly different.

The data shows that the overall drawdown in the pumped well tapping aquifer II was 102 cm in case of OW.

Whereas in case of Aquifer-I, 125m fall in water level is observed in OW. It is due to external factors like pumping from existing nearby private wells and a water supply well.

In case of Aquifer III, there is a fall of 89 cm in OW.

Observations During Pumping Test of Aquifer III

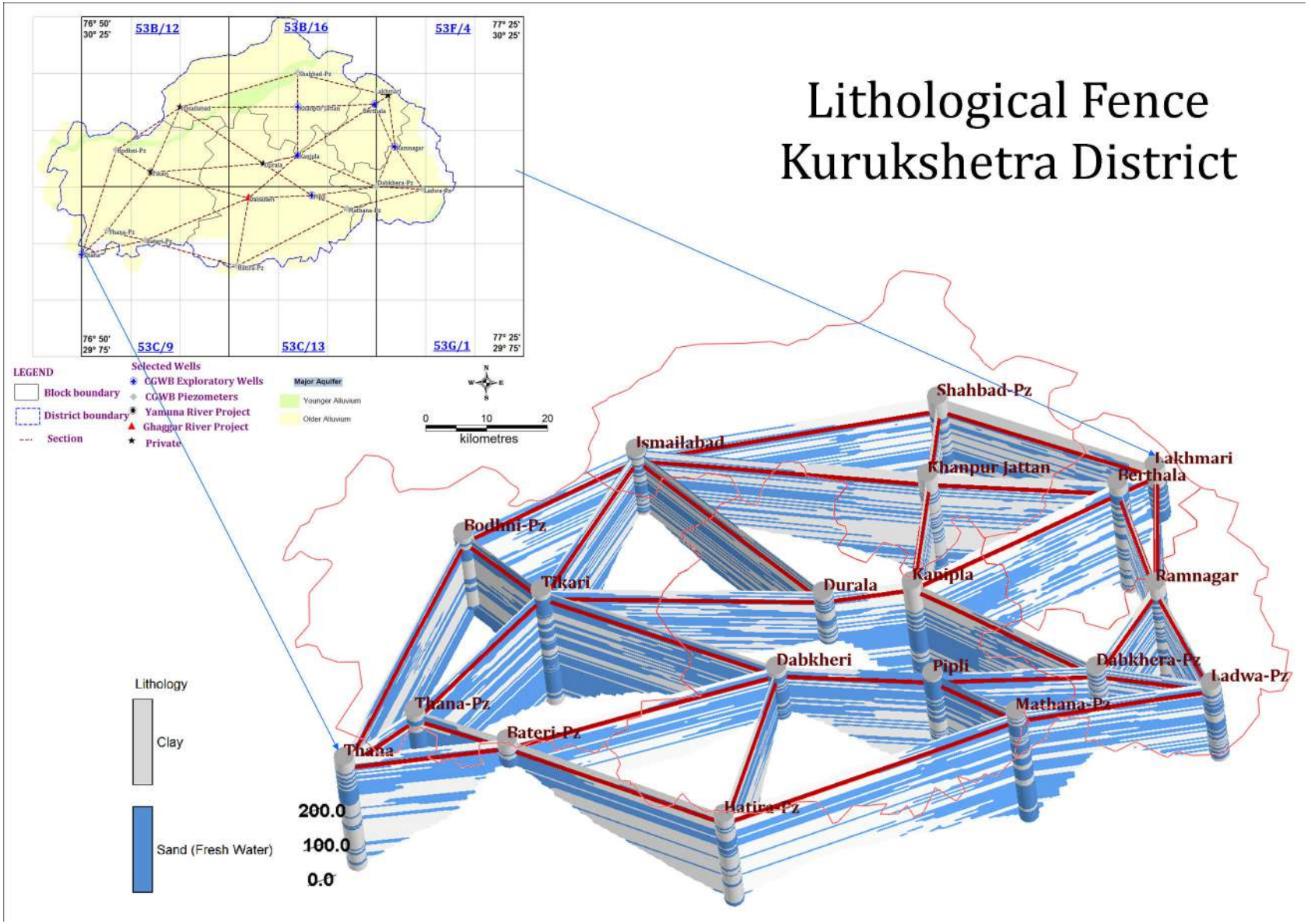
Time since pumping/ recuperation (hrs)	**Aquifer I** (4 zones between 41- 96m)	**Aquifer II** (8 zones between 107 -179 m)	**Aquifer III** (pumping condition)	
	OW	**OW**	**EW**	**OW**
	Depth to water Level (mbgl)			
0	44.64	48.45	40.90	41.10
3	45.13	48.62	44.34	42.20
4	45.13	48.70	44.35	42.20
Impact	0.49m fall	0.25m fall	4.45 m fall	0.90m fall
Pump stopped	Recuperation			
1	44.97	48.61	41.16	41.56
5	44.64	48.45	40.92	41.50
Impact	0.49m rise	0.25 m rise	3.43m rise	0.70m rise

The data shows that the overall drawdown in the pumped well tapping aquifer III was 4.45 m in case of EW and 90cm in case of OW.

Whereas in case of Aquifer-I, 49 cm fall in water level in OW is observed. The aquifers might be partially connected or It could be due to external factors like pumping from existing nearby 80 m deep water supply well.

In case of Aquifer II, there is a change of 25 cm in OW which could also be due to interference of existing irrigation wells noticed around the well during the test period.

Fig 9: 3 Dimension Lithological Fence of Kurukshetra District



3.3 Aquifer Geometry

Majority of the Kurukshetra District falls under the Ghaggar River Basin; therefore it belongs to a single aquifer system up to 180m depth with thin inter-layering of sand and clay and below that clay layer starts getting thickened (Ghaggar River Project Report). Based on the same criteria, to know the broad picture of the aquifer disposition, inter-relationship of granular zones, nature, geometry and extension of aquifers in the Kurukshetra district, the aquifer grouping has been done using the sub-surface lithology (Table 5) and a three-dimensional aquifer model has been prepared (Fig 10). The 2D aquifer map was also prepared using the aquifer model and is shown in Fig 11. The first aquifer is water table aquifer and extends all over the area. The aquifer is mainly composed of fine to coarse grained sand.

Table 5: Aquifer Grouping in Kurukshetra District

Aquifer Group	Depth Range (mbgl)		Thickness (m)	
	From	To	Min	Max
Aquifer I	6	146	42	95
Aquifer II	172	231	27	65
Aquifer III	236	274	28	37

Fig 10: 3-Dimension Aquifer model - Kurukshetra District

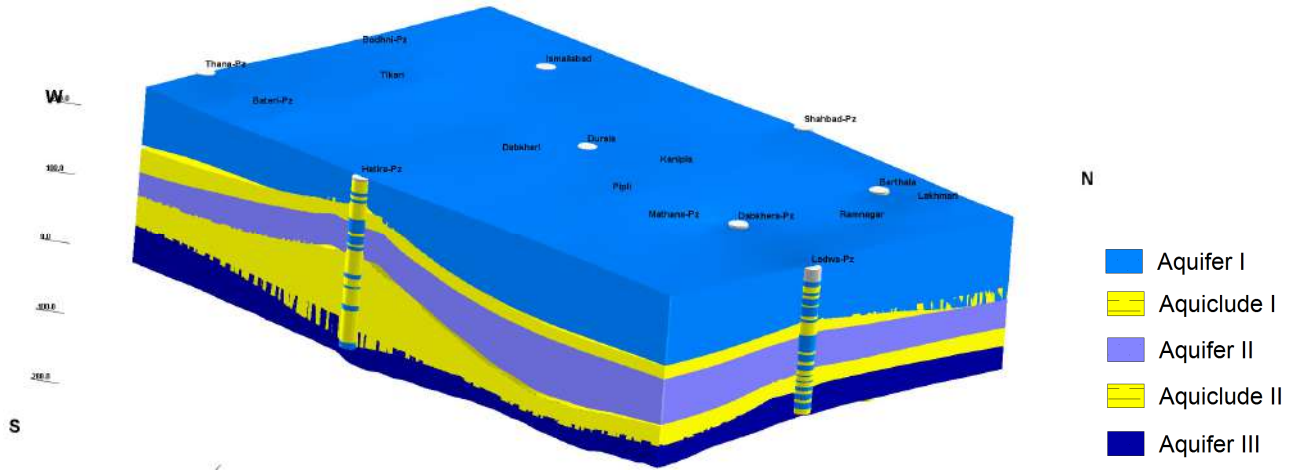
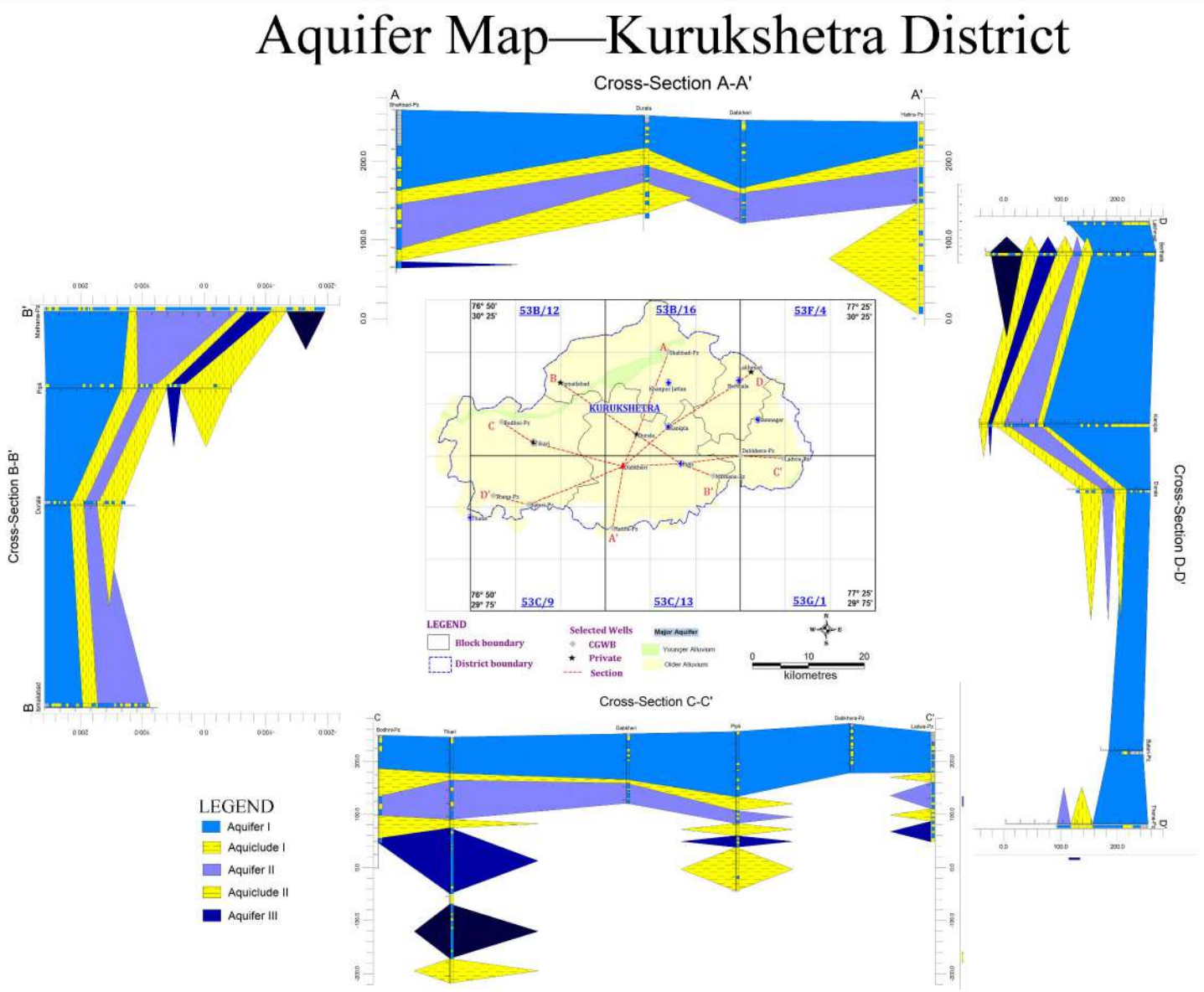


Fig 11: Cross sections of Aquifer Map of Kurukshetra District



4. GROUND WATER QUALITY

Ground water quality of shallow aquifer is assessed based on the chemical data of the ground water observation monitored regularly by CGWB on annual basis (Annexure-I) and during special study along palaeo-channels (Annexure-II & III). In addition to that chemical quality of different aquifers is assessed during ground water exploration (Annexure-IV & V) under NAQUIM. Aquifer wise ground water quality is given below.

Aquifer –I

Ground water of aquifer –I is alkaline with electrical conductivity (EC) values in ground water monitoring stations (Annexure-I & II) less than 1000 µS/cm at 25^0C, except at four locations i.e. Ishaq, Samalkhi, Pehowa and Thana where the EC value is 1588, 1092, 1254 and 1845 µS/cm at 25^oC respectively. Fluoride is below permissible limit in all water samples analyzed. Generally it is suitable for drinking purposes as chemical parameters are well within the permissible limits for safe drinking water set by Bureau of Indian standard (BIS) except for heavy metals (Annexure-III) at few places.

The cadmium (Cd) concentration is beyond permissible limit at 13 locations out of samples of 22 locations analyzed. It ranges from Below Detection Limit to 0.0064 mg/l at Tikoran. High Iron is reported at four location namely Dhani Rampura (0.333 mg/l) (Annexure-III), Khanpur Jatta –I (3.396 mg/l)), Challion (8.742 mg/l) and at Pipli – Zone test –I, (0.845 mg/l). Lead (Pb) & Copper is higher than respective permissible limit at Khanpur Jatta-I (0.899 mg/l & 5.475 mg/l respectively) (Annexure-V). Selenium (Se) is reported to be below detection limit to 0.0006 mg/l in the samples analyzed. Arsenic is also reported to be below detection limit in all samples collected along Palaeo channels. Microbiological, BOD/COD pesticide analysis was also carried out for well field at Khanpur Jatta. The results are given in Annexure-VI and summarized below.

Microbiological Analysis in Aquifer-I

Sl.No.	Location	Parameters	Result
1	Khanpur Jattan-I	E.Coli/100 ml T.Coliform/100 ml	Absent

BOD/COD (mg/l) analysis in Aquifer-I

Sl.No.	Location	Parameters	Result
1	Khanpur Jattan-I	BOD COD	<1 <1

Pesticide (in µg/l) in Aquifer II Samples

Sl.No.	Location	Result	Remarks
1	Khanpur Jattan-I	Not Detected	Pesticides are not found in all 18 parameters as per BIS 2012 Standards.

The aquifer –I is free from any Microbiological and Pesticide contamination and BOD/COD is also <1.

Aquifer-II

Ground water of aquifer-II is analyzed during ground water exploration at Khanpur Jatta-II and at Pipli, Zone test-II. Generally it is suitable for drinking purposes as chemical parameters are well within the permissible limits for safe drinking water set by Bureau of Indian standard (BIS) except for iron at Pipli which is reported to be 0.931 mg/l and Mn Pipli –zone test-II (0.325 mg/l)(Annexure-V). Microbiological, BOD/COD pesticide analysis was also carried out for aquifer-II at Khanpur Jatta and no contamination is observed in the aquifer.

Aquifer –III

Ground water of aquifer-III in samples analyzed is generally suitable for drinking purposes as chemical parameters are well within the permissible limits for safe drinking water set by Bureau of Indian standard (BIS) except for iron at Khanpur Jatta-III, Kanepala & Pipli –zone test-III which is reported to be 0.845, 2.245 & 1.321 mg/l respectively (Annexure-V). Manganese (Mn) is reported to be high than permissible limit in aquifer-III at Kanepla (0.379 mg/l).

Aquifer wise ground water quality is given in table-6.

Table-6 Ground water quality of individual Aquifer groups

Aquifer Group	Basic Analysis (15 Parameters)		Heavy Metals	Iron	Arsenic
	EC µS/cm at 25^{0}C	Other Parameters			
Aquifer-I	415 - 1845	Within permissible limits	Within permissible limit except (**Cd**-0.0032-0.0064 at twelve locations, , **Pb**-0.899 & **Cu**-5.475 at one place)	Within permissible limit except at four places (0.845 to 8.742)	Below Detection Limits
Aquifer-II	470-565	Within permissible limits	Within permissible limit except (**Mn**-0.325 at one place)	Within permissible limit except at one place (0.931)	Below Detection Limits
Aquifer-III	340-421	Within permissible limits	Within permissible limit except (**Mn**-0.379at one place)	Within permissible limit except at three place (0.845to 2.245)	Below Detection Limits

The following observations were made based on the ground water quality data:

- The aquifer I & II is free from Microbiological and Pesticide contamination.
- In aquifer I, BOD/COD is less than 1.
- Aquifer I shows the presence of Cd at various locations and Pb & Cu at sporadic locations.
- The Electrical conductivity is high in Aquifer I as compared to Aquifer II & III, indicating the better quality of ground water in deeper aquifer.
- In Aquifer I & III, Iron is present more than its permissible limit.
- In Aquifer-III, Mn is reported at one location.
- Arsenic & Fluoride contamination is absent in all the aquifers

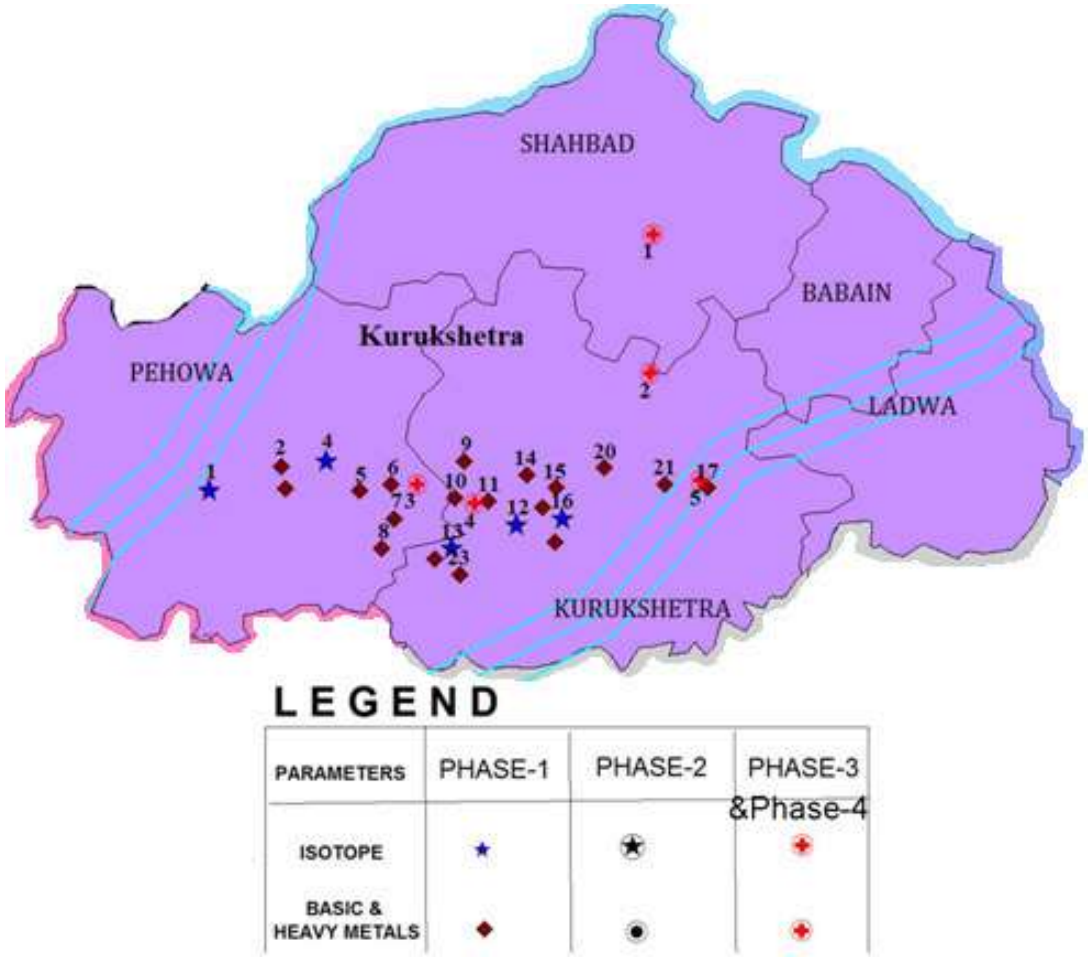
5. ISOTOPE STUDY

Isotope study has been taken up in the district for validation of the aquifer groups,

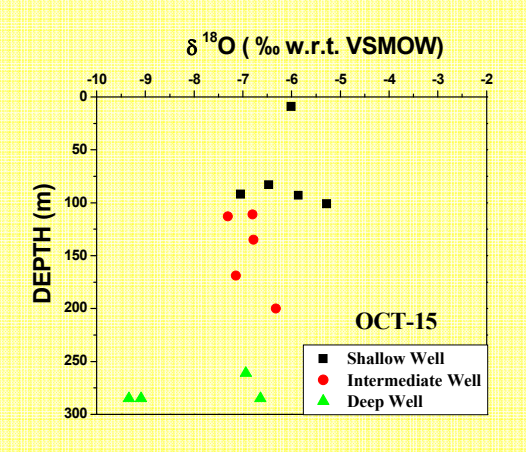
mechanism of recharge to aquifers and for the age determination of the aquifer water. The study is carried jointly with the BARC, Mumbai and CGWB, NWR for the purpose of Aquifer mapping and Paleo-channel studies in the district during 2014 to 2016 in three phases of sample collection.

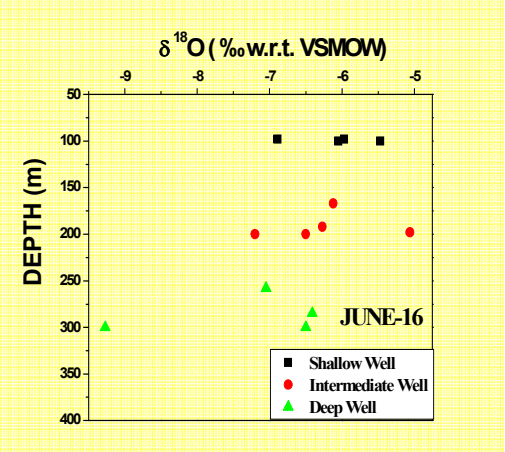
Reconnaissance survey in 2014 (5), October 2015 (6) and June 2016 (4) was carried out and the sampling location is shown in the Fig 11a (Annexure II). Comprehensive sampling was carried out only during last two seasons reflecting pre and post monsoon periods.

Fig 11a: Sampling location for isotope in Kurukshetra District

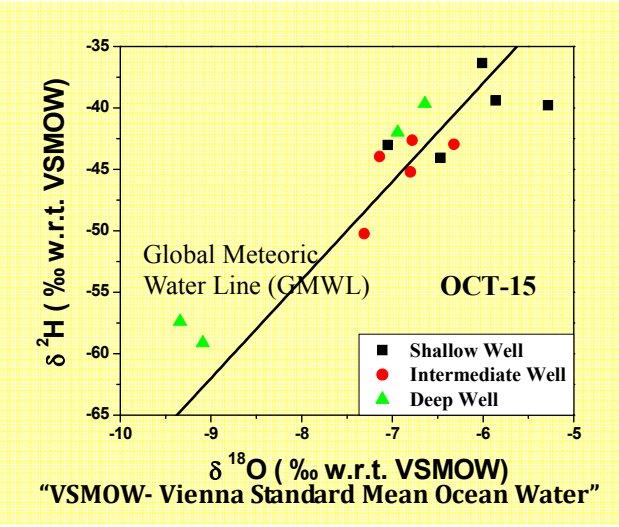


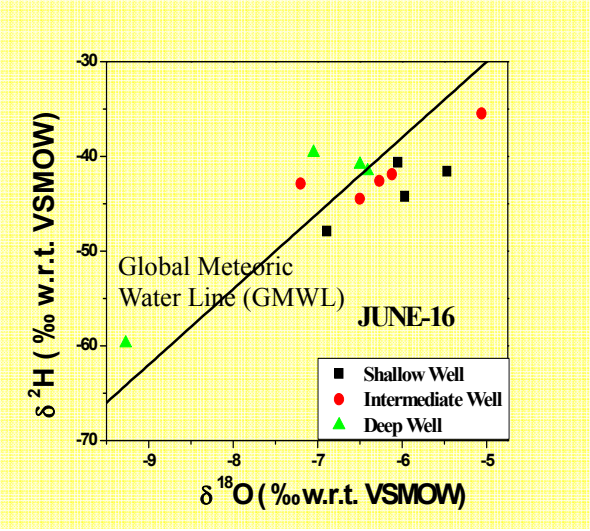
As per the result of the data, it is observed that shallow and intermediate aquifers show similar fluctuations in stable isotopic composition ($\delta^{18}O$: -7 to -5‰). Deep aquifer shows two trends, highly depleted and moderate $\delta^{18}O$ values as shown in the following plots.





Study of BARC indicates that all the samples fall along the Global Meteoric Water Line (GMWL) indicating precipitation as the dominant recharge and shallow and intermediate aquifers fall as a single cluster. A few samples from deeper aquifer shows mixed behaviour, whereas two samples from deeper aquifer (Khanpur and Pipli) show highly depleted isotopic composition. The graphical analysis is presented as follow;





Further analyses including C 14 are under progress at BARC. However the following conclusions are made so far:

- Groundwater from Aquifer-I and II is derived from local precipitation and is in dynamic condition.
- Groundwater from Aquifer-III is old and depleted indicating high altitude recharge and long residence time.

One more set of sampling is essential focussing on the deeper aquifer and few samples from south of Pipli.

6. 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.

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.

