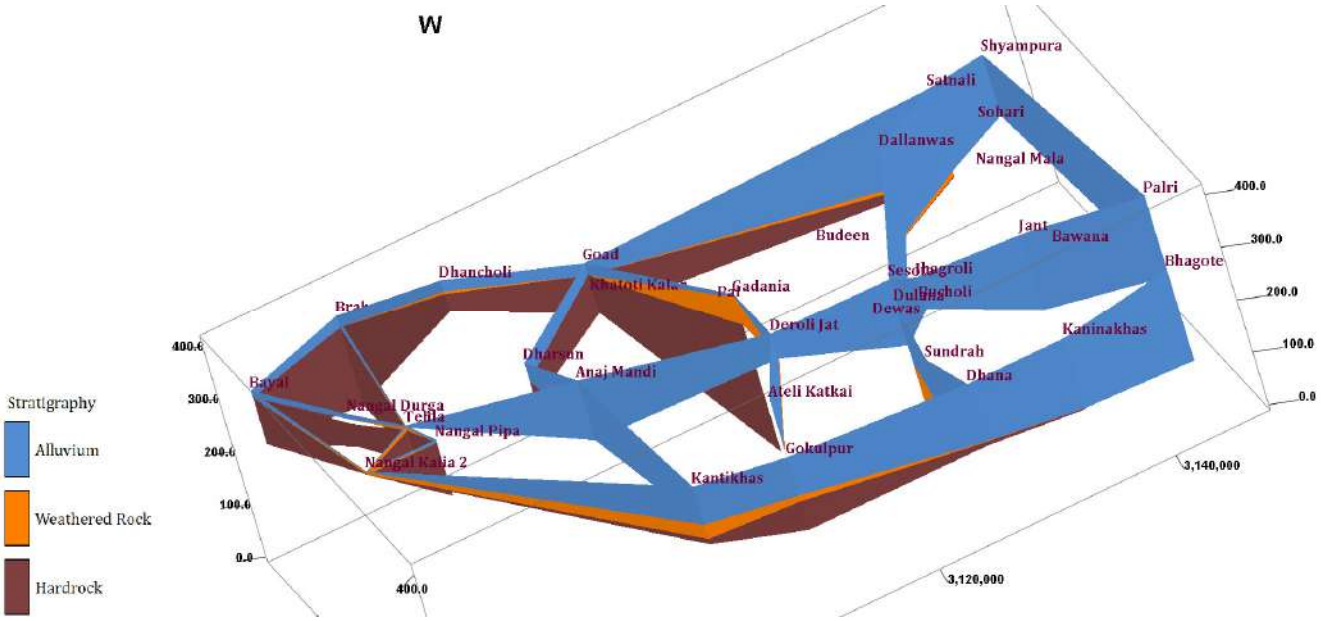
राष्ट्रीय जलभृत मानचित्रण एवम प्रबंधन योजना

महेंद्रगढ़ जिला

हरियाणा



केन्द्रीय भूमि जल बोर्ड

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भारत सरकार

2017

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AQUIFER MAPPING AND MANAGEMENT PLAN

MAHENDERGARH DISTRICT (1939 Sq Km)

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1. INTRODUCTION

1.1 Introduction & Physiographic Setup

Mahendragarh district occupies the southern extremity of the Haryana state jointly with Rewari and Gurgaon districts of Haryana. It has a total geographical area of 1939 sq km. and falls between Latitudes $27^0$48'10" and $28^0$8'30" and Longitudes $75^0$54' 00" and $76^0$51' 30". Mahendragarh district is bounded by Bhiwani and Rohtak districts in its north, Rewari in its east and Alwar and Jhunjhunu (Rajasthan) districts in its south and west respectively. Administratively, the district is divided into two sub divisions, namely Mahendragarh and Narnaul. There are five development blocks in the area namely Ateli, Kanina, Mahendragarh, Nangal Choudhary and Narnaul (Fig 1). The district is comprised of 370 villages and 5 towns with the population of 9,21,680 souls as per 2011 census.

1.2 Hydrology & Drainage Network

The main streams of the district are Dohan & Krishnawati which flow from south to north. These streams are known to carry copious supply of water to inundate large part of the district during monsoon and remain dry for major part of the year. The detailed drainage map has been prepared by HARSAC, Hissar and is shown in fig 2.