6.1 Unconfined aquifers

Dynamic Resources

The ground water development in all the blocks has exceeded the available

recharge, thus all the blocks have been categorized as over exploited. Stage of ground water development in the Kurukshetra district has been assessed to be 281% (Table-7).

Table 7: Dynamic Ground Water Resource & Development Potential (31.03.2013)

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	Stage of Ground Water Development (%)
Babain	**4092**	10802	1024	11826	1024	-7734	289
Ladwa	**5179**	16849	1441	18290	1441	-13111	353
Pehowa	**14233**	35599	1902	37501	2002	-23368	263
Ismailabad	**6503**	16638	1190	17828	1190	-11325	274
Shahbad	**6739**	17631	1490	19121	2490	-13382	284
Thaneswar	**14953**	37603	2946	40549	2946	-25596	271
Total (ham)	**51699**	**135122**	**9993**	**145115**	**11093**	**-94516**	**281**

Instorage Ground Water Resources

As per revised guidelines recommended by the Central Level Expert Group on ground water resources assessment, the resources are separately considered as dynamic and in-storage unconfined. In case of alluvial area, the in-storage resources of unconfined aquifer have been computed based on specific yield of the aquifer as detailed below:

In-storage Ground Water resources (unconfined Aquifer) = Thickness of the aquifer (granular/productive zone) below the zone of water level fluctuation down to the bottom layer of unconfined aquifer x Sp. Yield of the aquifer x Areal extent of the aquifer

6.2 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 8.1. 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-I, II & III are given in table-8, 9 & 10. Total block wise ground water resources are given in table-11.

Fig 12: Concept for Resource Estimation in Unconfined and Confined Aquifer System

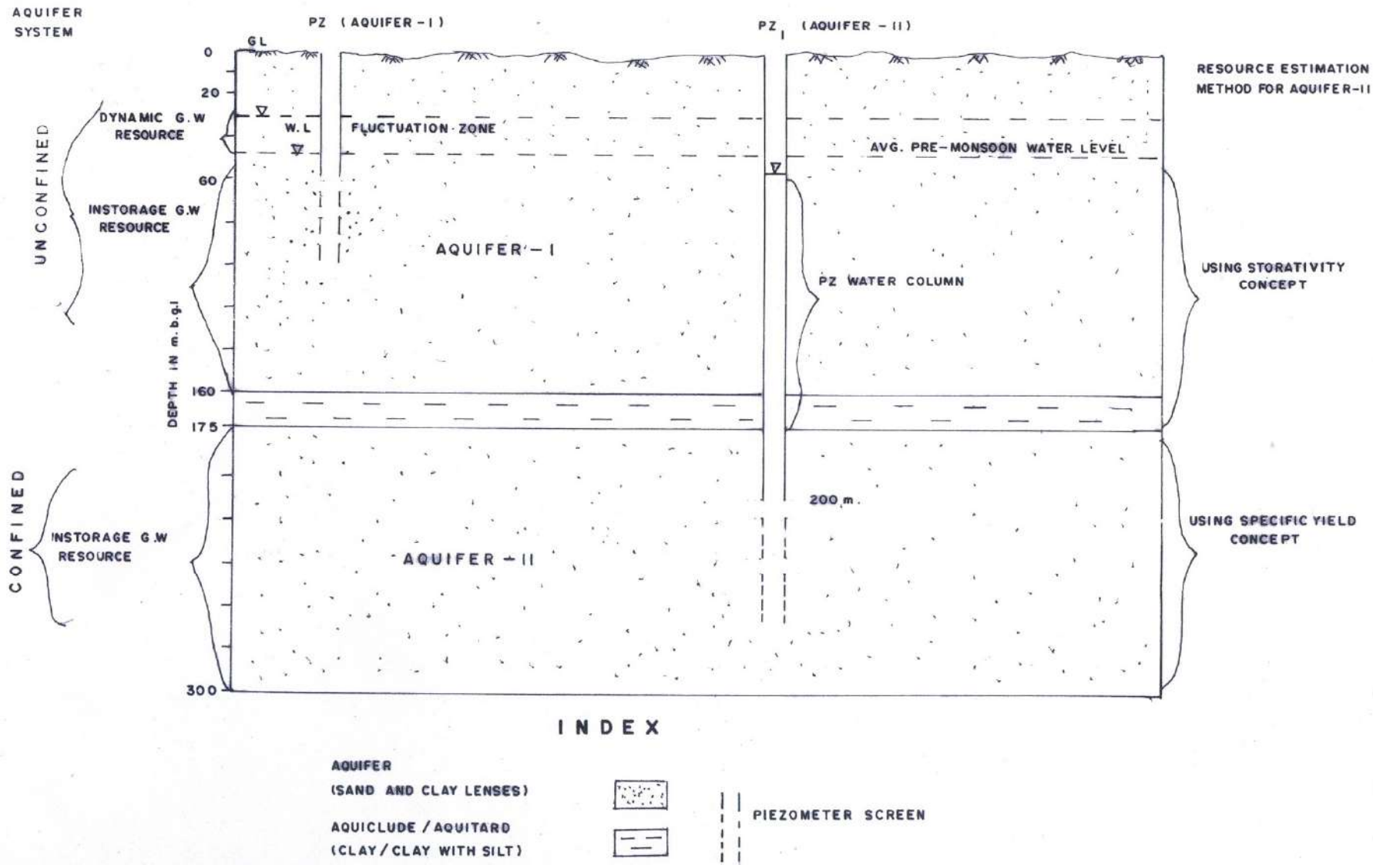


Table 8: BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED AQUIFER -I

S. N.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)				Average Pre-monsoon Water Level (m bgl)	Depth to bottom of unconfined aquifer I (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Thickness of the Granular Zone in unconfined aquifer I below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources [(6)*(11)*(12)*] 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	13
1	Babain	Alluvium	16784	16784	16784	0	34.34	148	113.66	65	0.072	78549
2	Ladwa	Alluvium	16230	16230	16230	0	32.55	149	116.45	63	0.072	73619
3	Pehowa	Alluvium	50700	50700	50700	0	31.55	150	118.45	64	0.072	200674
4	Shahbad	Alluvium	37712	37712	37712	0	33.02	123.5	90.48	42	0.072	84757
5	Thanesar	Alluvium	46827	46827	46827	0	32	160.34	128.34	92	0.072	276506
	Dist. Total (ham)		**168253**	**168253**	**168253**	**0**						**714104**
	Dist. Total (mcm)											**714.1**

Table 9: BLOCK WISE INSTORAGE GROUND WATER RESOURCES - CONFINED (AQUIFER II)

Name of Assessment Unit	Type of rock formation	Areal extent (ha)				Pz head AqII	Top of Confined Aquifer II (m bgl) Top Unconfined Aquifer II	Water Column in Piezometer	Bottom of Confined Aquifer II (m bgl)	Total Thickness of confined aquifer II (m) (9-8)	Thickness of the Granular Zone in confined aquifer II (m)	Average Specific Yield (Unconfined Aquifer)	Average value of Storativity (Confined Aquifer)	In-Storage Ground Water Resources within Peizometer of Aquifer II (Storativity Concept)[(6)*(10)*(15)*]FRESH	In-Storage Ground Water Resources Within Aquifer Thickness (Specifice Yield Concept)[(6)*(13)*(14)	Total In-Storage Ground Water Resources (Aquifer II) [(16)+(17)]
		Total Geographical Area	Assessment Area													
			Total	Fresh Water	Brackish /Saline Water											
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Kurukshetra																
Babain	Alluvium	16784	16784	16784	0	37	173.5	136.5	210.5	37	27	0.072	0.00663	15189	32024	47213
Ladwa	Alluvium	16230	16230	16230	0	37	170	133	208	38	28	0.072	0.00663	14311	32720	47031
Pehowa	Alluvium	50700	50700	50700	0	37	178	141	260	82	52	0.072	0.00663	47396	191281	238677
Shahbad	Alluvium	37712	37712	37712	0	37	142.5	105.5	175	32.5	22	0.072	0.00663	26378	59736	86114
Thaneswar	Alluvium	46827	46827	46827	0	37	196	159	300	104	65	0.072	0.00663	49364	219150	268514
Dist. Total (ham)		168253	168253	168253	0									152639	534911	687549
Dist. Total (bcm)														1.526	5.349	6.875

The average peizometer head of aquifer II is 37m bgl.

Table 10: BLOCK WISE INSTORAGE GROUND WATER RESOURCES - CONFINED (AQUIFER III- upto 300m depth)

Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)				Top of Confined Aquifer III (m bgl)	Bottom of Confined Aquifer III (m bgl)	Total Thickness of confined aquifer III (m) (9-8)	Thickness of the Granular Zone in confined aquifer III (m)	Average Specific Yield (Unconfined Aquifer)	In-Storage Ground Water Resources Within Aquifer Thickness (Specifice Yield Concept)[(6)*(11)*(12)*]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	13
1	Babain	Alluvium	16784	16784	16784	0	246.5	285	38.5	28	0.072	33232
2	Ladwa	Alluvium	16230	16230	16230	0	245	279	34	36	0.072	42068
3	Pehowa	Alluvium	50700	50700	50700	0	-	-	-	-	-	-
4	Shahbad	Alluvium	37712	37712	37712	0	217	258	41	37	0.072	100465
5	Thaneswar	Alluvium	46827	46827	46827	0	-	-	-	-	-	-
	Dist. Total (ham)		**168253**	**168253**	**168253**	**0**						**175765**
	Dist. Total (mcm)											**1758**

The Peizometer head value for confined Aquifer III is not available, therefore, resources within the aquifer thickness are estimated only.

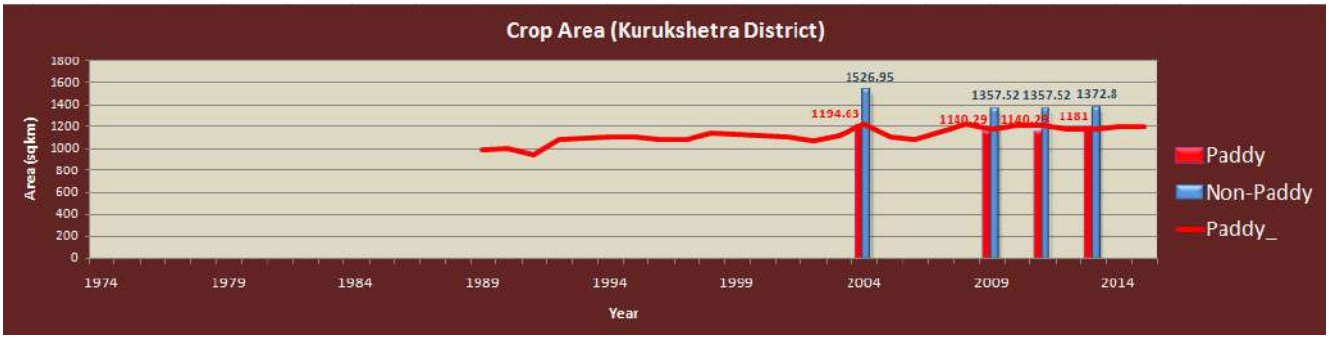
Table 11: BLOCK WISE TOTAL AVAILABLE GROUND WATER RESOURCES IN AQUIFERS UP TO 300m DEPTH

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 2013) (in ham)	Fresh In-Storage Ground Water Resources (Aquifer I)(in ham)	Total Ground water Resources Aquifer-I(in ham)	Fresh In-Storage Ground Water Resources (Aquifer II)(in ham)	Fresh In-Storage Ground Water Resources (Aquifer III)(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)**	**3**	**4**	**6=(5+3+4)**	**7**
					Based on Aquifer Mapping					
Babain	Alluvium	16784	16784	3116	78549	81665	47213	33232	162110	1.62
Ladwa	Alluvium	16230	16230	3096	73619	76715	47031	30383	154129	1.54
Pehowa	Alluvium	50700	50700	9664	200674	210338	238677	-	449015	4.49
Shahbad	Alluvium	37712	37712	7386	84757	92143	86114	100465	278722	2.78
Thaneswar	Alluvium	46827	46827	12071	276506	288577	268514	-	557091	5.57
Dist. Total (ham)		168253	168253	**35333**	**714104**	**749437**	**687549**	**164080**	**1601066**	**16.011**
Dist. Total (mcm)				**353**	**7141**	**7494**	**6875**	**1641**	**16011**	

7. GROUND WATER RELATED ISSUES

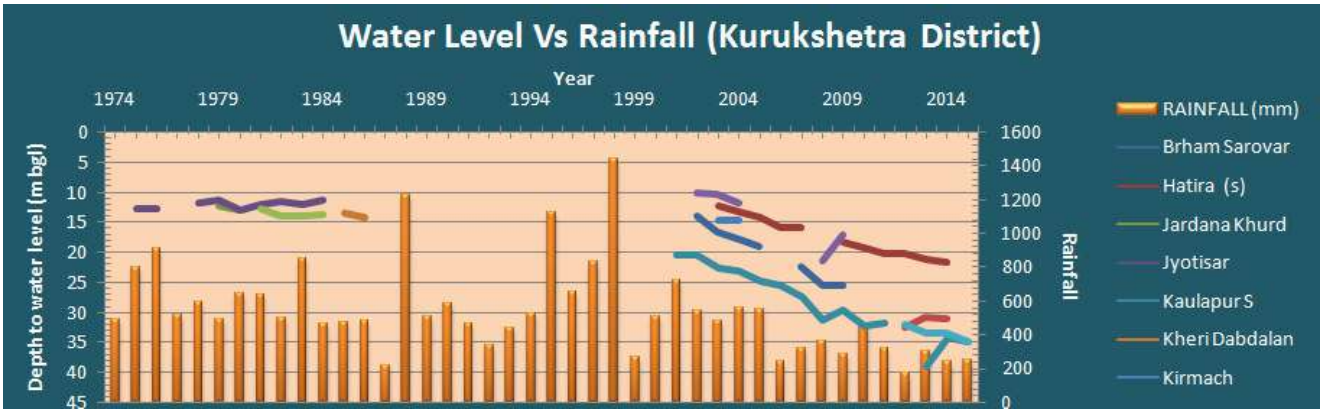
Kurukshetra is famous for its paddy cultivation and is also known as 'Rice Bowl' of Haryana. The quality of ground water in the district is potable for both the drinking and irrigation purposes therefore, the ground water is constantly being pumped for the irrigation due to its easy access through tube wells and they are the main source of irrigation.

Fig 13: Ground water irrigation for paddy crop.



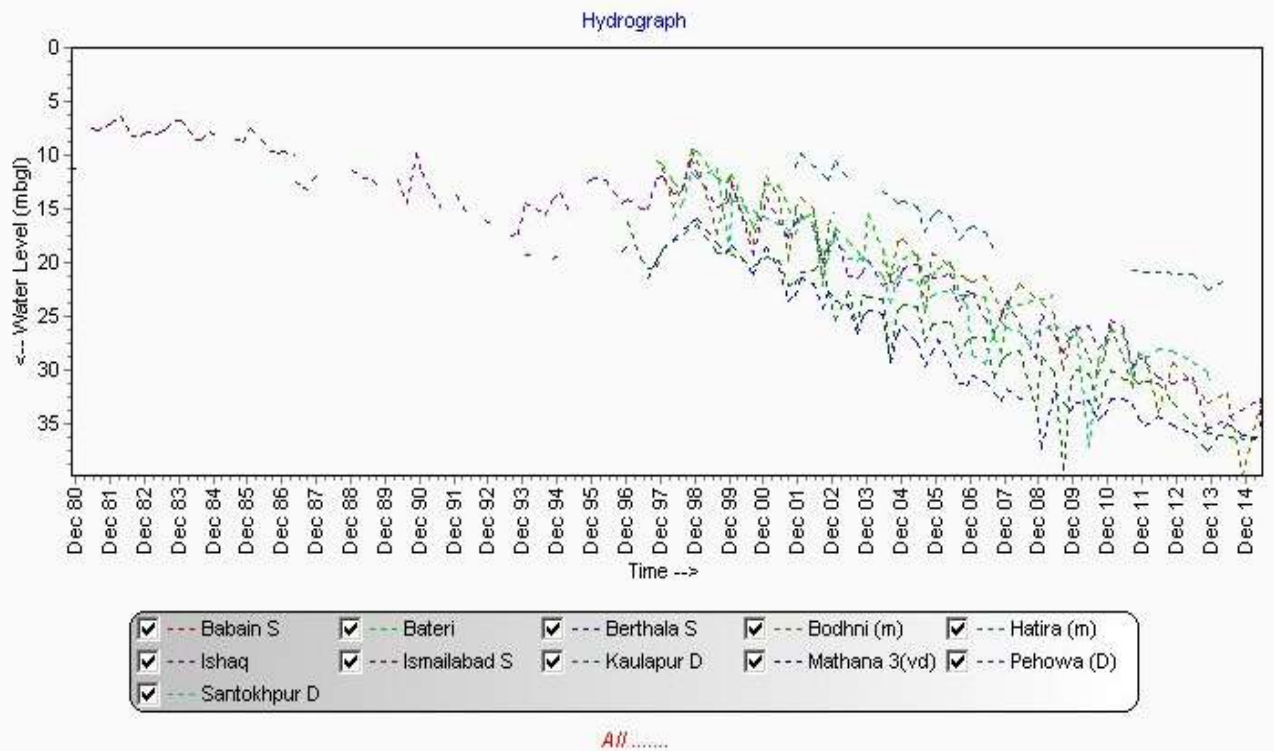
This will lead to its major ground water issue which is deepening of ground water level as the recharge of the groundwater through rainfall and other sources are less than the overall extraction.

Fig 14: Ground water trend versus rainfall.



The hydrographs also shows the declining water level trend over the years and the district is also categorized as over-exploited.

Fig 15: Long term ground water table variation.



7.1 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 in Table 10,11 and 12

Fig 16: Irrigation tube wells as per depth.

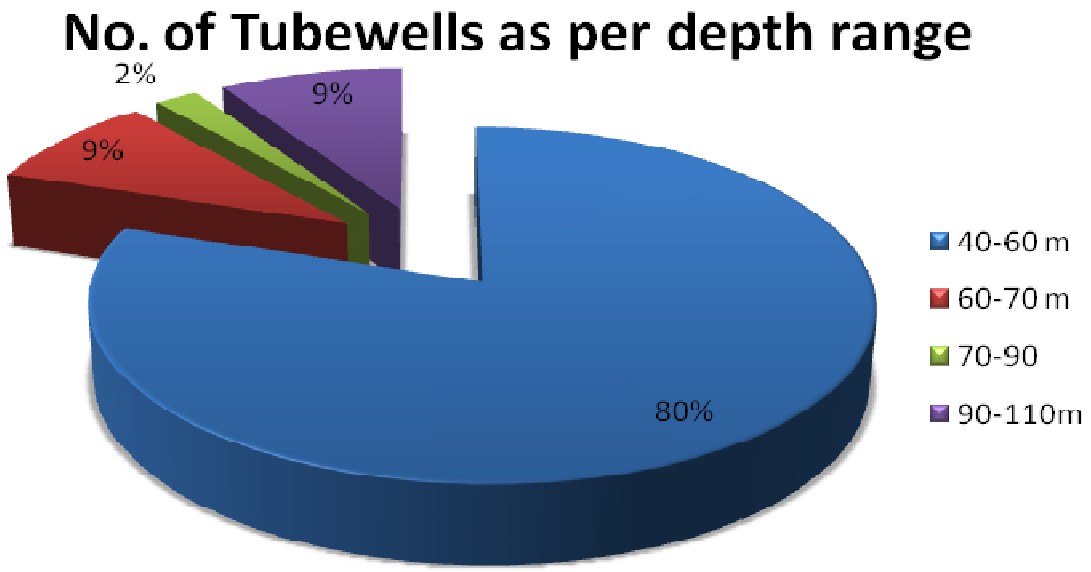


Table 12-Distribution of Tube wells According to Owner's holding Size

Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Public	Group of Farmers	Total
91	1851	5875	1475	630	22618	32540

Table13 -Distribution of Shallow Tube wells According to Depth of tube well

(0-20 mts)	(20-40 mts)	(40-60 mts)	(60-70 mts)	(>70 mts)	Total
0	26092	2852	0	3596	32540

Table14- Type of Ground water distribution device

Open Water Channel		
Lined/pucca	**Unlined/kutcha**	Total
27357	**5183**	32540

8. AQUIFER MANAGEMENT PLAN

An outline of the Aquifer Management Plan for each block is given in chapter-9. This includes details regarding population, rainfall, average annual rainfakk, agriculture and irrigation, water bodies, ground water resource availability, ground water extraction and water level behavior. Aquifer disposition and various cross sections have also been given. Ground water resources, extraction and other issues including ground water resource enhancement and demand side innervations have been given.

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 in the whole district.

8.1 SCOPE OF IMPLEMENTATION

This plan is focusing on the technical aspects of the ground water recharge through various means so 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.

8.2 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 in the state of Haryana, particularly in overexploited blocks.

There are around 5183 (out of 32540) tubewells (15.93%) operated by farmers for irrigation through unlined/Katcha open channel system in Kurukshetra district where water from the tubewell is discharge to the agricultural field. In this process, huge (around 25 %) quantity of ground water is wasted in soil moisture and evaporation losses.

Around 80% of the tube wells are of shallow depth (20 to 40m) and remaining are deeper (40 to >70 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 Kurukshetra district is estimated at 1451.15 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 gross draft will be reduced to the tune of 54 MCM assuming there is no crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks. The measure if implemented will bring down the ground water overdraft from 281 % to 270%. The category of the blocks will also improve resulting in boosting of agriculture and industrial development otherwise not sustainable in over-exploited blocks.

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. It is

expected to save 1% of the agricultural land occupied by open channels which can be utilized for cultivation purpose. Heavy ground water overdraft can be reduced by these efforts. This will ensure **more crop per drop**.

8.3 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 quantative impact on stage of ground water development 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 (%)	Change of paddy cultivation area (% of existing)
				Replace water courses by UG Pipes (mcm)	Adopt Artificial recharge (mcm)	Change Paddy to Maize (mcm)	Total (mcm) (2+3+4)		
			1	2	3	4	5		
Babain	40.9	118.3	289	4.3	1.7	71.31	77.3	100	89
Ladwa	51.8	182.9	353	6.71	2.3	93	102	156	100
Pehowa	142.3	375.0	263	14.18	3.7	214.81	232.7	100	61
*Ismailabad	65.0	178.3	274	6.63	0.8	105.84	113.3	100	62
Shahbad	67.4	191.2	284	7.02	2.8	114.04	123.8	100	49
Thaneswar	149.4	405.5	271	14.98	6.0	235.03	256	100	92
Total	516.8	1451.2	281	53.82	17.3	834.03	905.1		
*Ismailabad block has been created recently from parts of Pehowa, Shahbad & Thaneswar									

9.BLOCK WISE AQUIFER MAPS

AND

MANAGEMENT PLAN

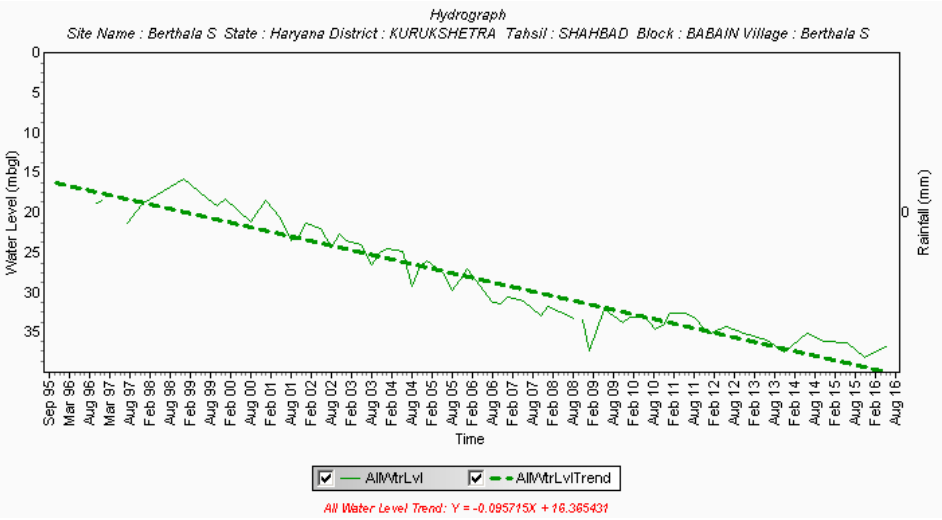
i. BABAIN BLOCK (167.84 SQ KM)

Population (2011)	Rural-62177 Urban-0 Total-62177
Rainfall 2014 (Kurukshetra Dist.)	Monsoon -320.5mm Non Monsoon-241.2mm
Average Annual Rainfall (Babain block)	580mm
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops-Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-119.67sqkm Total Irrigated Area-119.67sqkm
Water Bodies & Canal Irrigation	63 nos.

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (115m) is very prominent in terms of thickness and geographic extent. Aquifer II (37m) & III (39m) are less in thickness. Block is categorized as Over-Exploited as per 2013 assessment.

Ground water Extraction: Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~36.33m bgl &Post Monsoon-~36.12mbgl



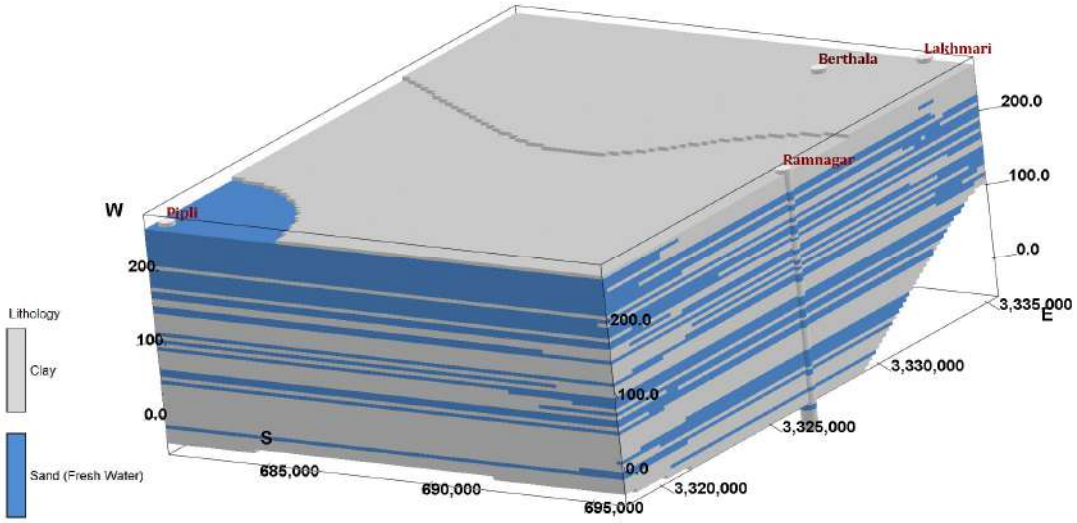
Aquifer Disposition: Multiple Aquifer System (3 Aquifer System)

Aquifer Group (Depth in m)	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (33-148)	Quaternary Alluvial deposits	Unconfined	67	2200	12	NA
II (173-210)		Unconfined to Confined	27	-	NA	$6.63x10^{-3}$
III (246-285)		Unconfined to Confined	28	-	NA	$6.63x10^{-3}$

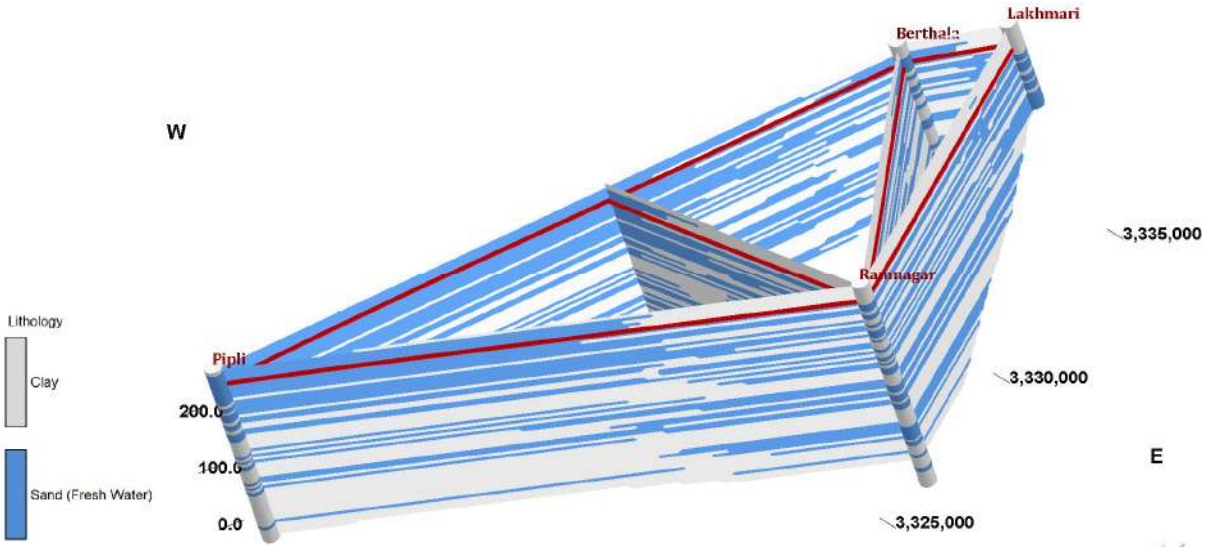
Aquifer comprises of freshwater only and the main aquifer formation is sand.

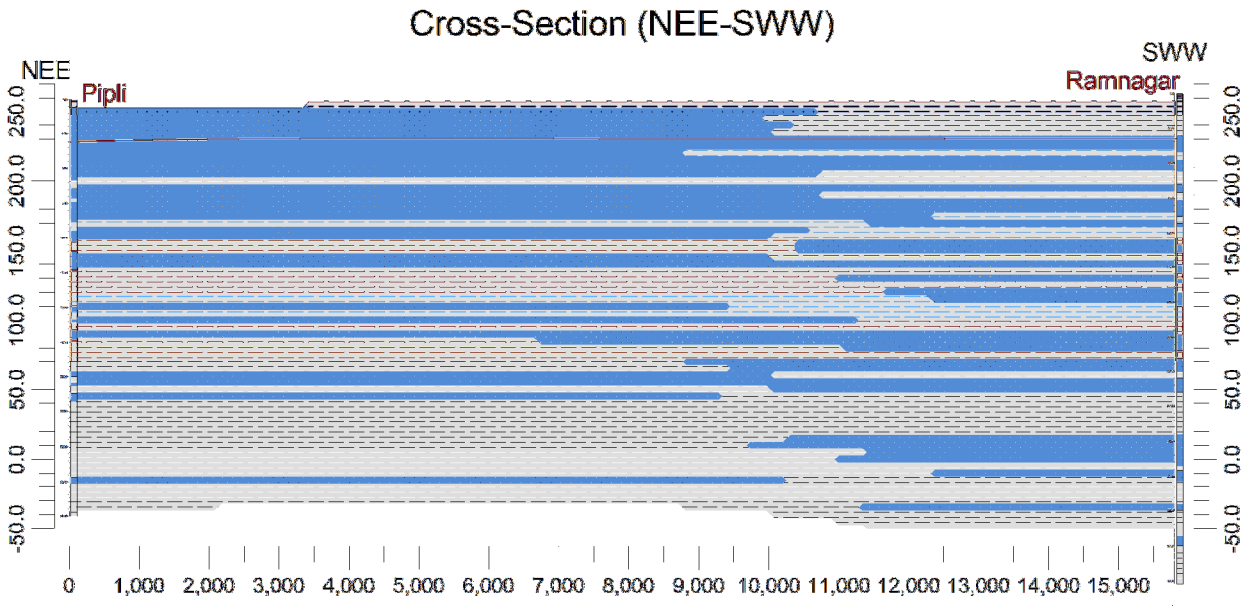
The non-aquifer material comprise of clay.

3D Lithology model



3D Lithology Fence




Cross-Section (NEE-SWW)
NEE
SWW
Pipli
Ramnagar
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
1,000
2,000
3,000
4,000
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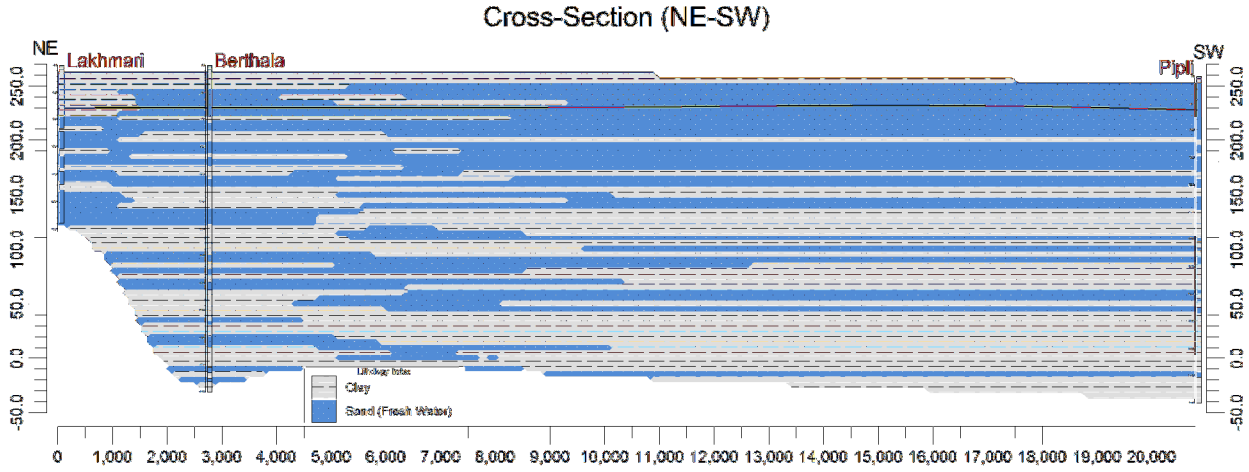
15,000


Cross-Section (NE-SW)
NE
SW
Lakhmani
Berthala
Pipli
Clay
Sand (Fresh Water)
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
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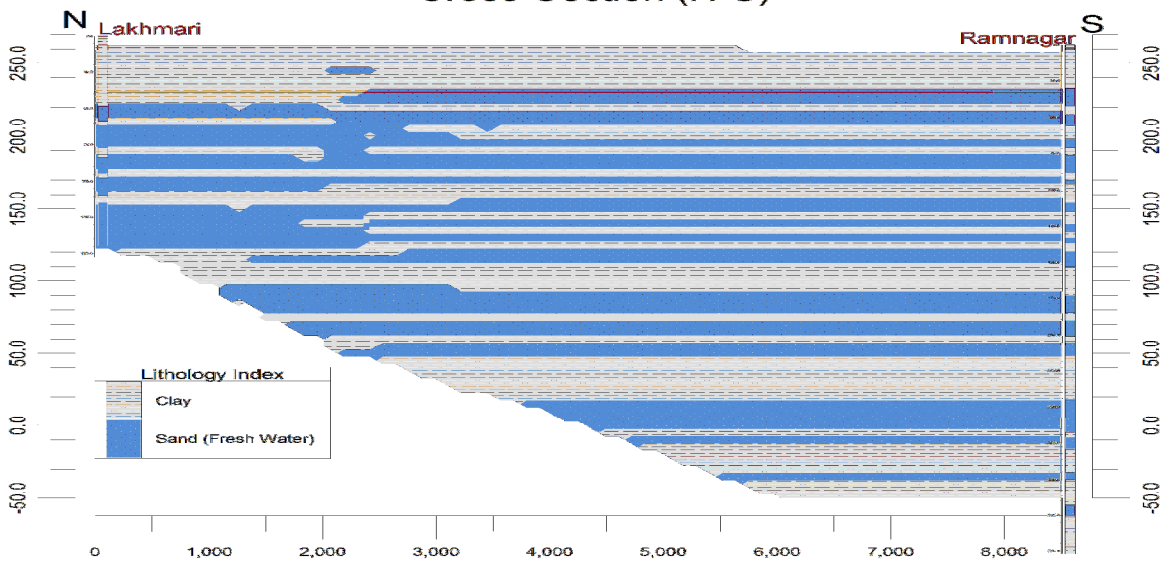
20,000


Cross-Section (N-S)
N
S
Lakhmani
Ramnagar
Lithology Index
Clay
Sand (Fresh Water)
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
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3,000
4,000
5,000
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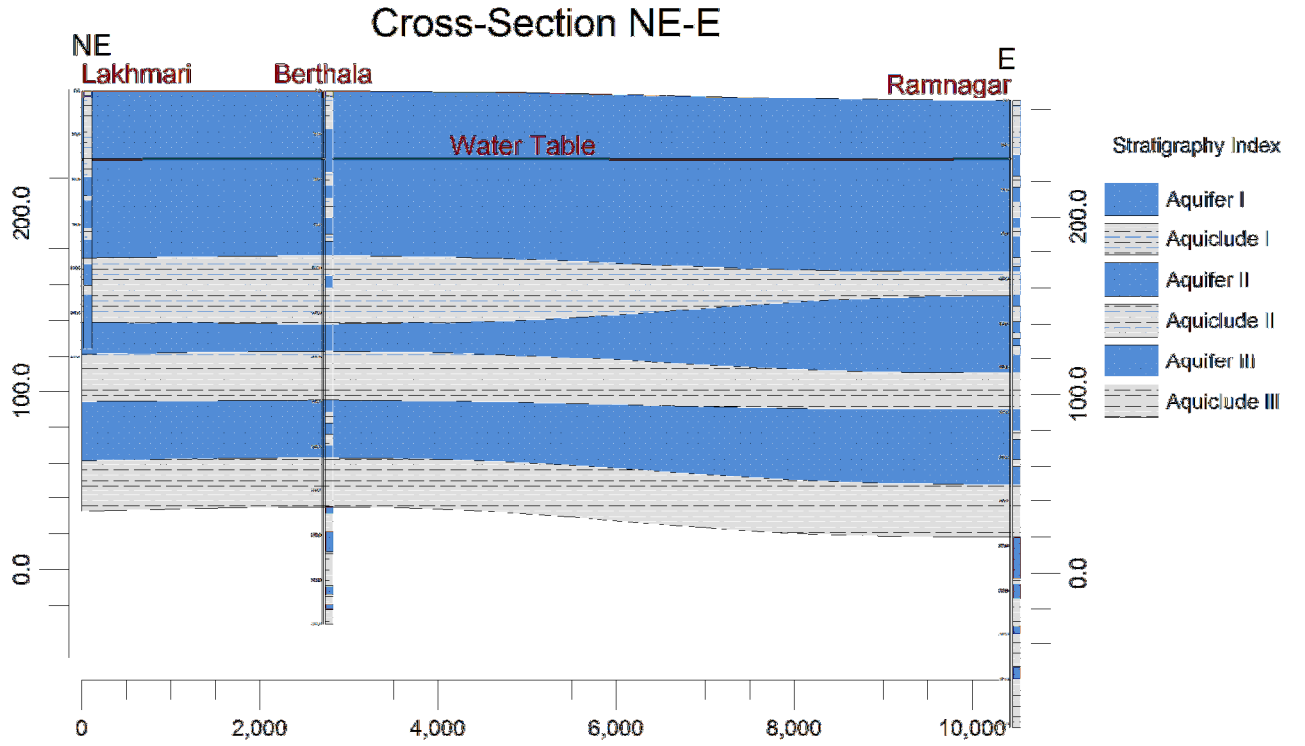
8,000


Cross-Section NE-E
NE
Lakhmari
Berthala
E
Ramnagar
Water Table
200.0
100.0
0.0
0
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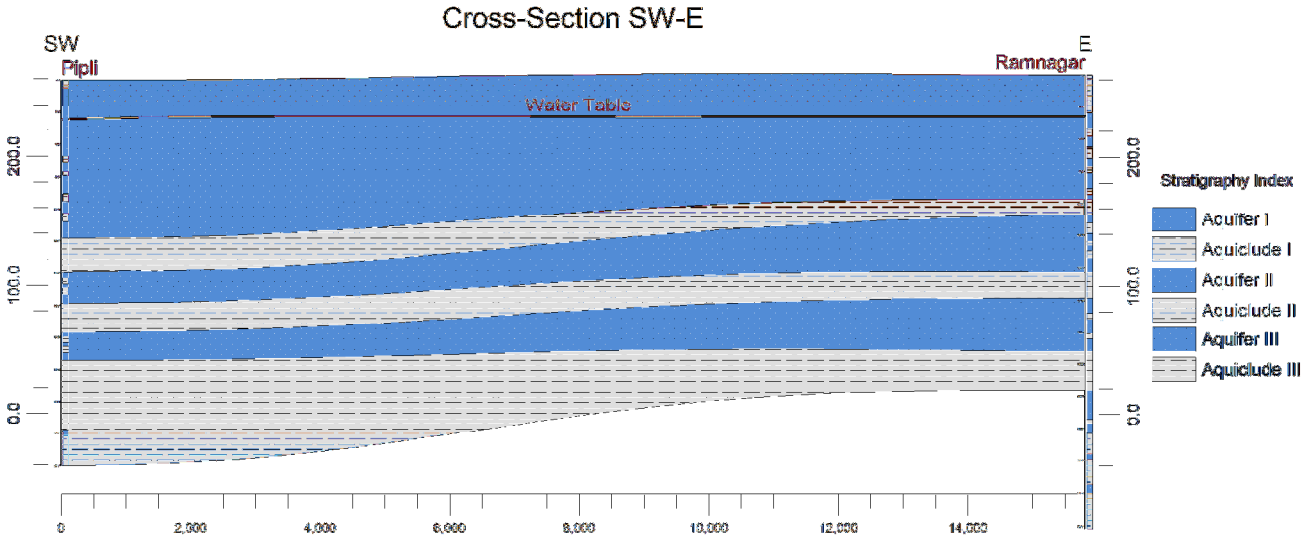
4,000
6,000
8,000
10,000
Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III
Aquiclude III


Cross-Section SW-E
SW
Pipli
Ramnagar
E
Water Table
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100.0
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0
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4,000
6,000
8,000
10,000
12,000
14,000
Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III
Aquiclude III

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm)	Dynamic Aquifer I (2013)	31.16
	In-storage Aquifer I (2013)	785.49
	Dynamic Aquifer II	151.89
	In-storage Aquifer II	320.24
	Dynamic Aquifer III	-
	In-storage Aquifer III	332.32
	Total	1621.11
Ground Water Extraction (mcm)	Irrigation (2013)	108.02
	Domestic & Industrial (2013)	10.24
Future Demand for domestic & Industrial sector (2025) (in mcm)		10.24
Chemical Quality of ground water		Potable for drinking and irrigation (Details in ANNEXURE I)
Other issues		Deeper water level (>5m) & declining water level trend (112.6-115.5cm/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 (34m) is 261.83 mcm.
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting & Farm pit Recharge will save 1.73mcm volume of water

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 4.3mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean in 89% of the total area. Anticipated volume of water saved by maize/ soyabean is 71.31mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

ii. LADWA BLOCK (162.30 SQ KM)

Population (2011)	Rural-88097 Urban-0 Total-88097
Rainfall 2014 (Kurukshetra Dist.)	Monsoon -320.5mm Non Monsoon-241.2mm
Average Annual Rainfall (Ladwa block)	580mm
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops-Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-161.93sqkm Total Irrigated Area-161.93sqkm
Water Bodies & Canal Irrigation	77 nos.

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (123m) is very prominent in terms of thickness and geographic extent. Aquifer II (38m) & III (34m) are less in thickness. Block is categorized as Over-Exploited as per 2013 assessment.

Ground water Extraction: Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior(2015): Pre Monsoon-~19.90m bgl &Post Monsoon-19.87-35.7mbgl

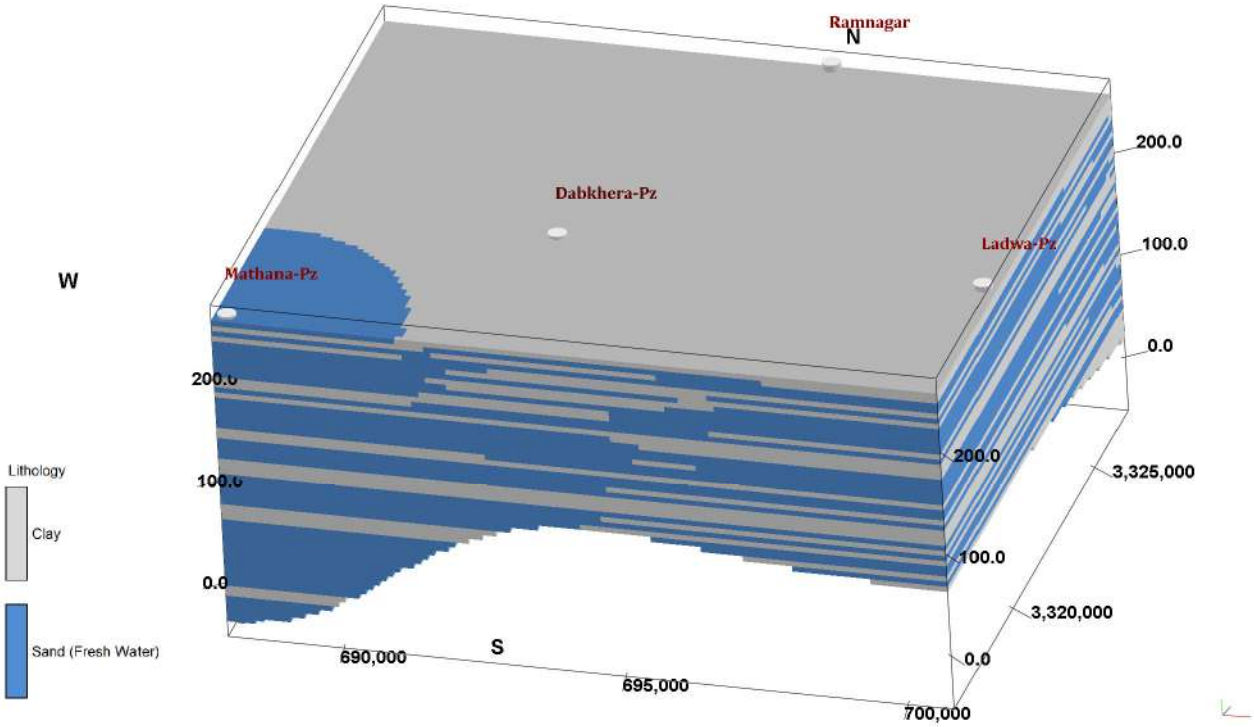
Aquifer Disposition: Multiple Aquifer System (3 Aquifer System)

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aq-I (26-149m)	Quaternary Alluvial deposits	Unconfined	66	2200	12	NA
Aq-II (170-208m)		Unconfined to Confined	28	-	NA	$6.63x10^{-3}$
Aq-III (245-279m)		Unconfined to Confined	26	-	NA	$6.63x10^{-3}$

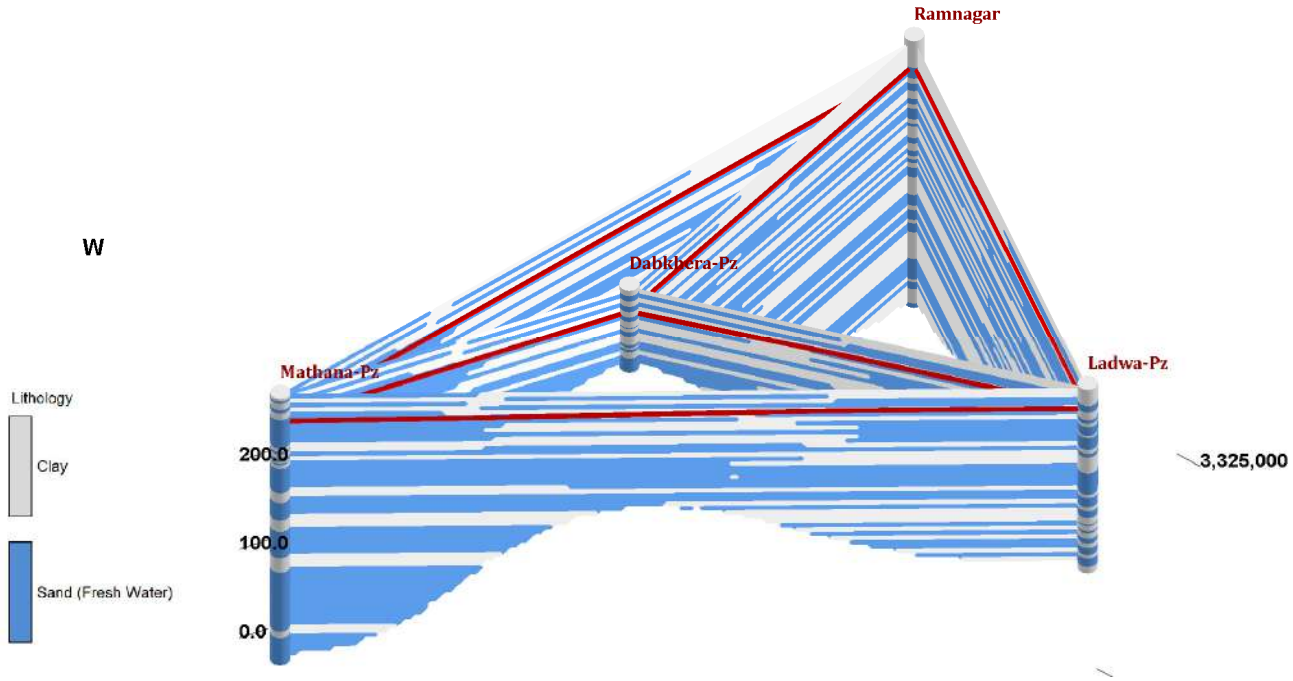
Aquifer comprises of freshwater only and the main aquifer formation is sand

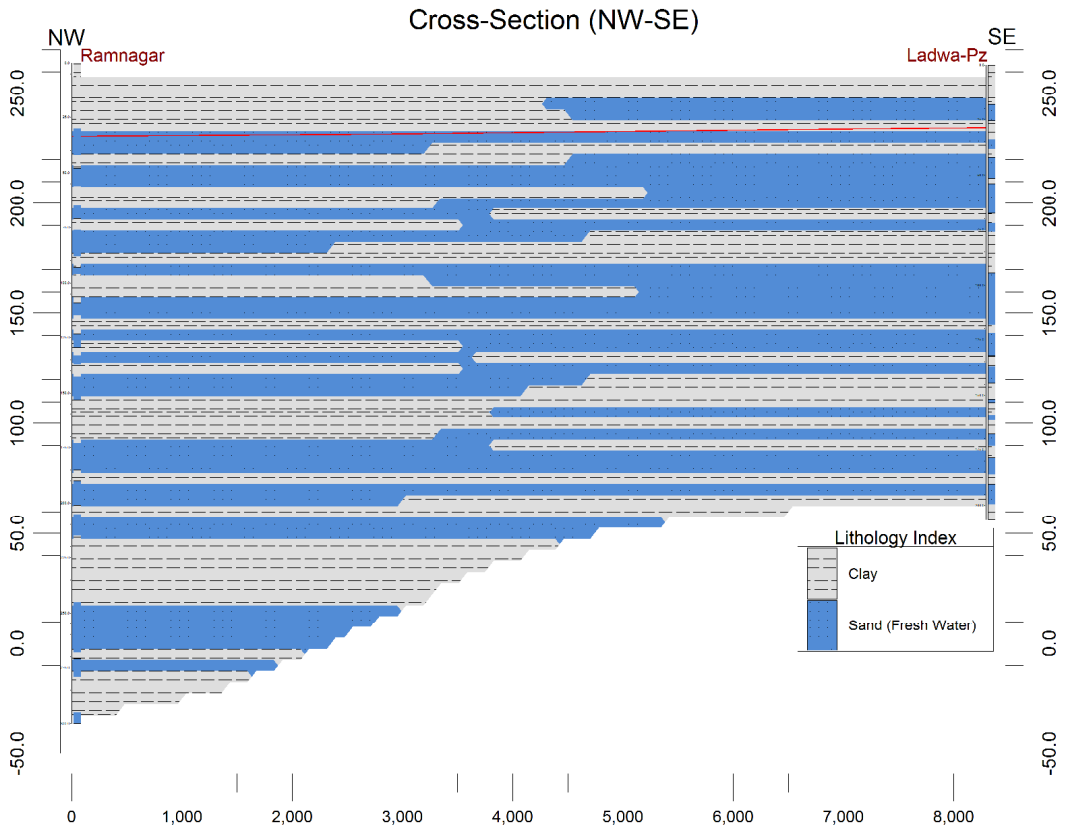
The non-aquifer material comprise of clay.

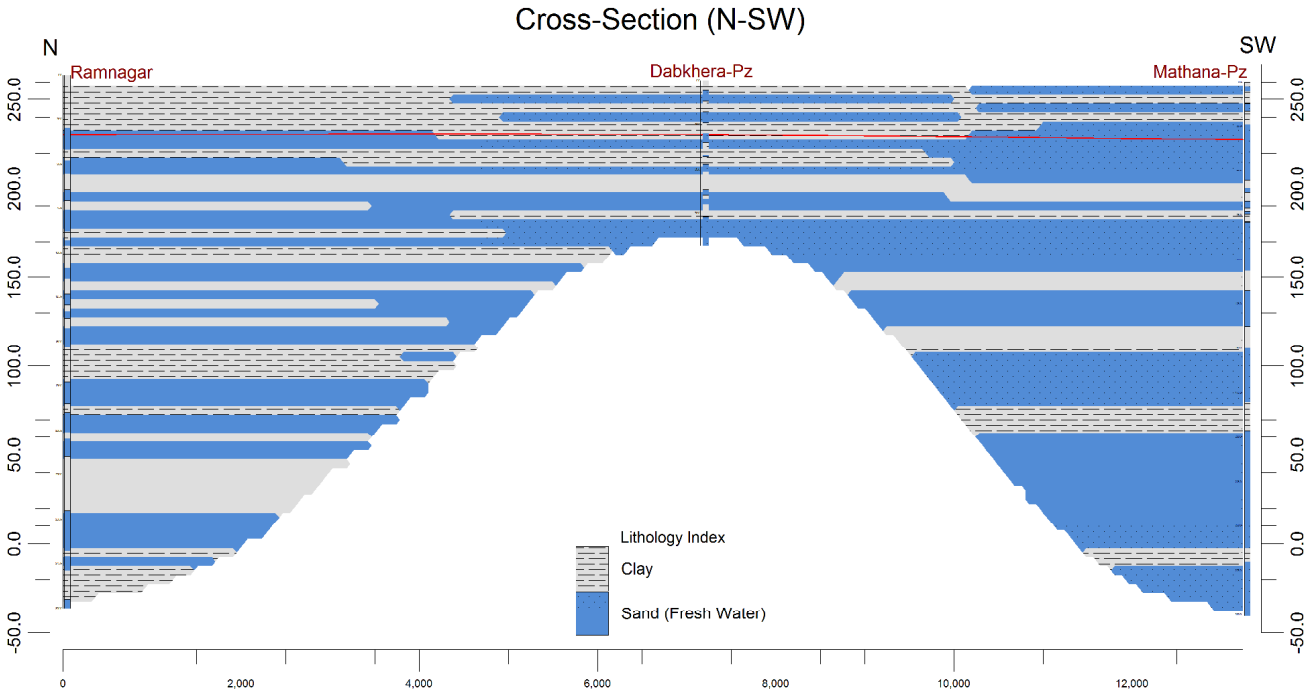
3D Lithology model



3D Lithology Fence




Cross-Section (NW-SE)
NW
SE
Ramnagar
Ladwa-Pz
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
Lithology Index
Clay
Sand (Fresh Water)


Cross-Section (N-SW)
N
SW
Ramnagar
Dabkhera-Pz
Mathana-Pz
250.0
200.0
150.0
100.0
50.0
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-50.0
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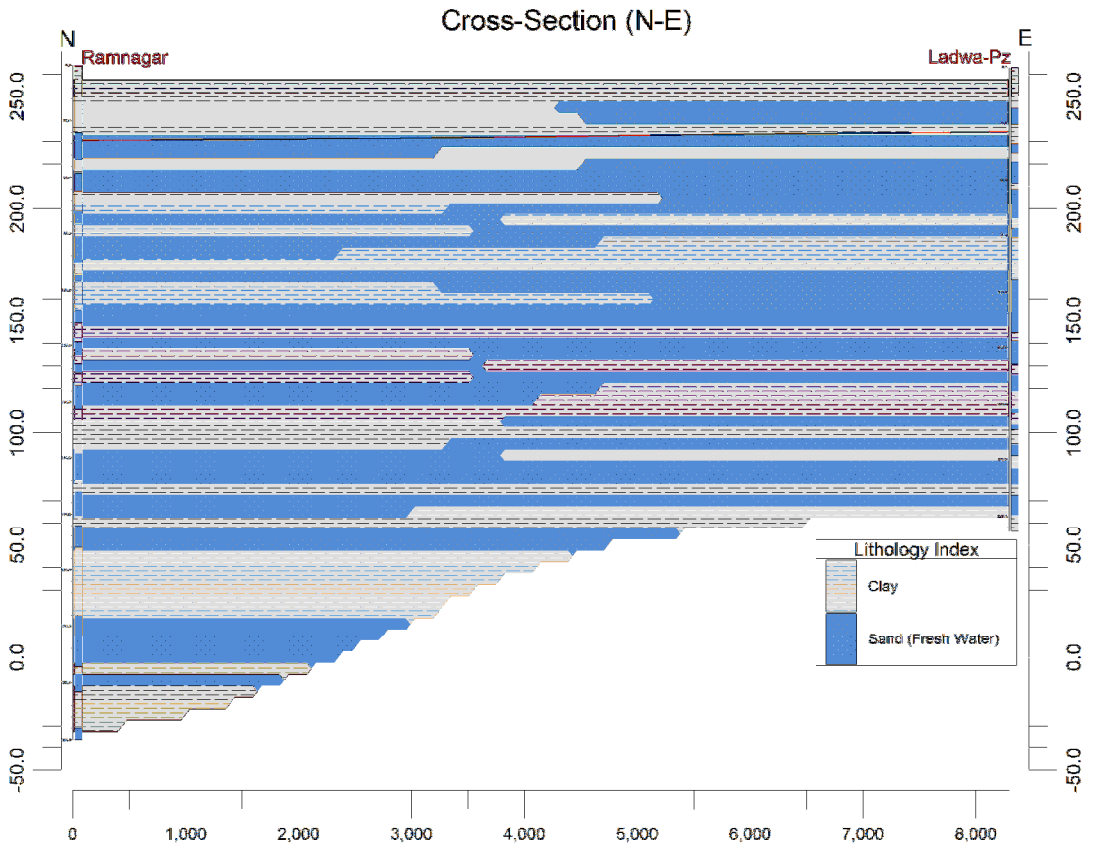
2,000
4,000
6,000
8,000
10,000
12,000
Lithology Index
Clay
Sand (Fresh Water)


Cross-Section (N-E)
N
E
Ramnagar
Ladwa-Pz
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
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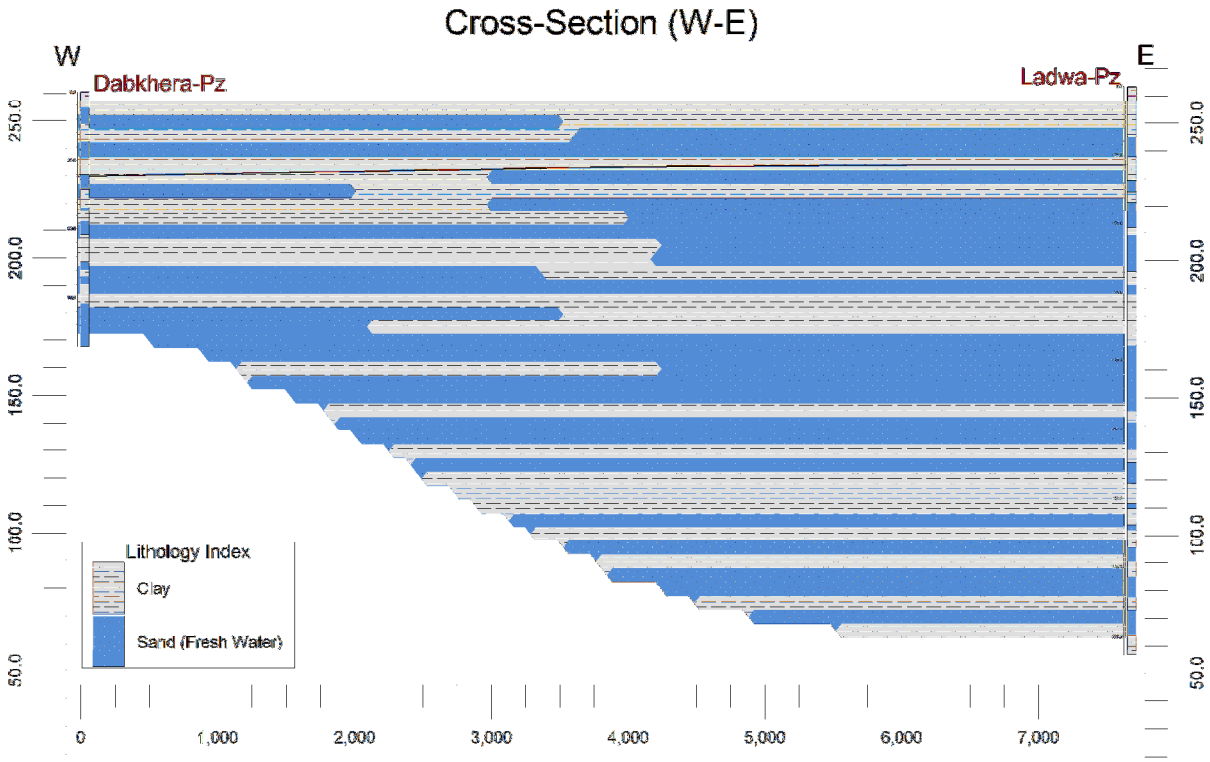
8,000
Lithology Index
Clay
Sand (Fresh Water)


Cross-Section (W-E)
W
E
Dabkhera-Pz
Ladwa-Pz
250.0
200.0
150.0
100.0
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3,000
4,000
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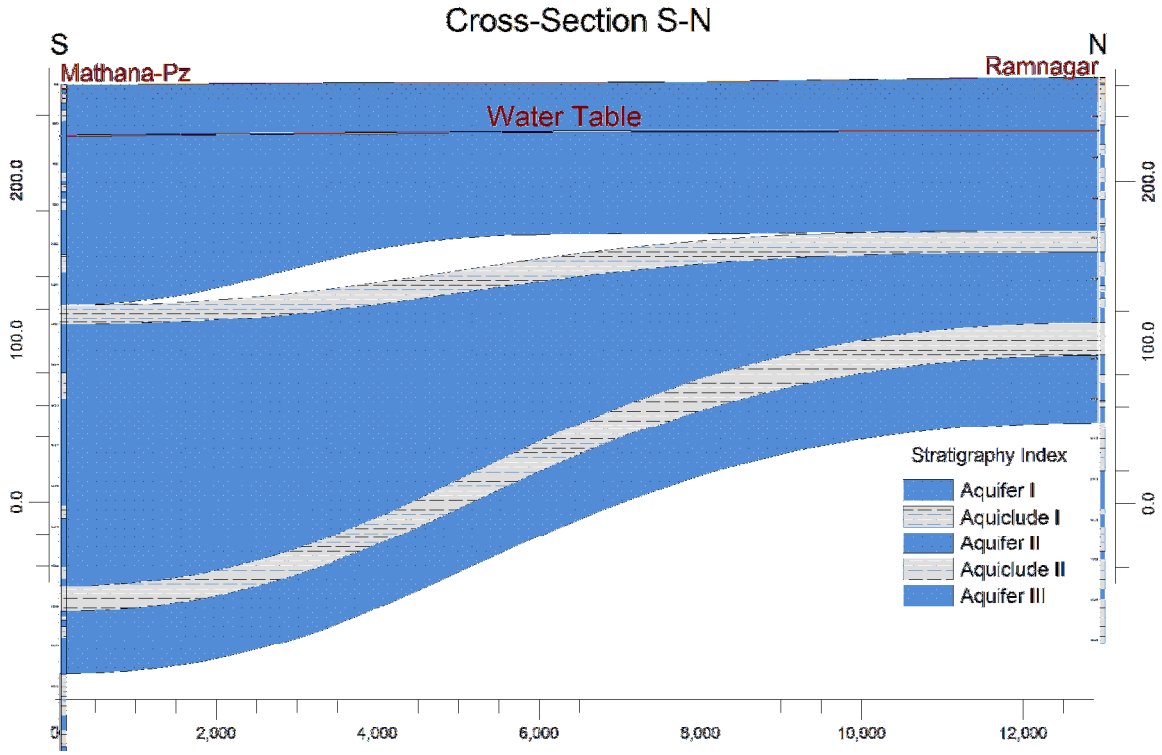
6,000
7,000
Lithology Index
Clay
Sand (Fresh Water)


Cross-Section S-N
S
N
Mathana-Pz
Ramnagar
Water Table
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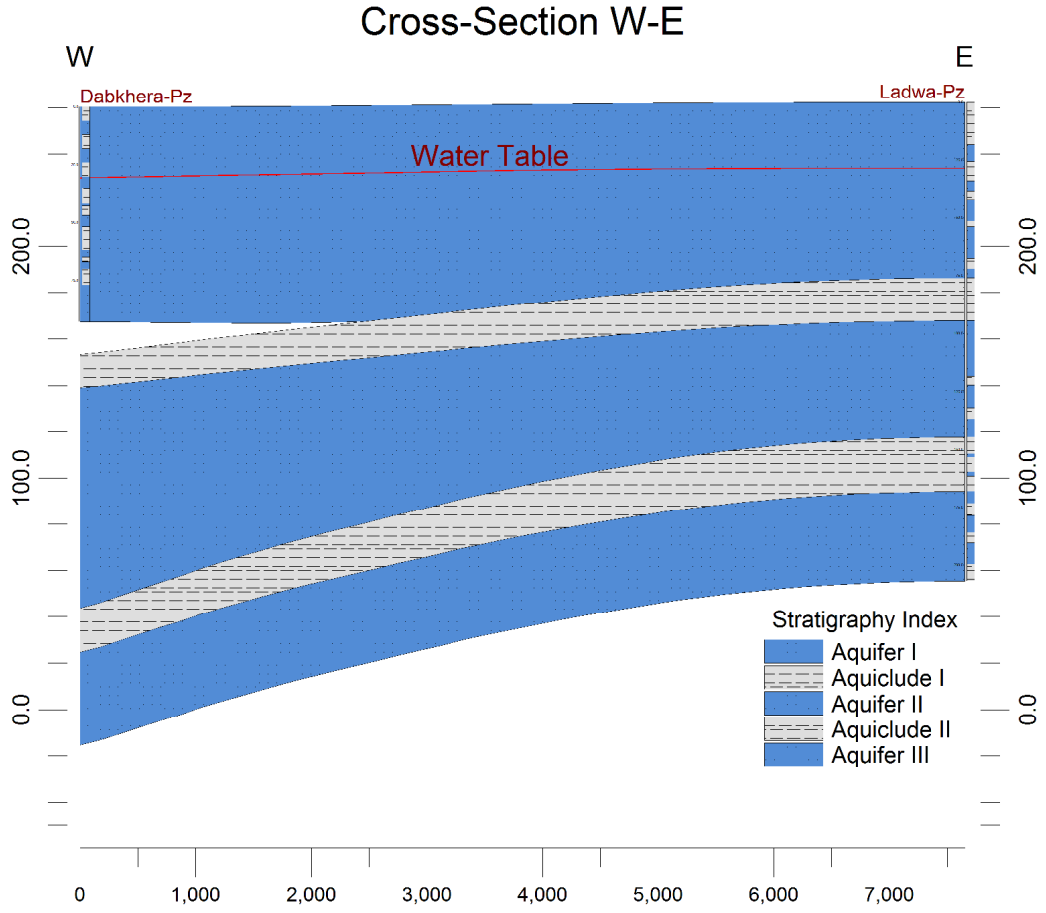
100.0
0.0
Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III
2,000
4,000
6,000
8,000
10,000
12,000


Cross-Section W-E
W
E
Dabkhera-Pz
Ladwa-Pz
Water Table
200.0
100.0
0.0
Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm)	Dynamic Aquifer I (2013)	30.96
	In-storage Aquifer I (2013)	736.19
	Dynamic Aquifer II	143.11
	In-storage Aquifer II	327.20
	Dynamic Aquifer III	-
	In-storage Aquifer III	303.83
	Total	1541.29
Ground Water Extraction (in mcm)	Irrigation (2013)	168.49
	Domestic & Industrial (2013)	14.41
Future Demand for domestic & Industrial sector (2025) (in mcm)		14.41
Chemical Quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level (>5m) & declining water level trend (62-62.3cm/yr)

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (33m) is 214.24 mcm.
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting & Farm pit Recharge will save 2.29mcm volume of water

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 6.71mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean in whole area of the block. Anticipated volume of water to be saved by maize is 122.11mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

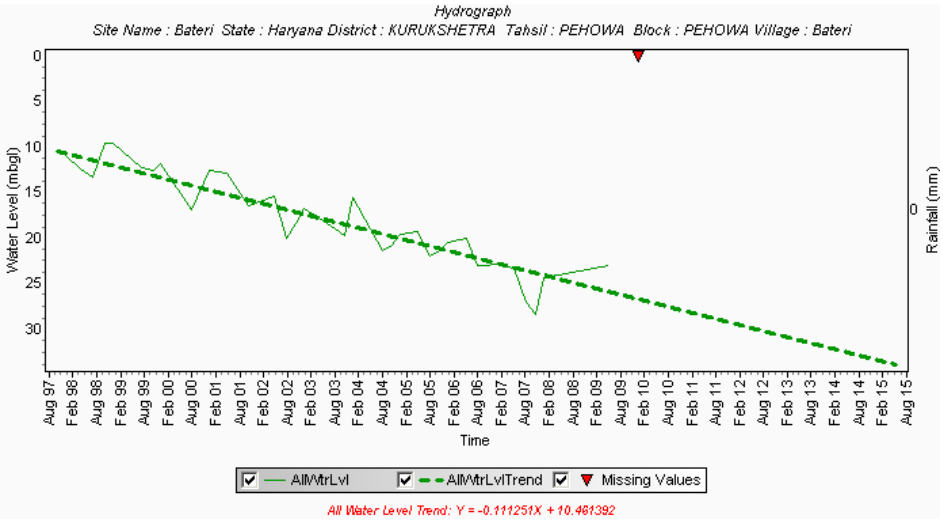
iii. PEHOWA BLOCK (507 SQ KM)

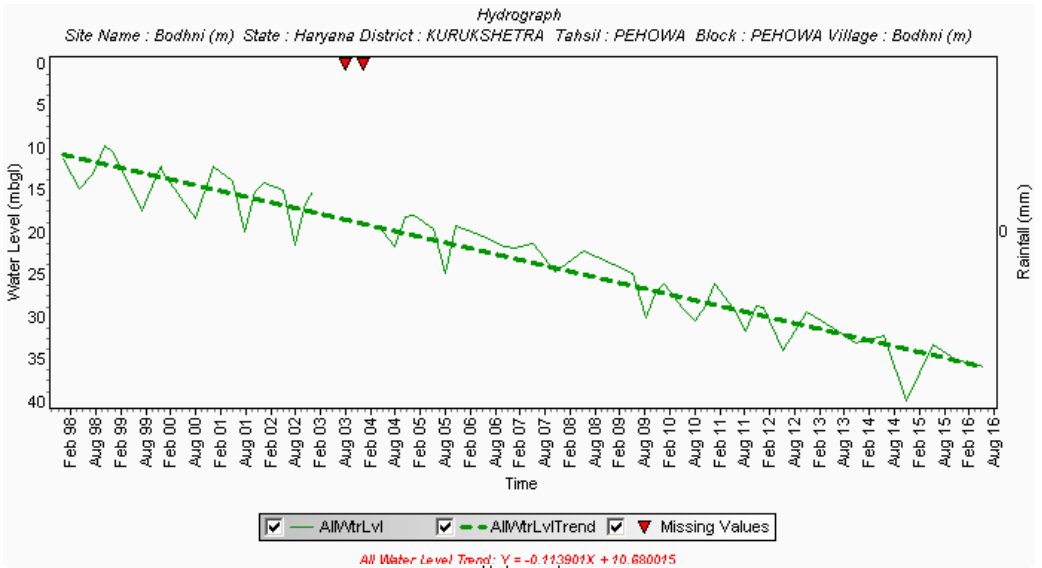
Population (2011)	Rural-159668 Urban-0 Total-159668
Rainfall 2014 (Kurukshetra Dist.)	Monsoon -320.5mm Non Monsoon-241.2mm
Average Annual Rainfall (Pehowa block)	580mm
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops-Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-161.93sqkm Total Irrigated Area-161.93sqkm
Water Bodies & Canal Irrigation	104 nos

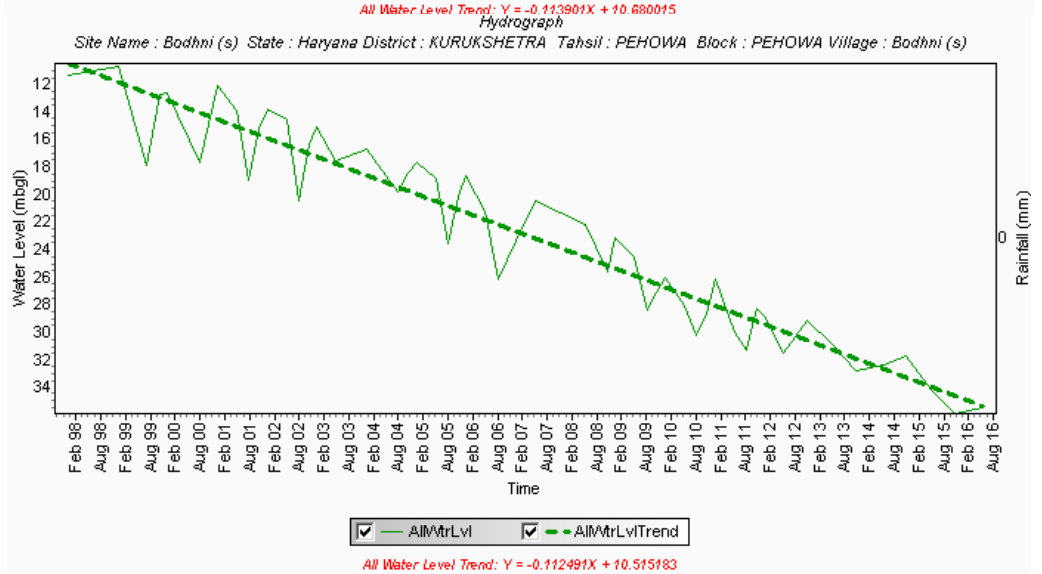
Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Only two aquifers have been identified up to 300m depth of which Aquifer I (122m) is very prominent in terms of thickness and geographic extent. Aquifer II (82m) is less in thickness. Block is categorized as Over-Exploited as per 2013 assessment.

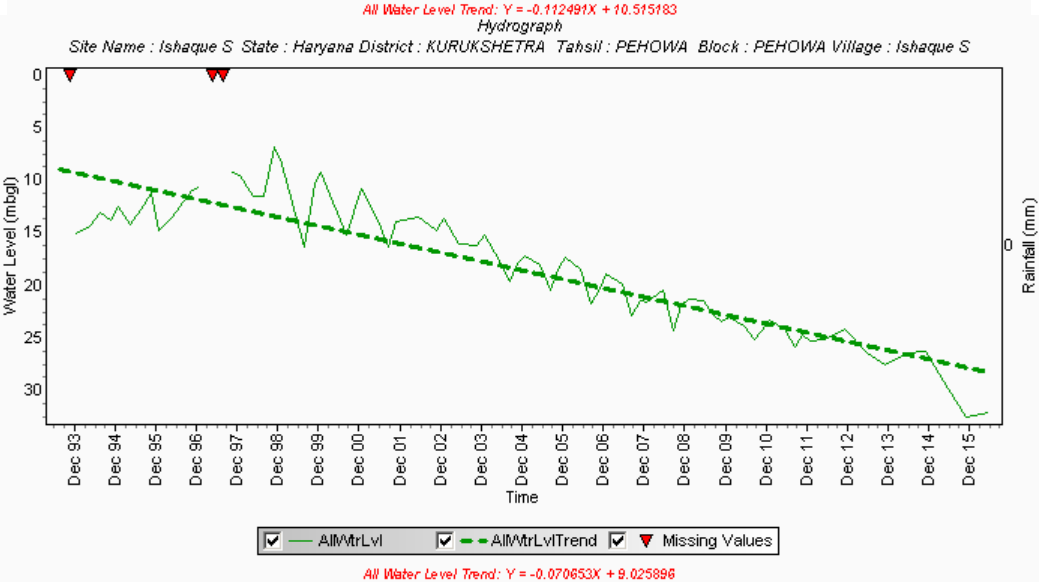
Ground water Extraction: Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply tapping combined aquifer and separate aquifer could not be assessed separately.

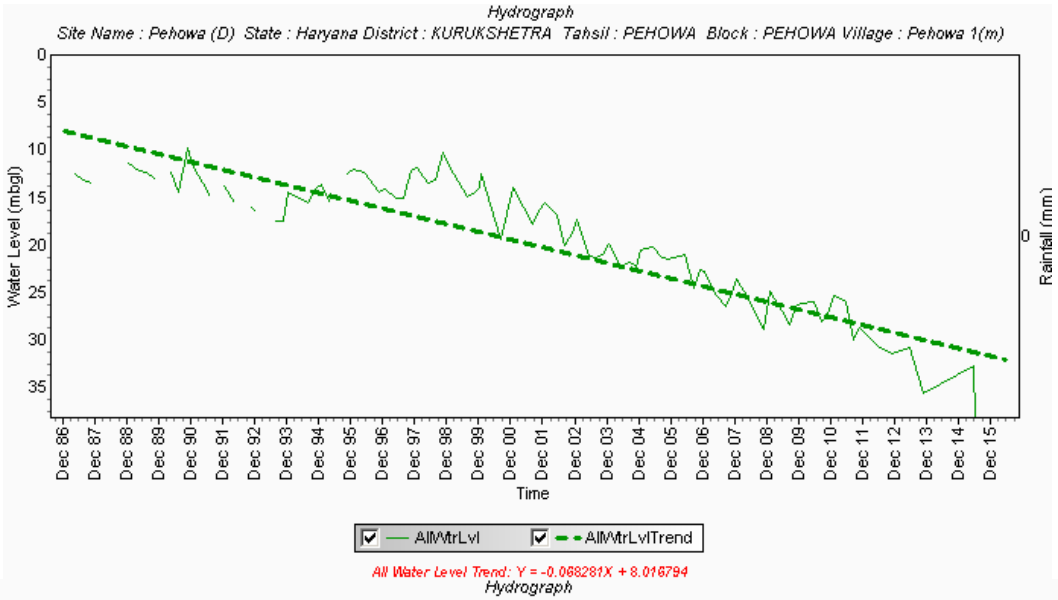
Water level Behavior(2015): Pre Monsoon-26.4-32.9mbgl & Post Monsoon-29.9-35.9mbgl

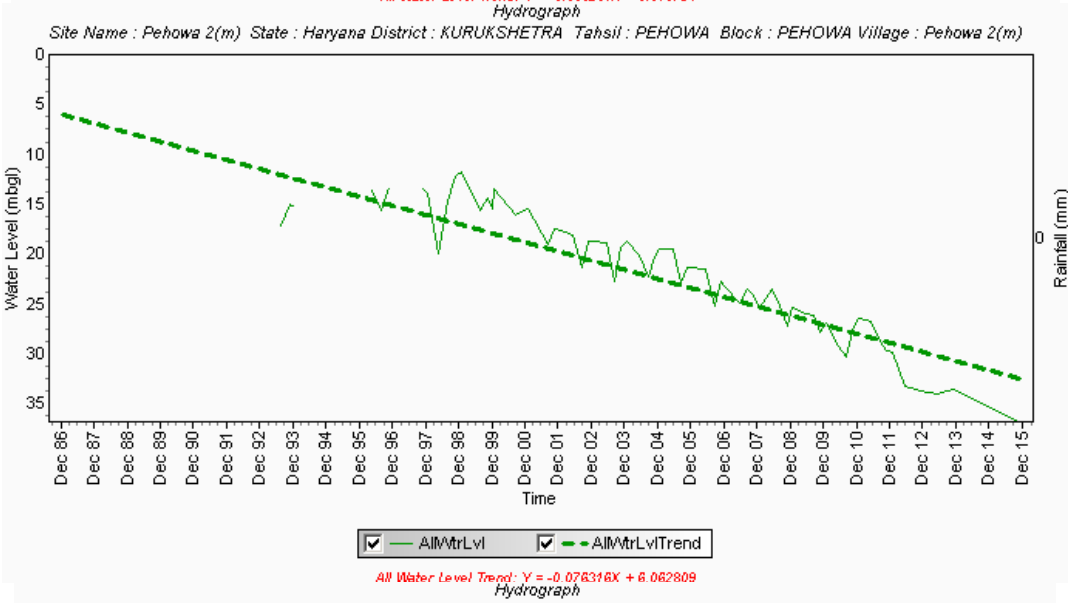


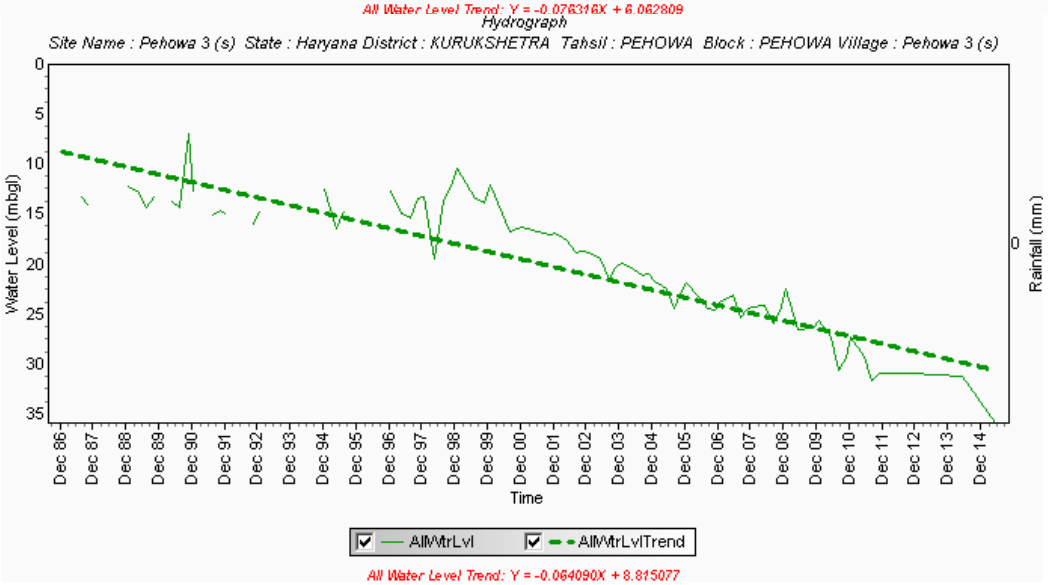

Hydrograph
Site Name : Bodhni (m) State : Haryana District : KURUKSHETRA Tahsil : PEHOWA Block : PEHOWA Village : Bodhni (m)
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
AllWtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.113901X + 10.680015

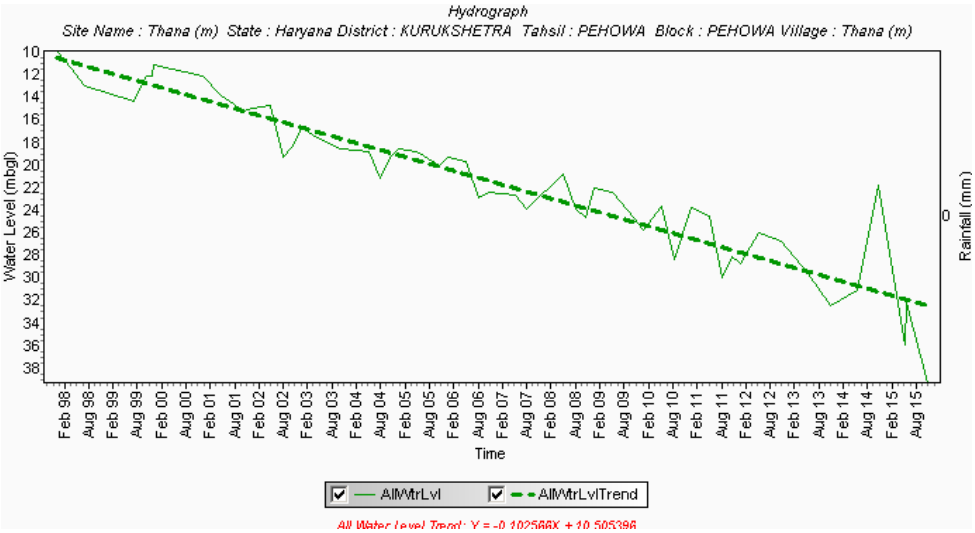

Hydrograph
Site Name : Bodhni (s) State : Haryana District : KURUKSHETRA Tahsil : PEHOWA Block : PEHOWA Village : Bodhni (s)
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
AllWtrLvlTrend
All Water Level Trend: Y = -0.112491X + 10.515183


Hydrograph
Site Name : Ishaque S State : Haryana District : KURUKSHETRA Tahsil : PEHOWA Block : PEHOWA Village : Ishaque S
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
AllWtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.070653X + 9.025896


Hydrograph
Site Name : Pehowa (D) State : Haryana District : KURUKSHETRA Tahsil : PEHOWA Block : PEHOWA Village : Pehowa 1(m)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
All Water Level Trend: Y = -0.068281X + 8.016794


Hydrograph
Site Name : Pehowa 2(m) State : Haryana District : KURUKSHETRA Tahsil : PEHOWA Block : PEHOWA Village : Pehowa 2(m)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
All Water Level Trend: Y = -0.07631GX + 6.062809


Hydrograph
Site Name : Pehowa 3 (s) State : Haryana District : KURUKSHETRA Tahsil : PEHOWA Block : PEHOWA Village : Pehowa 3 (s)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
All Water Level Trend: Y = -0.064090X + 8.815077



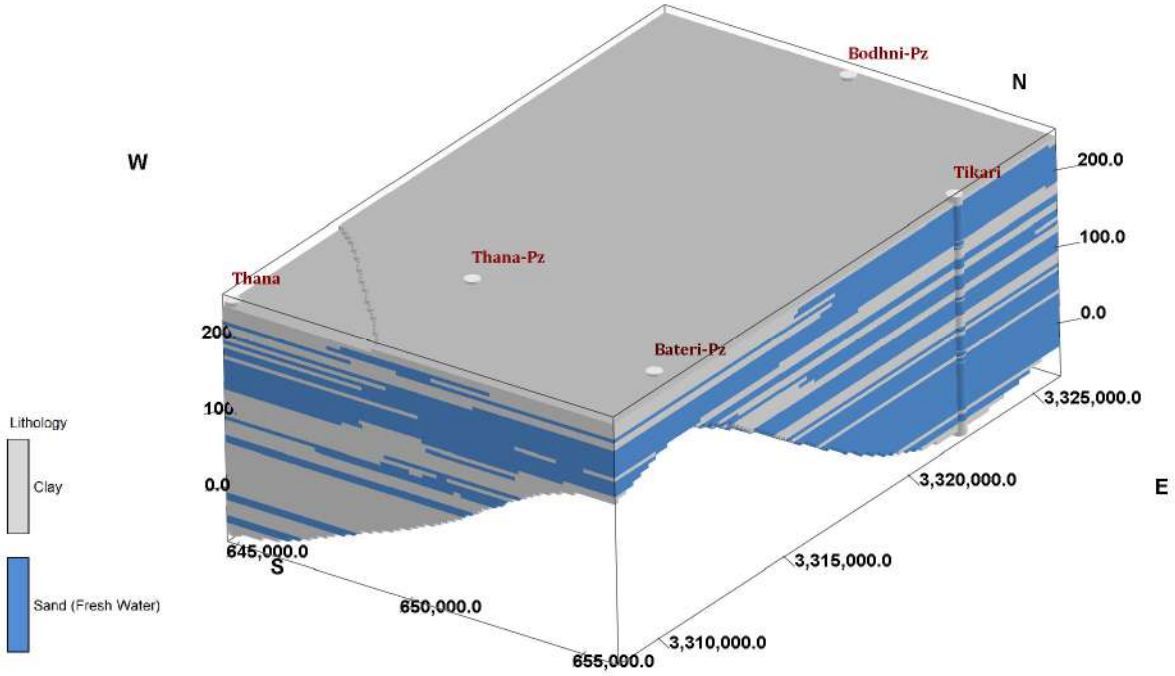
Aquifer Disposition: Multiple Aquifer System (2 Aquifer System)

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aq-I (28-150m)	Quaternary Alluvial deposits	Unconfined	67	2200	12	NA
Aq-II (178-260m)		Unconfined to Confined	52	-	NA	6.63×10^{-3}

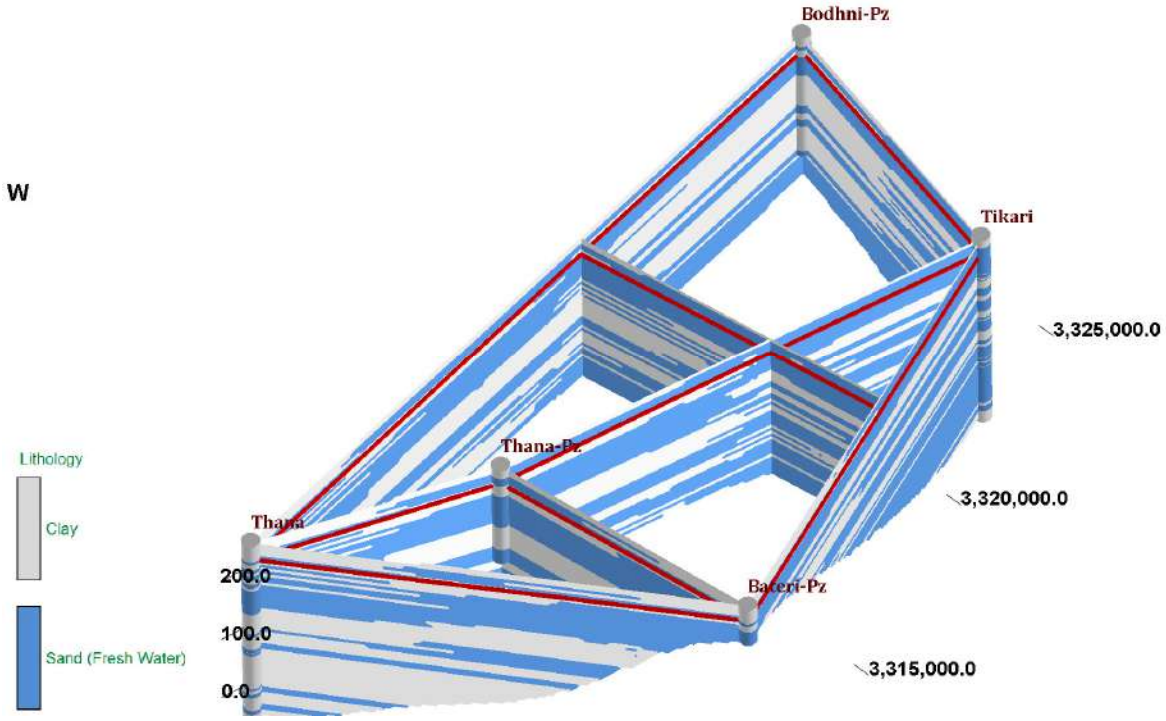
Aquifer comprises of freshwater only and the main aquifer formation is sand

The non-aquifer material comprise of clay.

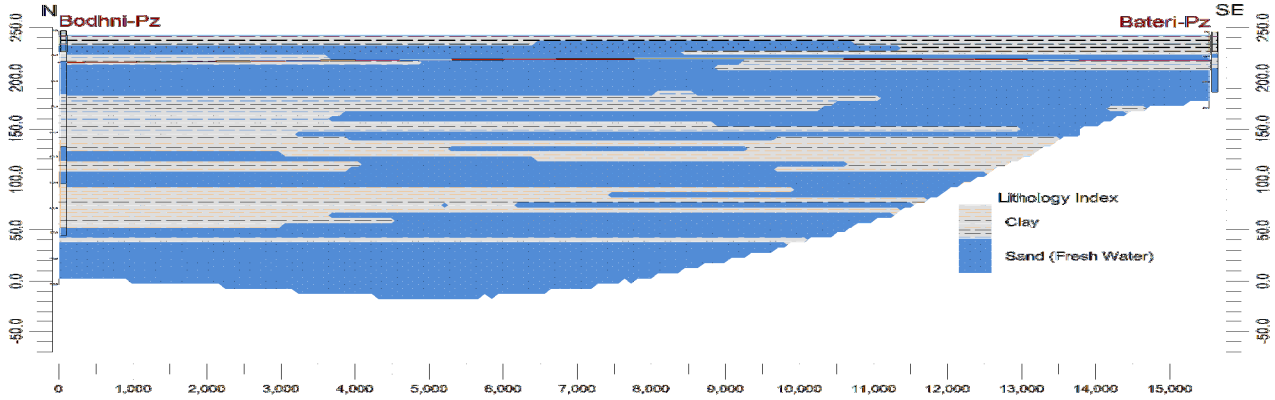
3D Lithology model



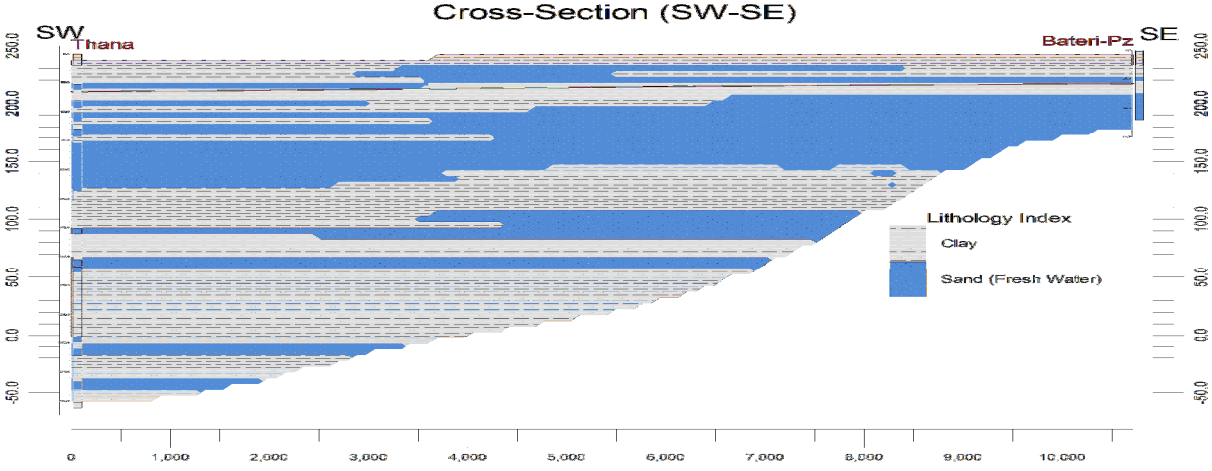
3D Lithology Fence

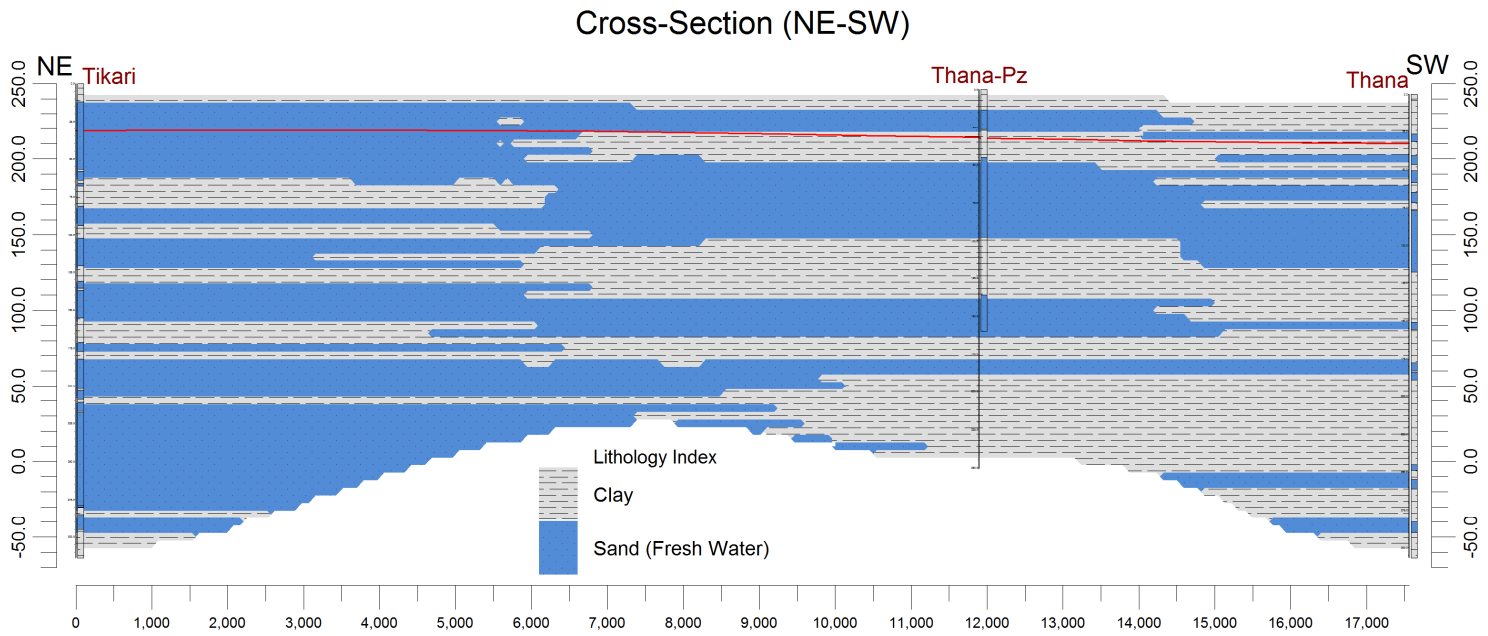


Cross-Section (N-SE)



Cross-Section (SW-SE)




Cross-Section (NE-SW)
NE
Tikari
Thana-Pz
Thana
SW
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
Lithology Index
Clay
Sand (Fresh Water)
0
1,000
2,000
3,000
4,000
5,000
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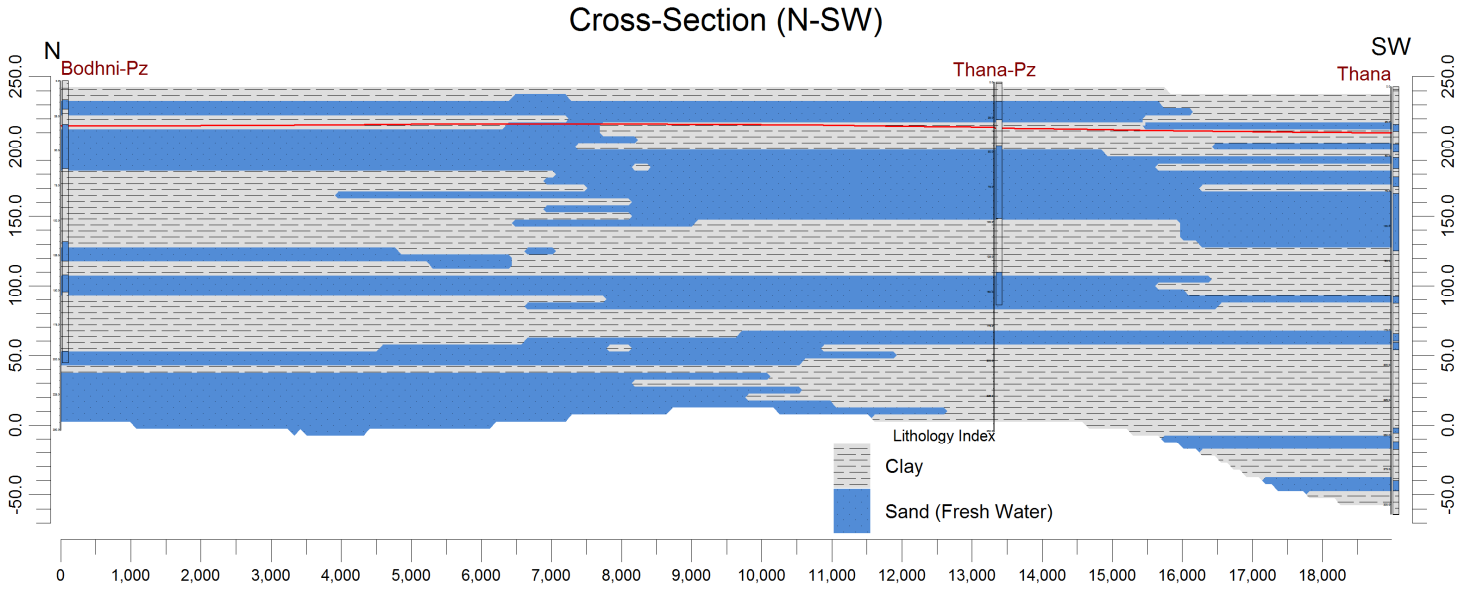
Cross-Section (N-SW)
N
Bodhni-Pz
Thana-Pz
Thana
SW
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
Lithology Index
Clay
Sand (Fresh Water)
0
1,000
2,000
3,000
4,000
5,000
6,000
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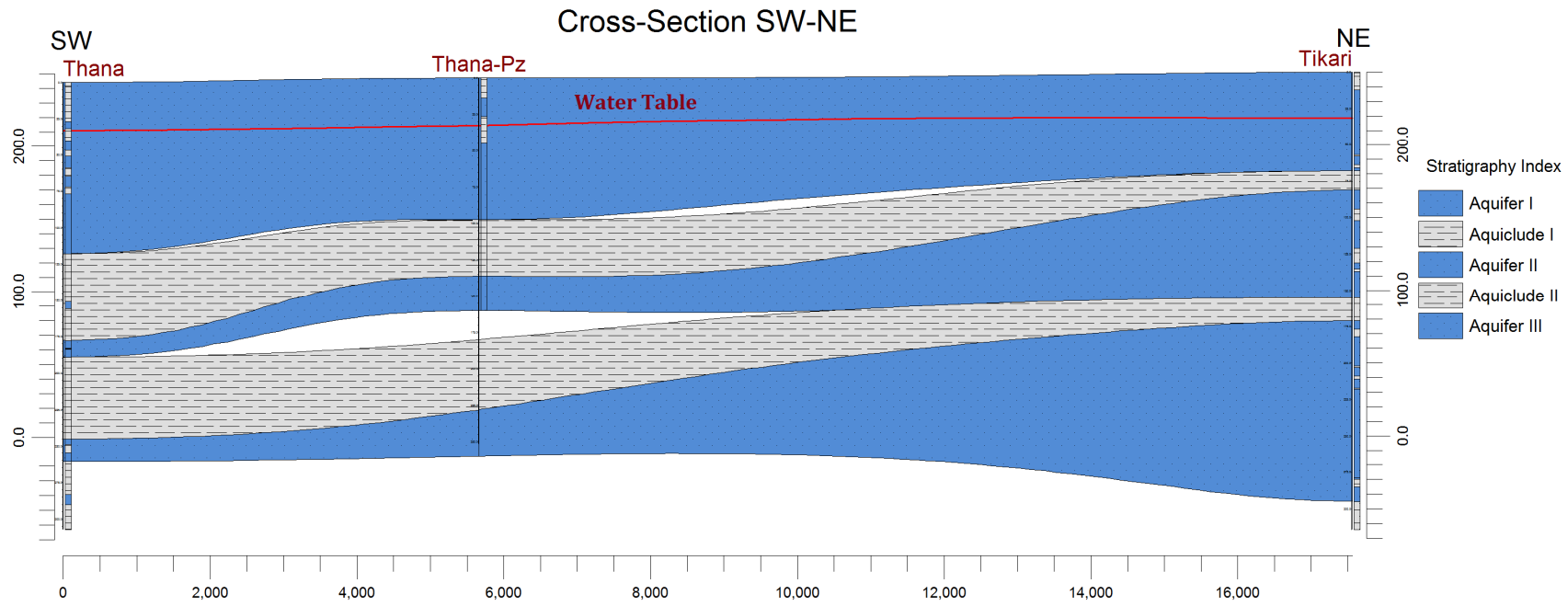
Cross-Section SW-NE
SW
NE
Thana
Thana-Pz
Tikari
Water Table
200.0
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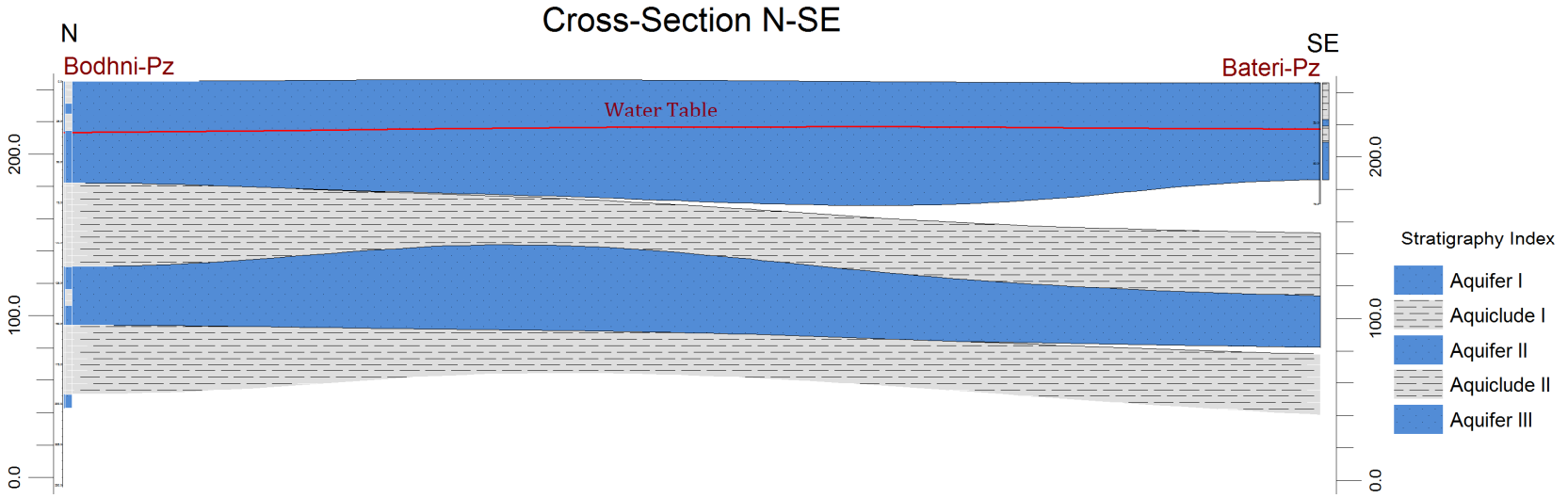
Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III


Cross-Section N-SE
N
SE
Bodhni-Pz
Bateri-Pz
Water Table
200.0
100.0
0.0
Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm)	Dynamic Aquifer I (2013)	96.64
	In-storage Aquifer I (2013)	2336.26
	Dynamic Aquifer II	473.96
	In-storage Aquifer II	1912.81
	Total	4819.67
Ground Water Extraction (in mcm)	Irrigation (2013)	355.99
	Domestic & Industrial (2013)	19.02
Future Demand for domestic & Industrial sector (2025) (in mcm)		20.02
Chemical Quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level (>5m) & declining water level trend (93.8-105.3cm/yr)

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (31m) is 912.6 mcm.
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting & Farm pit Recharge will save 3.69mcm volume of water

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 14.18mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean in 61% of the total area. Anticipated volume of water to be saved by maize is 214.81mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

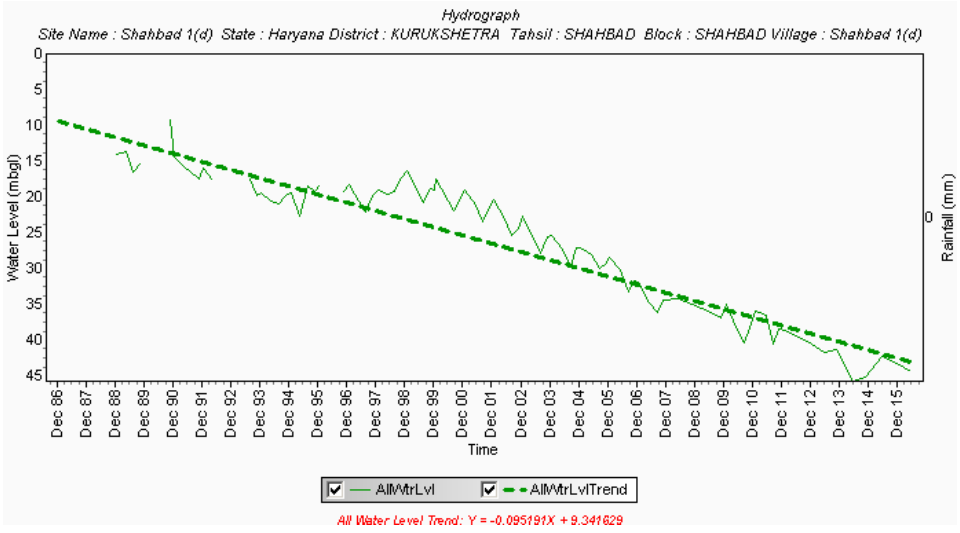
iv. SHAHBAD BLOCK (377.12 SQ KM)

Population (2011)	Rural-154040 Urban-13726 Total-167766
Rainfall 2014 (Kurukshetra Dist.)	Monsoon -320.5mm Non Monsoon-241.2mm
Average Annual Rainfall (Shahbad block)	580mm
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops-Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-308.56sqkm Total Irrigated Area-308.53sqkm
Water Bodies & Canal Irrigation	173 nos

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (91m) is prominent in terms of thickness and geographic extent. Aquifer II (32.5m) & III (41m) are less in thickness. Block is categorized as Over-Exploited as per 2013 assessment.

Ground water Extraction: Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply tapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior(2015): Pre Monsoon-~46.01m bgl & Post Monsoon-~41.58 mbgl



A well field consisting of 1 Exploratory Well and 3 Observation well (I, II & III) tapping depth within 0-100m, 100-200m and 200-300m respectively has been constructed at site Khanpur Jattan. The water level monitoring for the same has been done and given below:

Observation Well	SWL on 13.05.16 (mbgl)	SWL on 23.06.16 (mbgl)	Fluctuation (m)
I	41.55	44.64	3.09m fall
II	42.78	48.45	5.67 m fall
III	39.88	41.10	1.22 m fall

The water level fluctuation indicates that the tubewells in the area are tapping within the depth of 100-200m mainly causing decline in water level.

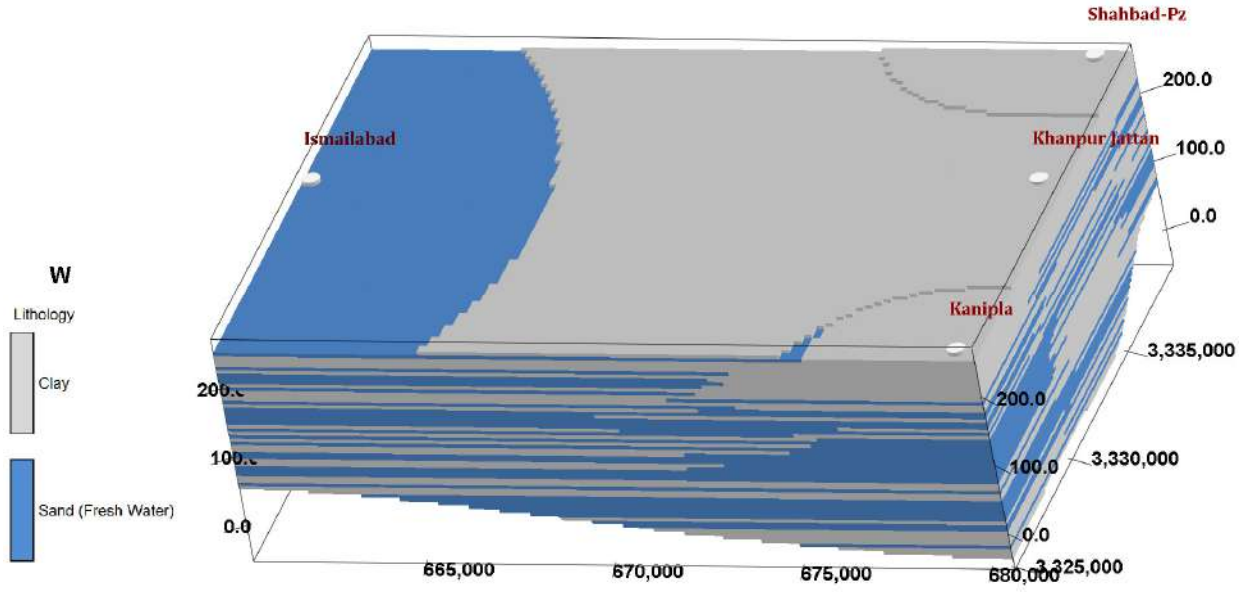
Aquifer Disposition: Multiple Aquifer System (3 Aquifer System)

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aq-I (33-124m)	Quaternary Alluvial deposits	Unconfined	42	2200	12	NA
Aq-II (142-175m)		Unconfined to Confined	22	1400	NA	$4.4x10^{-5}$
Aq-III (217-258m)		Unconfined to Confined	37	1700	NA	$1.5x10^{-4}$

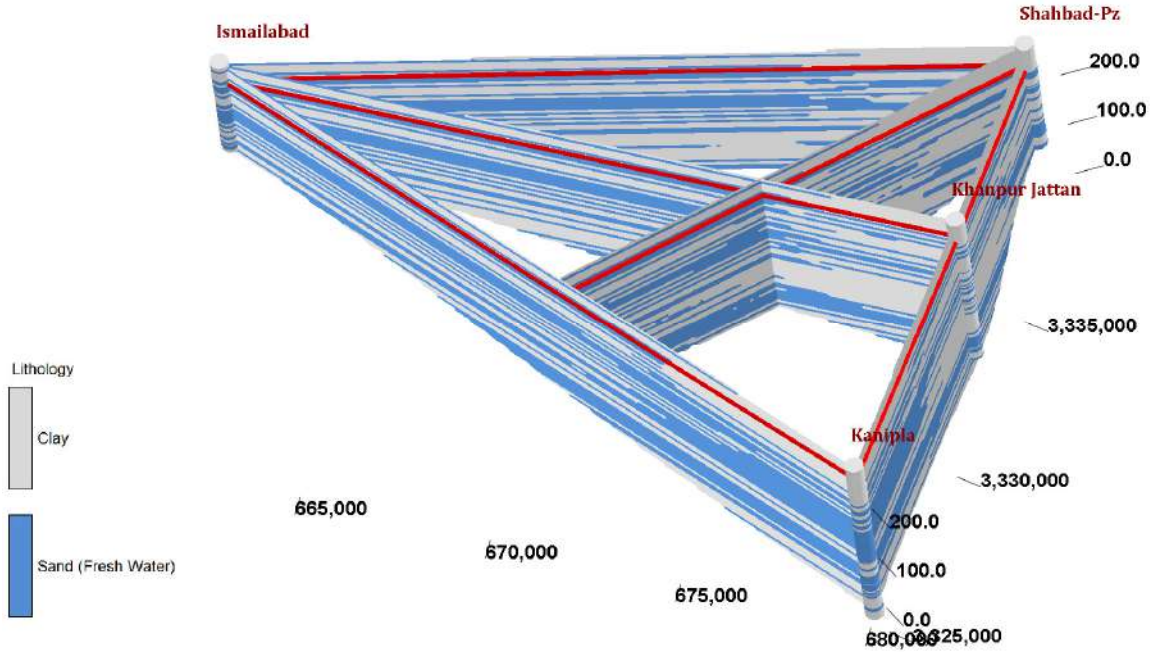
Aquifer comprises of freshwater only and the main aquifer formation is sand

The non-aquifer material comprise of clay.

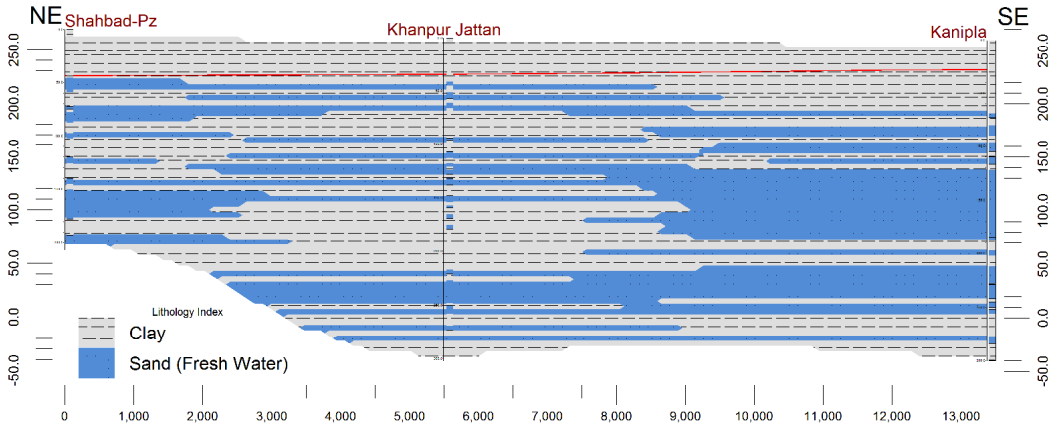
3D Lithology model



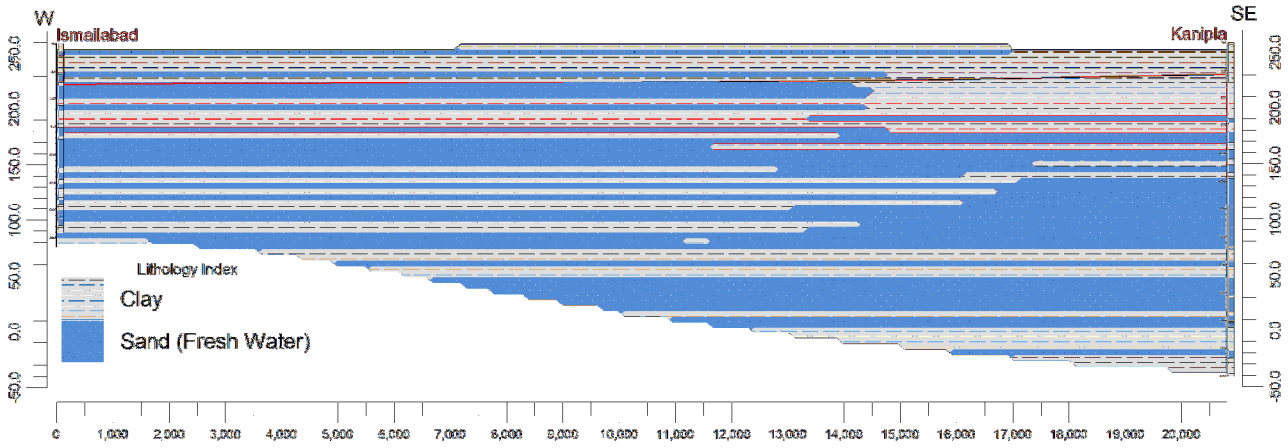
3D Lithology Fence



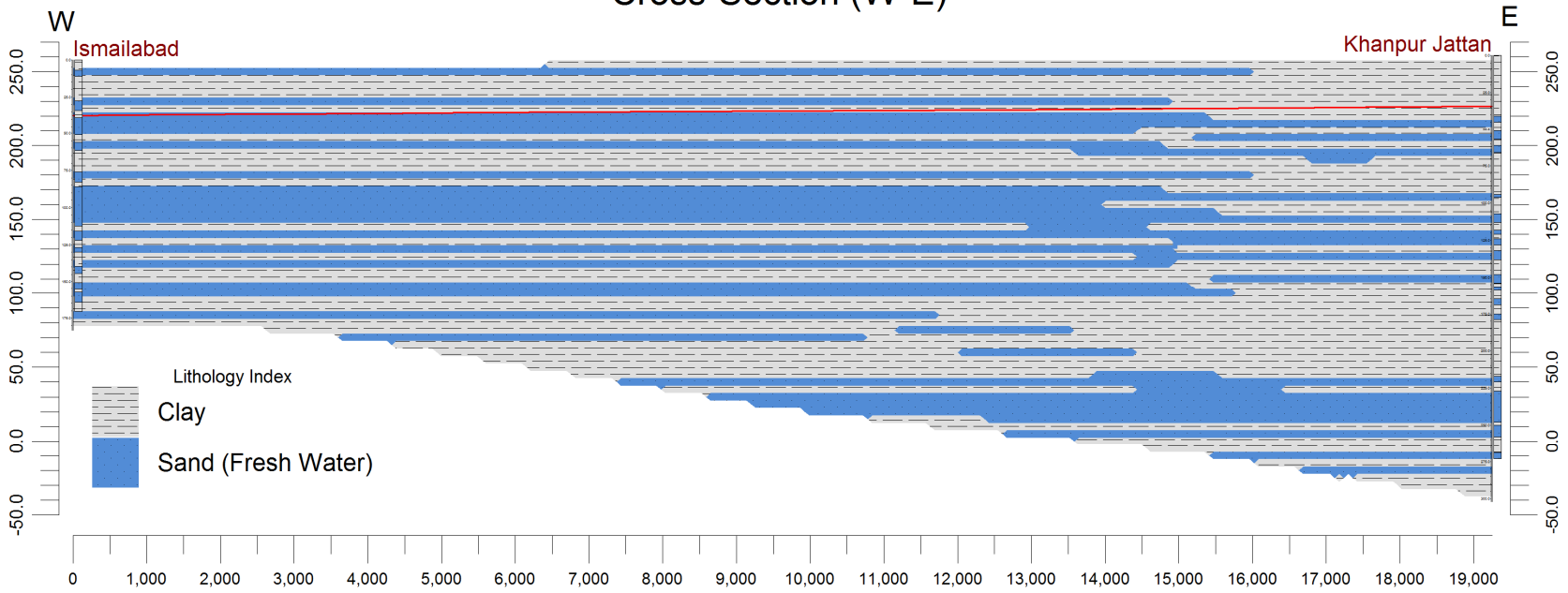
Cross-Section (NE-SE)



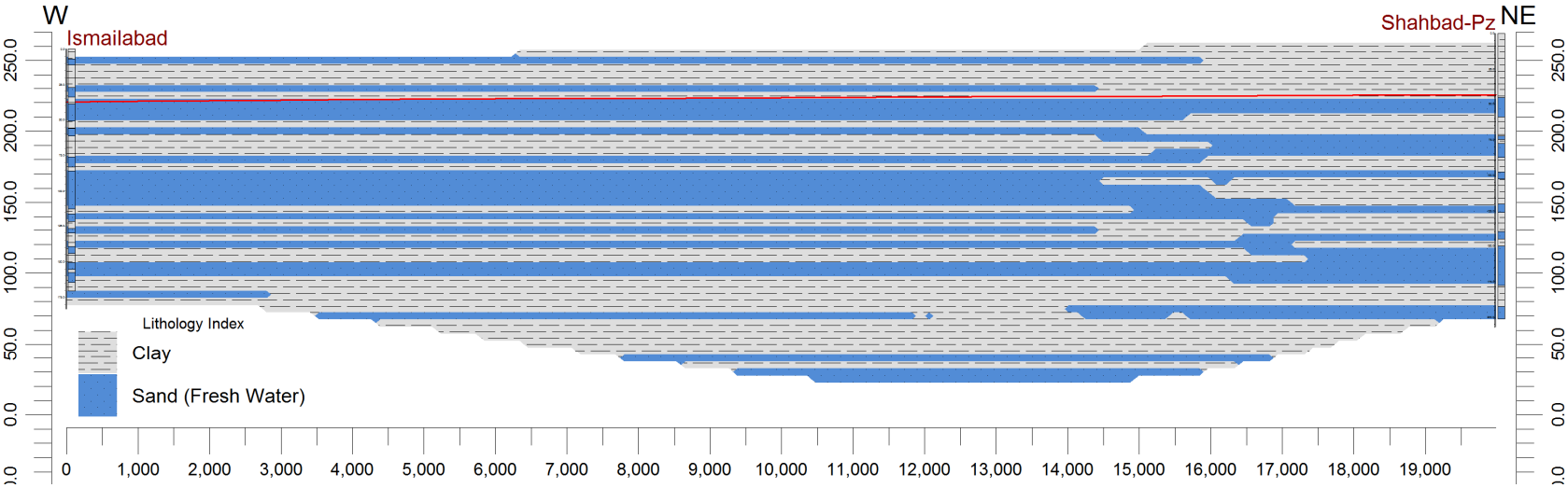
Cross-Section (W-SE)

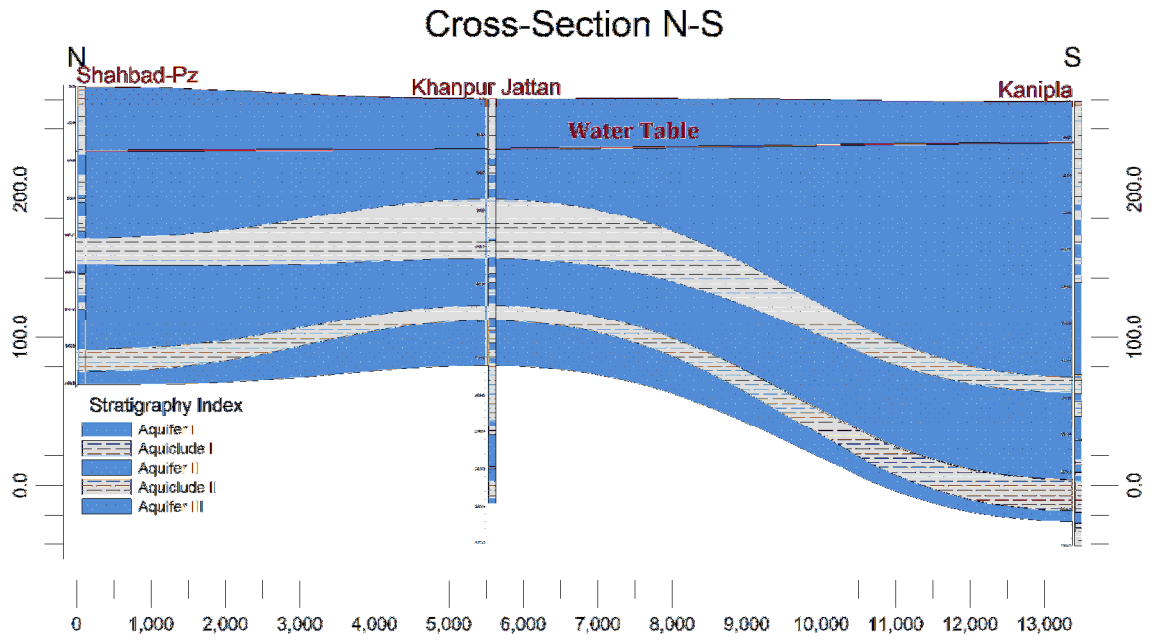


Cross-Section (W-E)



Cross-Section (W-NE)




Cross-Section N-S
N
S
Shahbad-Pz
Khanpur Jattan
Kanipla
Water Table
200.0
100.0
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Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III
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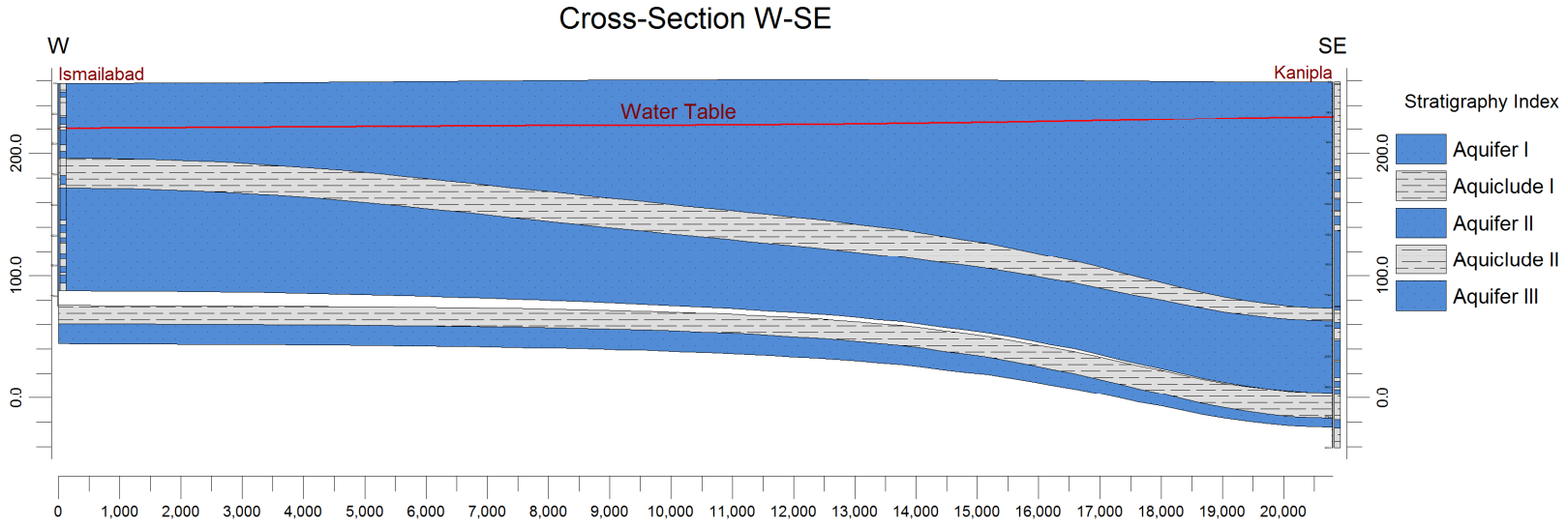
Cross-Section W-SE
W
SE
Ismailabad
Kanipla
Water Table
200.0
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Stratigraphy Index
Aquifer I
Aquiclude I
Aquifer II
Aquiclude II
Aquifer III
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20,000

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm)	Dynamic Aquifer I (2013)	73.86
	In-storage Aquifer I (2013)	1140.41
	Dynamic Aquifer II	263.78
	In-storage Aquifer II	597.36
	Dynamic Aquifer III	-
	In-storage Aquifer III	1004.65
	Total	3080.06
Ground Water Extraction (in mcm)	Irrigation (2013)	176.31
	Domestic & Industrial (2013)	14.90
Future Demand for domestic & Industrial sector (2025) (in mcm)		24.90
Chemical Quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level (>5m) & declining water level trend (123.9-135.2cm/yr)

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone up to the average depth to water level (33m) is 226.27mcm.
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting & Farm pit Recharge will save 3.55mcm volume of water

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 13.65mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean in 63% of the total area. Anticipated volume of water to be saved by maize is 119.88mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	Block Notified by CGWA
Other interventions proposed, if any	-

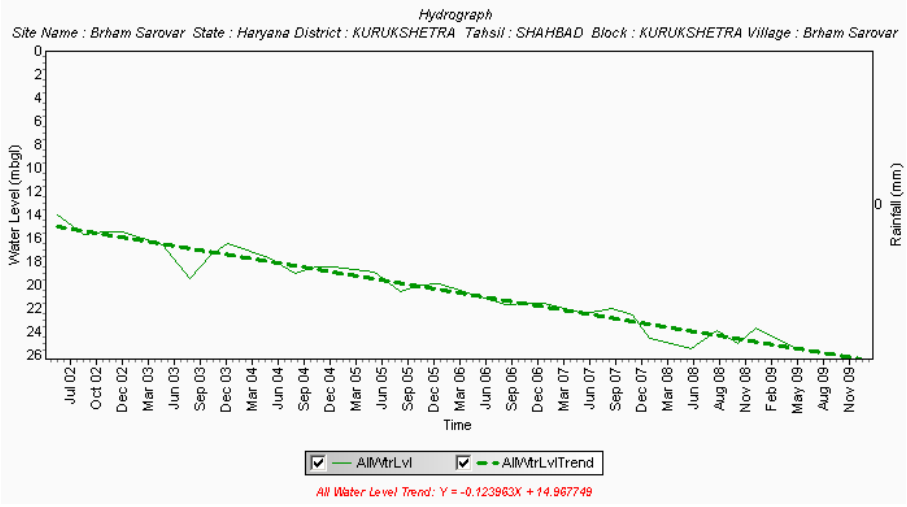
V. THANESWAR BLOCK (468.27 SQ KM)

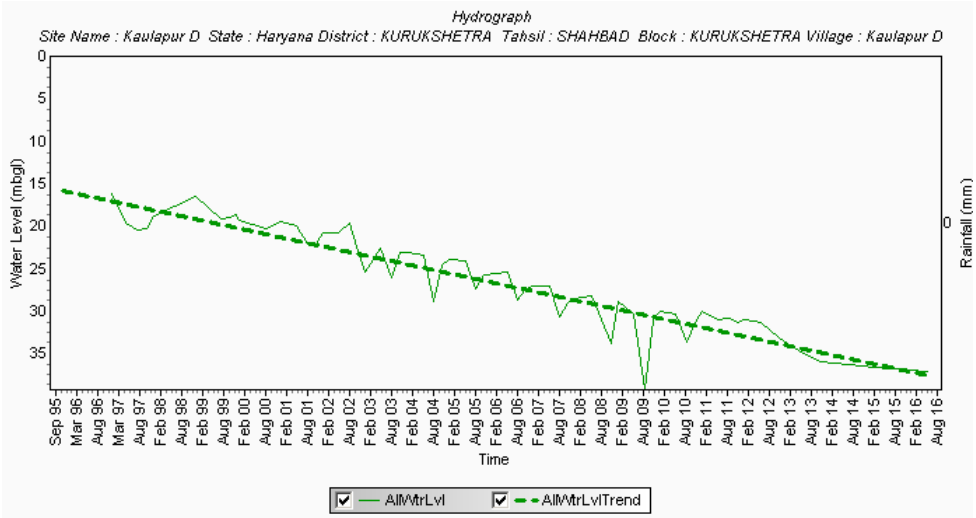
Population (2011)	Rural-221448 Urban-0 Total-221448
Rainfall 2014 (Kurukshetra Dist.)	Monsoon -320.5mm Non Monsoon-241.2mm
Average Annual Rainfall (Thanesar block)	580mm
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops-Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-404.24sqkm Total Irrigated Area-404.01sqkm
Water Bodies & Canal Irrigation	165 nos

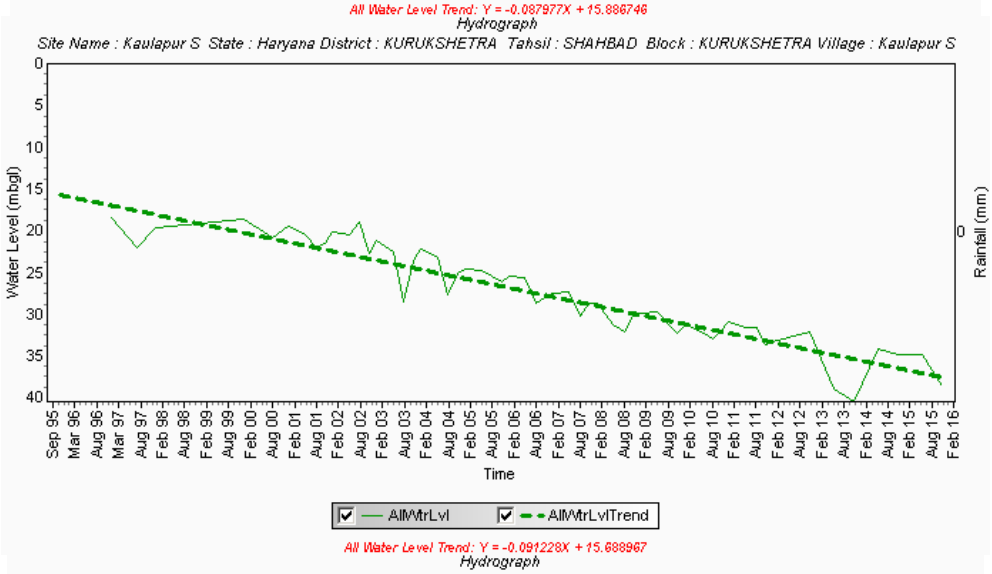
Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Only two aquifers have been identified up to 300m depth of which Aquifer I is having a thickness of 132m and Aquifer II is of 104m. Block is categorized as Over-Exploited as per 2013 assessment.

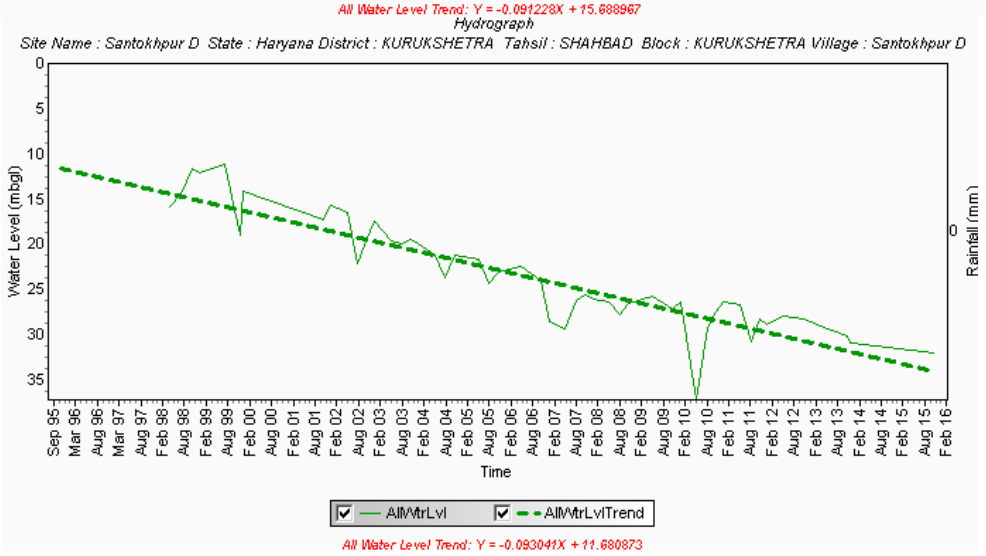
Ground water Extraction: Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply tapping combined aquifer and separate aquifer could not be assessed separately.

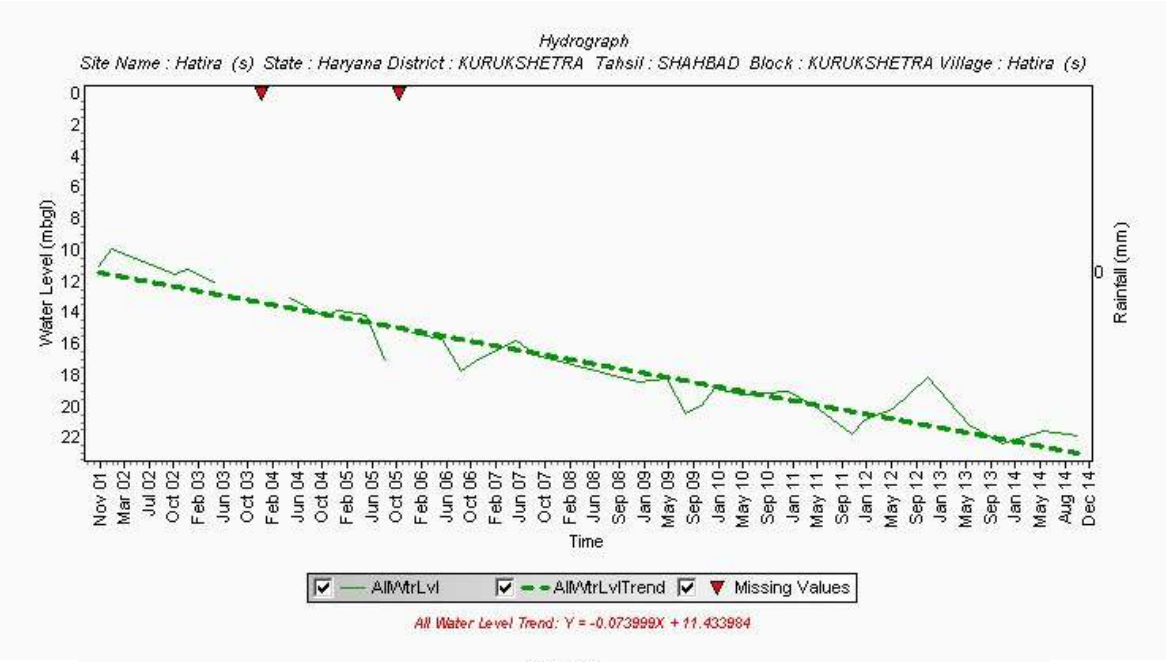
Water level Behavior(2015):Pre Monsoon-28.4m to34.76m bgl & Post Monsoon-~34mbgl

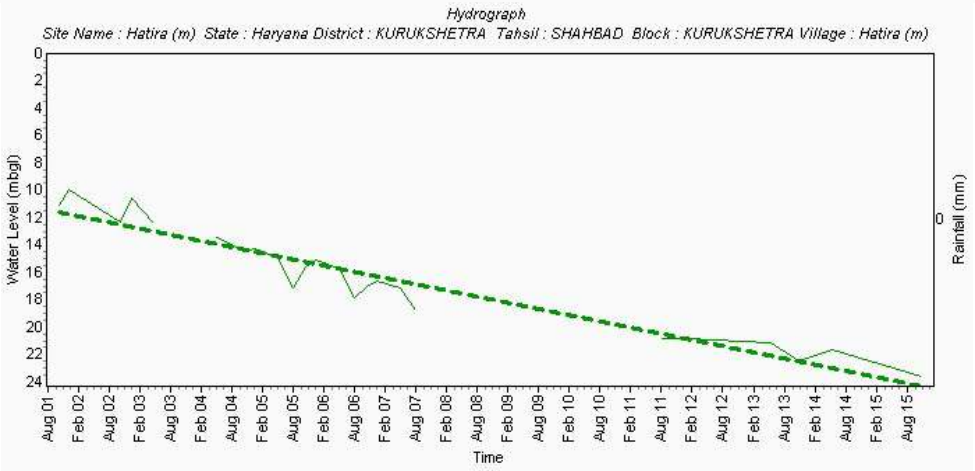


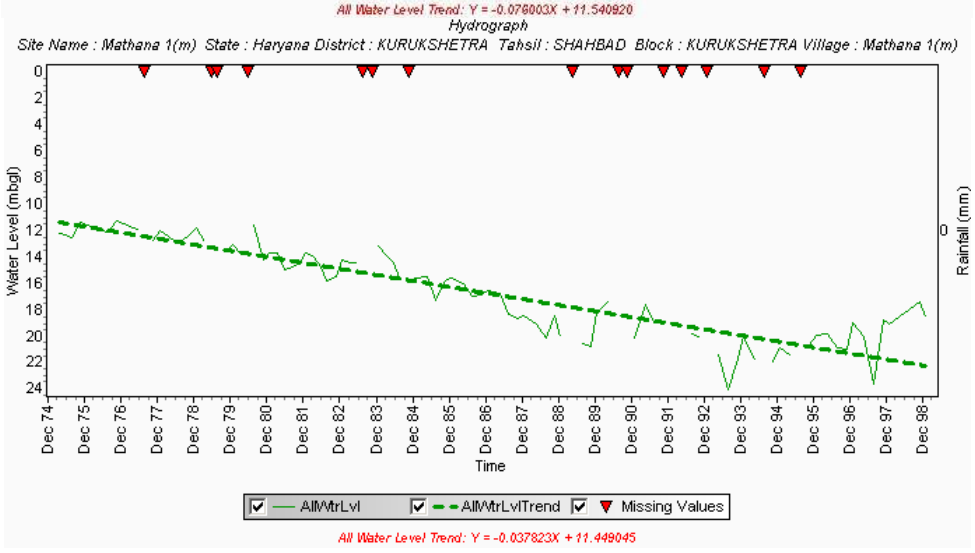

Hydrograph
Site Name : Kaulapur D State : Haryana District : KURUKSHETRA Tahsil : SHAHBAD Block : KURUKSHETRA Village : Kaulapur D
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
All Water Level Trend: Y = -0.087977X + 15.886746

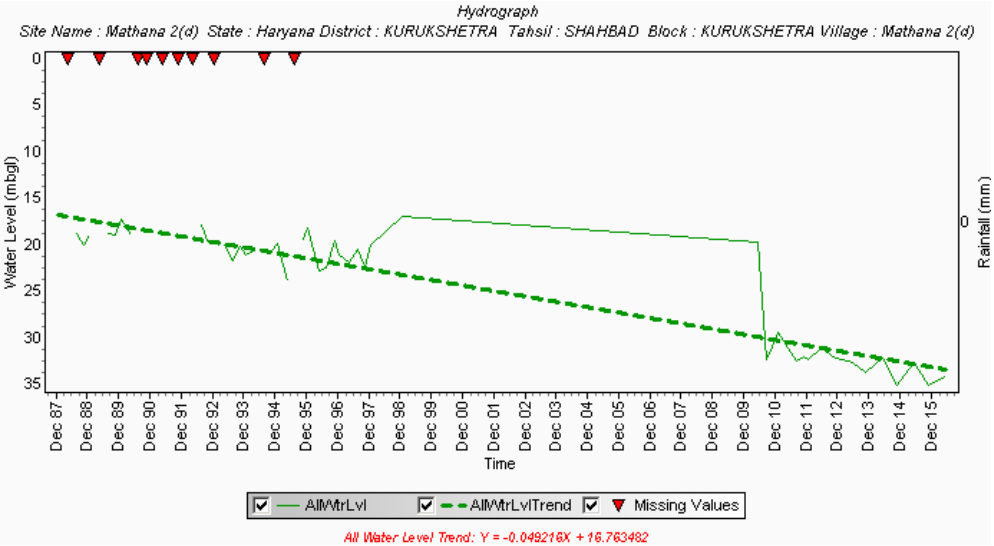

Hydrograph
Site Name : Kaulapur S State : Haryana District : KURUKSHETRA Tahsil : SHAHBAD Block : KURUKSHETRA Village : Kaulapur S
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
All Water Level Trend: Y = -0.091228X + 15.688967


Hydrograph
Site Name : Santokhpur D State : Haryana District : KURUKSHETRA Tahsil : SHAHBAD Block : KURUKSHETRA Village : Santokhpur D
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
All Water Level Trend: Y = -0.093041X + 11.680873


Hydrograph
Site Name : Hatira (s) State : Haryana District : KURUKSHETRA Tahsil : SHAHBAD Block : KURUKSHETRA Village : Hatira (s)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.073999X + 11.433984


Hydrograph
Site Name : Hatira (m) State : Haryana District : KURUKSHETRA Tahsil : SHAHBAD Block : KURUKSHETRA Village : Hatira (m)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.076003X + 11.540920


Hydrograph
Site Name : Mathana 1(m) State : Haryana District : KURUKSHETRA Tahsil : SHAHBAD Block : KURUKSHETRA Village : Mathana 1(m)
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
AllMtrLvlTrend
Missing Values
All Water Level Trend: Y = -0.037823X + 11.449045



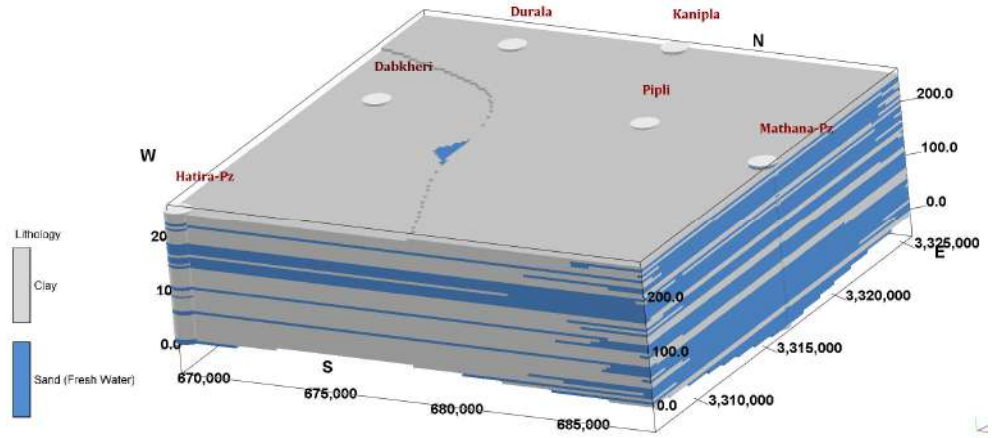
Aquifer Disposition: Multiple Aquifer System (2 Aquifer System)

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aq-I (28-160m)	Quaternary Alluvial deposits	Unconfined	94.5	2200	12	NA
Aq-II (196-300m)		Unconfined to Confined	65	-	NA	$6.63*x\ 10^{-3}$

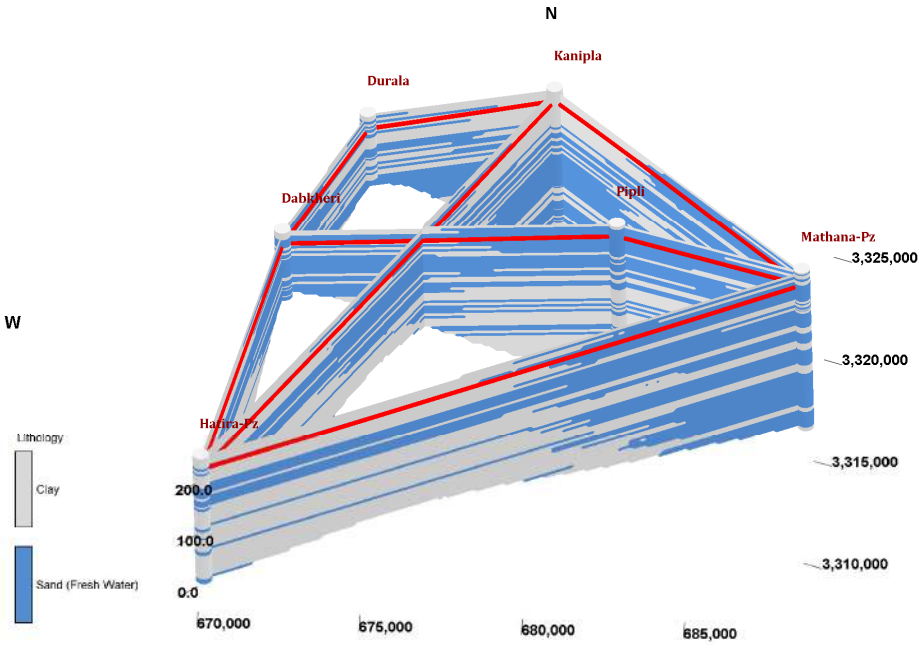
Aquifer comprises of freshwater only and the main aquifer formation is sand

The non-aquifer material comprise of clay.

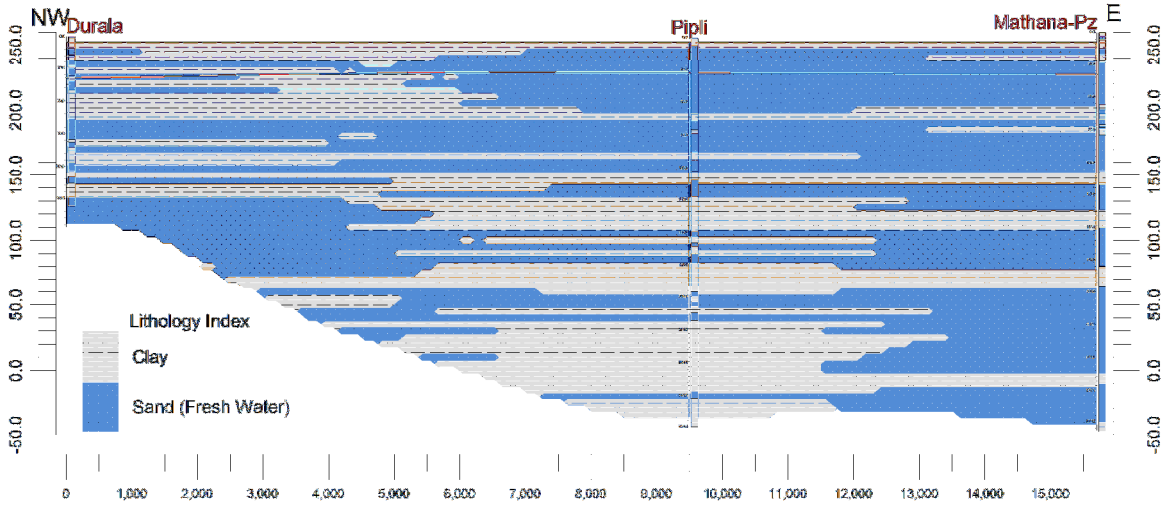
3D Lithology model



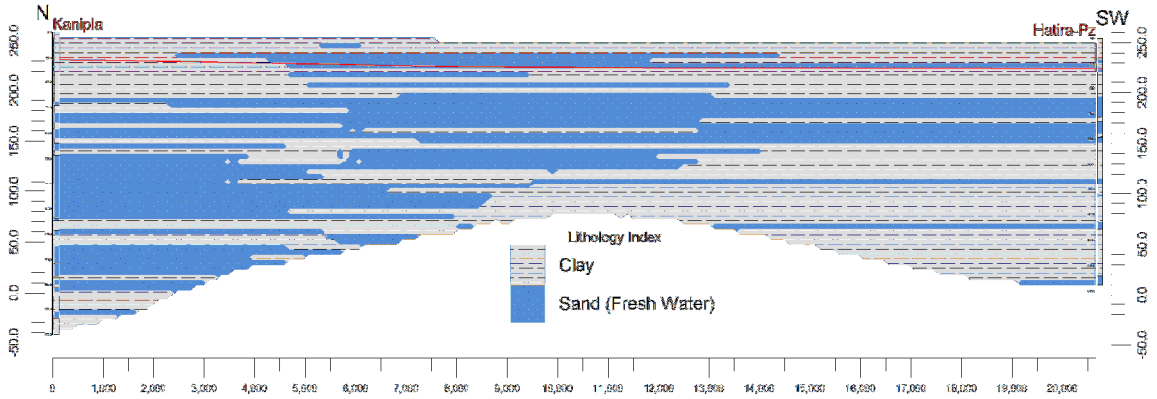
3D Lithology Fence



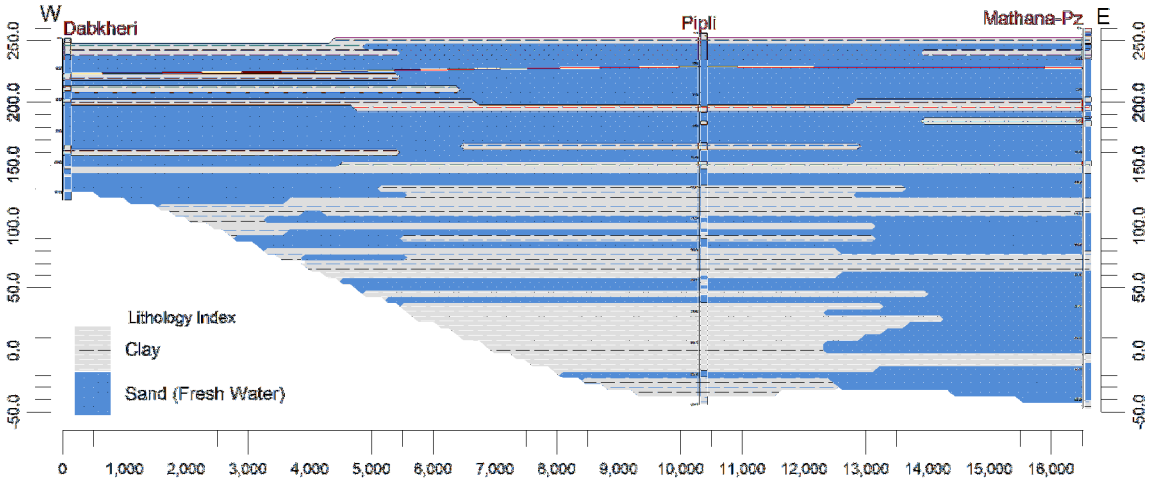
Cross-Section (NW-E)



Cross-Section (N-SW)



Cross-Section (W-E)



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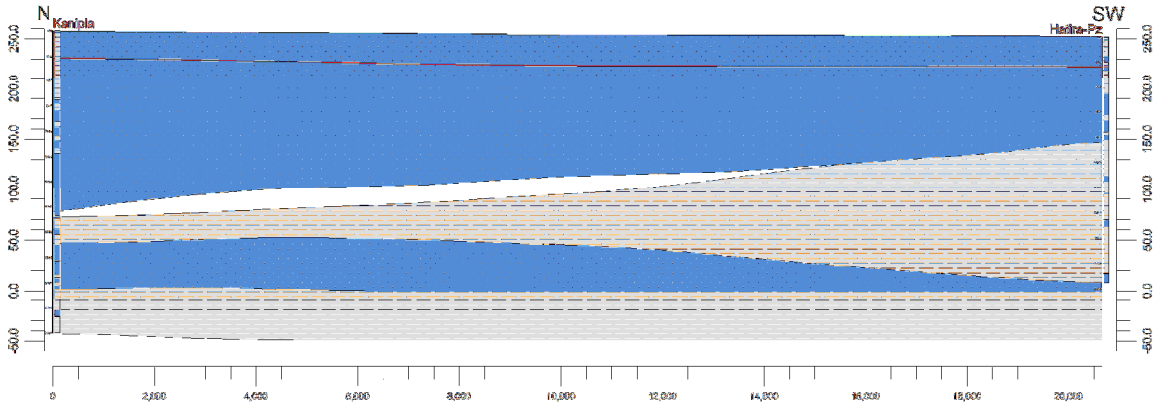

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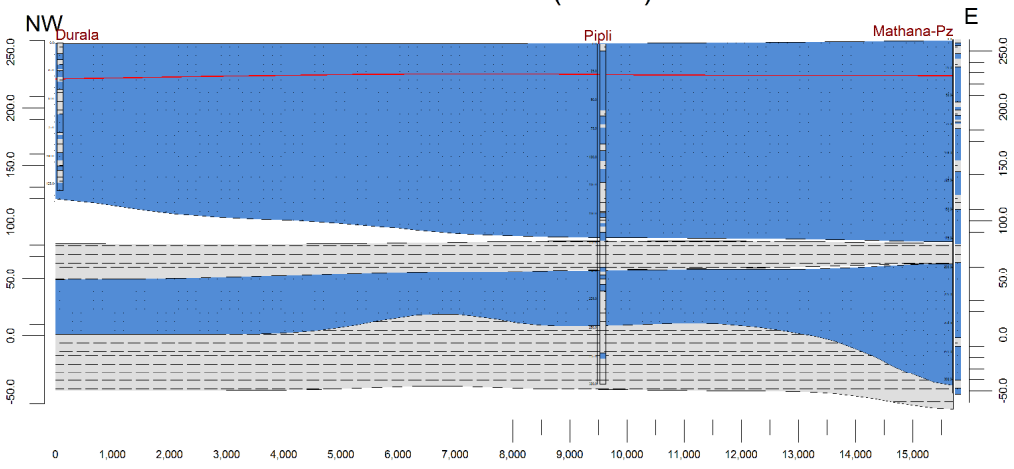

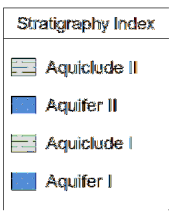

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm)	Dynamic Aquifer I (2013)	120.71
	In-storage Aquifer I (2013)	3101.82
	Dynamic Aquifer II	493.64
	In-storage Aquifer II	2191.50
	Total	5907.67
Ground Water Extraction (in mcm)	Irrigation (2013)	376.03
	Domestic & Industrial (2013)	29.46
Future Demand for domestic & Industrial sector (2025) (in mcm)		29.46
Chemical Quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level (>5m) & declining water level trend (113.6-116.9cm/yr)

Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (32m) is 969.32 mcm.
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting & Farm pit Recharge will save 5.95mcm volume of water

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 14.98mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean in 92% of the total area. Anticipated volume of water to be saved by maize is 235 mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

11. CONCLUSION

- The area of Kurukshetra district belongs to Upper Yamuna and Ghaggar Basins and occupied by geological formations of Quaternary age.
- The major aquifer system of the Kurukshetra district is alluvial deposit having older and younger alluvium which mainly comprised of sand, silt and clay.
- The major lithological formations are sand & clay and silt is found admixed with sand and clay
- Three aquifer groups have been identified in the district up to a depth of 300 meters. Aquifer- I ranges from 6 m bgl to 146 m bgl with thickness ranges from 42 meters to 95 meters. Aquifer –II ranges from 172 m bgl to 231 m bgl with thickness ranges from 27 to 65 meters. Aquifer –III ranges from 236 m bgl to 278 m bgl with thickness ranges from 28 to 37 meters.
- Isotope study reveals that ground water from aquifer-I and aquifer-II is derived from local precipitation and is in dynamic condition, whereas ground water from aquifer-III is old and depleted indication high altitude recharge and long residence time.
- As per dynamic ground water resources as on March 2013, all six blocks of the district under over exploited category. Stage of ground water development of the blocks ranges from 263% (Pehowa block) 353 % (Ladwa block). Over all stage of ground water development of the district is 281%.
- Dynamic & In- storage ground water resources has also been carried out to a depth of 300 meters for all aquifer groups.
- Ground water resources (Dynamic + In- storage) of Aquifer –I is 7494MCM, Fresh In- storage ground water resources of Aquifer- II is 6875 MCM, whereas Fresh In- storage ground water resources of Aquifer- III is 1641 MCM. Total ground water resources upto 300 m depth in the district is 16011 MCM.
- Based on Dynamic ground water resources(as on March 2013) and considering the high ground water abstraction (1451mcm) and overdraft (945mcm), it is suggested that proposed artificial recharge measures (17mcm) and conserving ground water through laying of pipe line (54 mcm) will be useful.
- Long-term sustainability remains a serious issue until change of the paddy cultivation takes place in the area of all the blocks of Kurukshetra district.

- Other techniques of water saving and modern irrigation technology to be enforced to maximize the per drop of water use in the district.
- Electrical Conductivity of Aquifer II & Aquifer –III is better than aquifer-I. Aquifer I shows the presence of Cd, Pb & Cu at few places where as in Aquifer-III Mn is reported at one place. In Aquifer II & II, Iron is present above permissible limits, whereas Arsenic is within limits.
- The aquifer –I & II is free from any Microbiological and Pesticide contamination and BOD/COD is also <1
- Ground water regulation for protecting the Aquifer I from rampant irrigation by the paddy crops in all blocks of the district is needed.

Annexure I: Details of water quality analysis of Ground Water Observation wells, Kurukshetra District

Sr. No.	LOCATION	Block	pH	EC in µS/cmat 25^0C	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	SiO_2	TH	Fe
1	Berthala	BABAIN	7.47	815	436	31	30	6.7	0.28	72	33	52	5.4	28	316	0.16
2	Bam	LADWA	7.54	787	464	17	10	14	0.56	84	27	45	6.8	31	322	0.12
3	Baronda	LADWA	7.3	823	513	6.7	0	18	0.36	53	43	51	6.6	31	311	0.05
4	Samalakhi	SHAHBAD	7.37	1092	567	58	25	**23**	0.51	**94**	41	83	**7.2**	22	403	0.04
5	Shabad	SHAHBAD	7.94	639	378	10	8	0.3	0.3	57	16	53	3.4	22	209	-
6	Kaulpur	KURUKSHETRA	7.39	455	268	17	0	0	0.24	37	9.8	48	5	28	133	0.07
7	Sisaula	KURUKSHETRA	7.57	563	353	20	0	1.9	0.72	45	19	54	5.4	30	189	0.05
8	Malikpur Singhpura	KURUKSHETRA	7.9	870	555	20	10	3.1	0.36	57	45	70	6.8	26	327	0.04
9	Hatira	KURUKSHETRA	7.58	519	244	27	25	3.2	0.55	47	14	44	3.8	18	174	-
10	Santokhpur	KURUKSHETRA	7.25	917	586	14	10	11	0.72	53	16	141	5.4	26	199	0.02
11	Matahana	KURUKSHETRA	7.45	796	494	6.7	20	5.4	**0.82**	65	27	73	6.7	**32**	276	0.15
12	Thana	PEHOWA	7.66	**1845**	**1037**	27	60	0.6	0.54	65	**47**	**269**	7	28	**357**	**1.28**
13	Murtajapur	PEHOWA	7.69	490	256	20	10	8.1	0.42	59	17	16	2.9	30	219	0.07
14	Bachki	PEHOWA	7.91	743	391	44	20	1.2	0.73	39	21	100	4.8	20	184	0.09
15	Ishaq	PEHOWA	7.71	1588	342	**293**	145	0	0.38	78	37	225	**7.2**	23	347	0.18
16	Pehowa	PEHOWA	7.83	1254	683	48	35	9.1	0.64	59	38	162	11	27	305	0.05

Maximum values in bold letters

Arsenic (As) and Po_4 were tested and found below detection limits in all samples

Annexure II : Results of chemical analysis for sample collected from Aquifer-I along Palaeo-channels in District Kurukshetra, Haryana																	
Sr. No		**LOCATION**	**pH**	**EC in µS/cm at 25^0 c**	**CO_3**	**HCO_3**	**Cl**	**SO_4**	**NO_3**	**F**	**PO_4**	**Ca**	**Mg**	**Na**	**K**	**SiO_2**	**TH as $CaCO_3$**
					(<----------mg/l----------)												
1		Mohan Nagar	7.3	370	Nil	244	14	3	0.02	0.31	0.01	29	22	26	3.9	21	163
2		Narkatari	7.35	419	Nil	293	14	BDL	0.02	0.29	BDL	45	22	22	6.2	22	204
3		JoganaKhera	7.08	782	Nil	549	14	BDL	5.88	0.2	BDL	90	22	70	5.2	27	316
4		Dab Kheri	7.55	610	Nil	403	21	4	2.98	0.41	BDL	45	30	58	5.1	22	235
5		MuntaKhera	7.02	**1498**	Nil	**708**	**104**	**34**	**115**	0.45	0.01	**106**	**47**	**173**	17	22	459
6		Samaspur	7.35	696	Nil	476	21	22	5.58	0.29	0.01	53	35	76	5.6	21	276
7		Berthala	7.32	604	Nil	403	14	4	2.85	0.64	BDL	45	27	58	5.7	22	225
8		Challon	7.95	885	Nil	561	42	19	3.05	**0.98**	BDL	65	42	91	7.5	23	337
9		Surmi	7.35	615	Nil	378	28	10	6.08	0.64	BDL	25	25	92	3.7	19	163
10		Mirjapur	7.29	815	Nil	452	42	27	15	0.21	**0.1**	90	25	60	10	27	327
11		LuharMajra	7.32	470	Nil	262	7	30	0.12	0.41	BDL	48	17	31	3.6	21	188
12		KhijerPura	7.61	750	Nil	433	30	29	0.64	0.41	BDL	59	28	74	**7.7**	24	262
13		Bohr Saida	7.53	610	Nil	348	16	26	10	0.25	BDL	67	22	38	5.1	23	256
14		Muqimpura	7.6	548	Nil	305	12	33	0.05	0.41	BDL	61	20	30	4.1	21	235
15		GarhiSingha	7.53	625	Nil	366	19	22	2.6	0.38	BDL	42	23	71	4.3	21	199
16		Pehowa	7.46	546	Nil	323	19	9	3.4	0.46	BDL	42	33	31	4.1	21	241
17		Bilochpura	7.4	715	Nil	409	21	28	11	0.75	BDL	55	38	52	7.4	24	293
18		DhaniRampura	7.53	824	Nil	488	25	28	11	0.52	BDL	82	36	53	**7.7**	**28**	**350**
19		Sainsa	7.33	517	Nil	299	9	14	0.1	0.54	BDL	55	17	32	3.9	27	204
20		Murtazapur	7.5	720	Nil	378	32	34	12	0.43	BDL	71	28	49	4.7	25	293
21		Jyotisar	7.15	475	Nil	250	9	35	1.5	0.33	BDL	48	20	22	4.4	21	204
			7.5	685	Nil	403	9	**38**	5	0.61	BDL	63	27	54	5.3	23	267

Heavy Metal in Ground Water along Palaeo-channels from Kurukshetra District **Annexure III**

S.No.	Location	Cd	Cr	Cu	Mn	Pb	Zn	Fe	As	Se
		<----------Concentration in mg/l---------->								
1	Mohan Nagar	BDL	BDL	0.016	0.0732	BDL	0.034	0.013	BDL	0.0006
2	Narkatar	BDL	BDL	0.006	0.0304	BDL	0.066	BDL	BDL	0.0004
3	Jogana Kharta	0.0008	BDL	0.0064	0.136	**0.040**	0.018	0.020	BDL	0.001
4	Dab Kheri	BDL	BDL	0.0154	0.012	BDL	0.076	0.030	BDL	BDL
5	Munta Khera	0.002	BDL	0.0044	BDL	BDL	0.0516	BDL	BDL	0.0054
6	Samarpur	0.0016	BDL	0.0066	0.018	BDL	0.0326	BDL	BDL	BDL
7	Bagthala	BDL	BDL	BDL	BDL	BDL	0.0524	0.030	BDL	BDL
8	Cholla	0.002	BDL	BDL	0.1288	BDL	0.0206	0.020	BDL	BDL
9	Surmi	0.002	BDL	BDL	0.016	BDL	0.0178	0.030	BDL	BDL
10	Mirjapur	**0.004**	BDL	BDL	0.0648	BDL	0.1346	0.060	BDL	BDL
11	Luhar Majra	**0.0034**	BDL	BDL	0.02	BDL	0.0104	0.1348	BDL	BDL
12	Khijer Pura	**0.0032**	BDL	BDL	0.067	BDL	0.0112	0.0341	BDL	BDL
13	Bohr Saida	**0.0032**	BDL	BDL	0.0264	BDL	0.0482	0.0169	BDL	BDL
14	Muqimpura	**0.004**	BDL	BDL	0.0284	BDL	0.016	0.0232	BDL	BDL
15	Garhi Singha	**0.0034**	BDL	BDL	BDL	BDL	0.182	0.0083	BDL	BDL
16	Pehowa	**0.0048**	BDL	BDL	0.0042	BDL	0.018	0.0255	BDL	BDL
17	Bilochpura	**0.0046**	BDL	BDL	0.056	**0.020**	0.0286	0.0083	BDL	BDL
18	Dhani Rampura	**0.0052**	BDL	BDL	0.02	BDL	0.02	**0.3332**	BDL	BDL
19	Sainsa	**0.0032**	BDL	BDL	0.03	BDL	0.3479	0.0286	BDL	BDL
20	Murtazapur	**0.0048**	BDL	BDL	0.014	BDL	0.012	0.0083	BDL	BDL
21	Jyotisar	**0.004**	BDL	BDL	0.005	BDL	0.004	0.0083	BDL	BDL
22	Tikoran	**0.0064**	BDL	BDL	0.141	BDL	0.022	0.0903	BDL	BDL
BIS Permissible Limit(2012)		**0.003**	0.05	1.5	0.3	0.01	15	0.3	0.05	0.01

Ground Water Quality Data of Exploratory Wells drilled under NAQUIM in Kurukshetra District **Annexure IV**

Sr. No	LOCATION	pH	EC in µS/cm at 25^{0} C	CO_3^*	HCO_3^*	Cl	SO_4^*	NO_3	F	PO_4^*	Ca	Mg	Na*	K*	SiO_2^*	TH as $CaCO_3$	Aquifer
1	KHANPUR JATTAN	7.92	842	NIL	483	63	2	8.9	0.39	0.01	54	15	106	6.9	16	247	I
2	KHANPUR JATTAN	8.32	565	36	242	21	25	BDL	0.62	BDL	29	16	79	4.9	12	139	II
3	KHANPUR JATTAN	8.63	421	24	133	42	40	BDL	0.07	0.0593	12	10	81	2.8	16	72	III
4	BERTHALA	8.2	390	NIL	223	14	19	3	BDL	0.166	21	6.3	66	3.4	12	78	III
5	KANEPLA	8	339	NIL	206	21	4	BDL	0.16	BDL	8.2	7.5	69	2.2	ND	52	III
6	PIPLI (Zone Test –I)	8.3	587	NIL	317	80	BDL	6.8	0.62	BDL	19	19	115	3.8	15	126	I
7	PIPLI (Zone Test –II)	8.3	470	NIL	244	35	BDL	2.5	0.58	BDL	8.4	10	85	3.6	15	63	II
8	PIPLI (Zone Test –III)	8.3	340	NIL	207	14	BDL	4.1	0.39	BDL	13	5	65	2.9	12	53	III
9	PIPLI	7.83	658	NIL	391	17	17	2.8	0.36	BDL	11	47	79	6.4	10	221	II&III

Heavy Metal in Ground water of Exploratory Wells in Kurukshetra District **Annexure V**

Sr. No.	Location	Date of collection	Zones tapped (m bgl)	Cd	Cu	Mn	Pb	Zn	Fe	As
				←----------Concentration in mg/litre---------->						
1	KHANPUR JATTAN-I	June 2016	60-68	BDL	**5.475**	0.227	**0.899**	0.288	**3.396**	BDL
2	KHANPUR JATTAN-II		153-159, 172-175, 186-189	BDL	BDL	0.063	BDL	0.012	0.234	0.001
3	KHANPUR JATTAN-III		228-240, 251-257	BDL	0.009	0.025	BDL	0.012	**0.845**	0.003
4	KANEPLA-III		215-225, 278-281	BDL	BDL	**0.379**	BDL	0.163	**2.245**	BDL
5	CHALLON-I		74-80, 86-95, 107-109	BDL	BDL	0.048	BDL	0.008	**8.742**	BDL
6 a 6.b	PIPLI (Zone Test –I)	Jan 2015	149-153	BDL	BDL	0.088	BDL	0.065	**0.845**	BDL
6.c	PIPLI (Zone Test –II)	Jan 2015	188-192	BDL	BDL	**0.325**	BDL	0.302	**0.931**	BDL
6.d	PIPLI (Zone Test –III)	Jan 2015	260-266	BDL	BDL	0.106	0.01	0.101	**1.321**	BDL
6.e	PIPLI -EW	March 2015	166-172, 204-207, 213-218, 272-276	BDL	BDL	0.204	0.006	0.288	-	-
	Permissible limit			0.003	1.5	0.3	0.01	15	0.3	0.05

Annexure-VI

Results of Pesticide Analysis from the Aquifer –I of the well field at Khanpur Jattan, Sahabad block, Yamunanagar

S.No.	Parameters(micro gram/l)	Results
1	Alachlor	ND (0.1)
2	Atrazine	ND (0.1)
3	Aldrine / Dialdrin	ND (0.1)
4	Alpha HCH	ND (0.1)
5	Beta HCH	ND (0.1)
6	Butachlor	ND (0.1)
7	Chlorpyriphos	ND (0.1)
8	Delta HCH	ND (0.1)
9	2,4- Dichlorophenoxyacetic acid	ND (0.1)
10	DDT (o,p and p, DDE, p-Isomers of DDT)	ND (0.1)
11	Endosulfan	ND (0.1)
12	Ethion	ND (0.1)
13	Gamma-HCH (Lindane)	ND (0.1)
14	Isoproturon	ND (0.1)
15	Malathion	ND (0.1)
16	Methyl Parathion	ND (0.1)
17	Monocrotophos	ND (0.1)
18	Phorate	ND (0.1)

Above results confirms IS: 10500-2012 for drinking purpose

PROJECT TEAM

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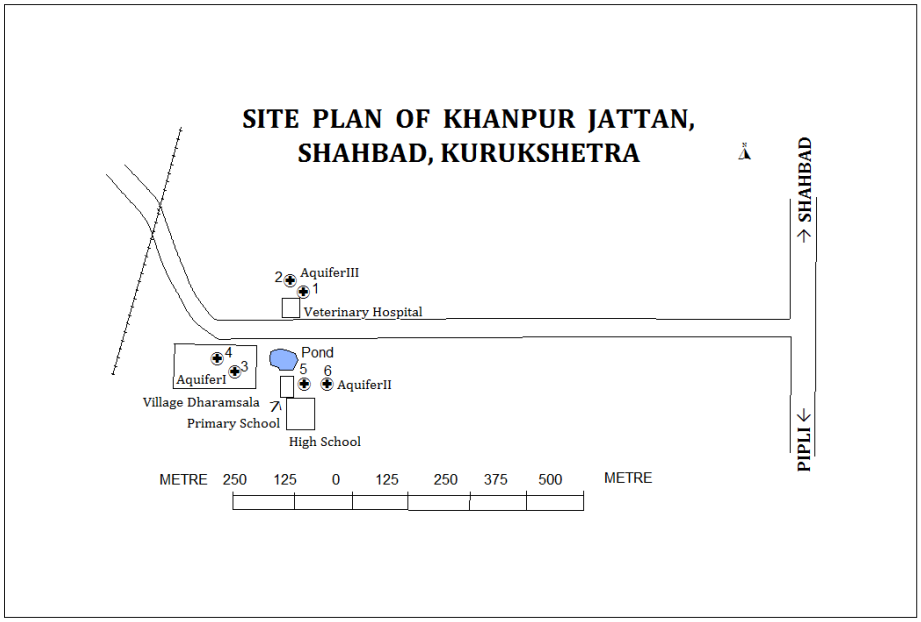
PLATE-1

SITE PLAN OF WELL FIELD AT KHANPUR JATTAN, KURUKSHETRA



DRILLING RIG AT EXPLORATORY WELL SITE AT KURUKSHETRA

REMAINENT CHANNEL OF SARASWATI AT PIPLI, KURUKSHETRA

GROUND WATER SAMPLE COLLECTION FOR ISOTOPE ANALYSIS

SAMPLING OF GROUND WATER FOR CHEMICAL ANALYSIS IN THE FIELD

TREATMENT PLANT TO RECYCLE WATER AT SARASWATI GHAT, PEHOWA, KURUKSHETRA

DRY CHANNEL OF SARASWATI, PEHOWA, KURUKSHETRA

RESISTIVITY SURVEY AT BEED PIPLI, KURUKSHETRA

NATURAL GAMMA LOGGING, KURUKSHETRA (WELL FIELD)

PUMPING TEST AT KHANPUR JATTAN (WELL FIELD)

GROUND WATER MONITORING OF OBSERVATION WELL

COLLECTION OF WATER SAMPLES DURING PUMPING TEST