1.3 Rainfall and Climate

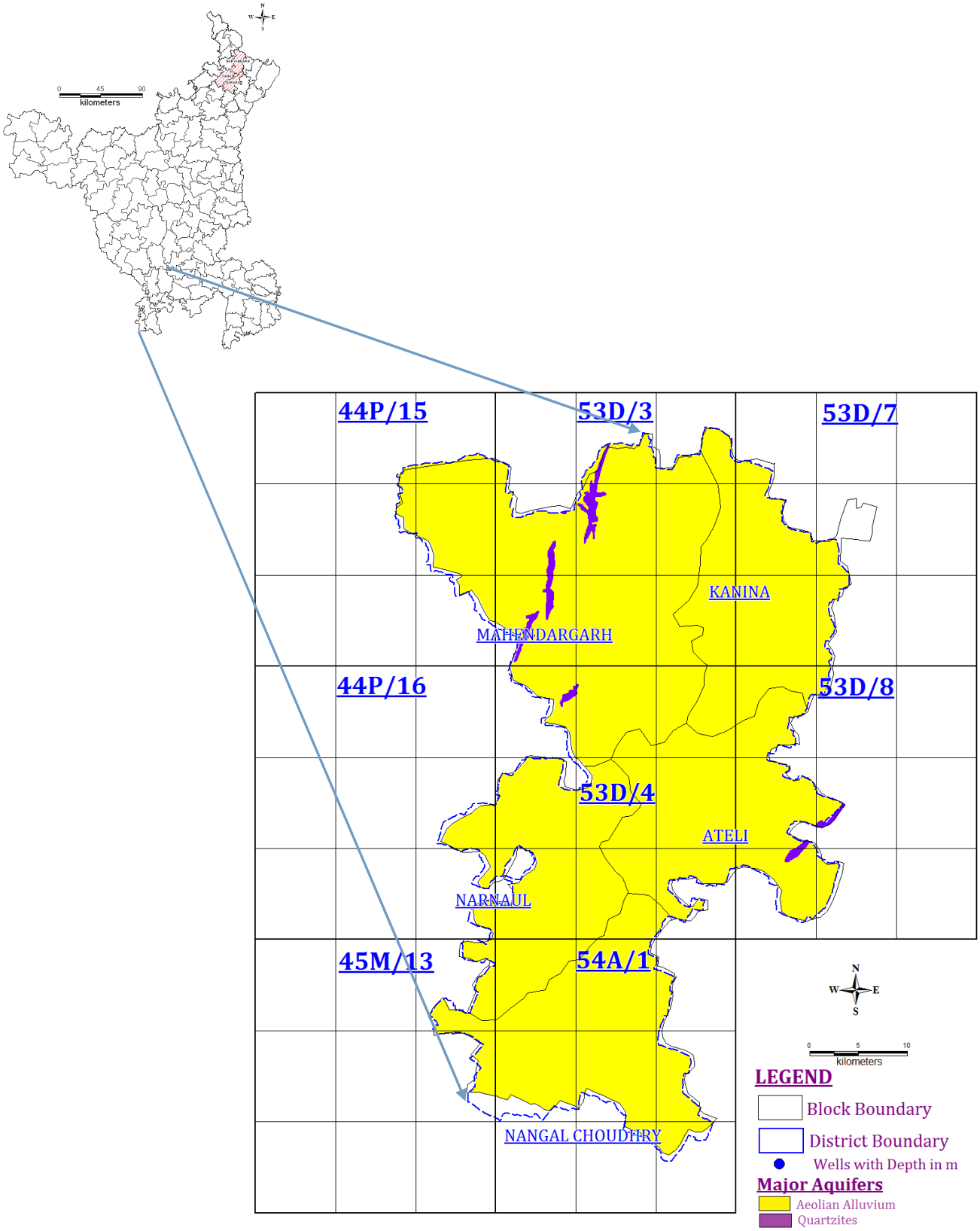
The climate of Mahendragarh district can be classified as tropical steppe, semi-arid and hot which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrates into the district. There are four seasons in a year. The hot weather season starts from mid March to last week of the June followed by the south-west monsoon which lasts up to September. The transition period from September to October forms the post-monsoon season. The winter season starts late in November and remains up to first week of March.

The normal annual rainfall and the normal monsoon rainfall of the district are 500 & 420 mm respectively which are unevenly distributed over the area 26 days. The south west monsoon sets in from last week of June and withdraws in end of September, contributed about 84% of annual rainfall. July and August are the wettest months. Rest 16% rainfall is received

during non-monsoon period in the wake of western disturbances and thunder storms. Generally rainfall in the district increases from southwest to northeast.

Temperature: Mean Maximum- 41°C (May June) & Mean Minimum- 5.6°C (January)

Fig 1: Base Map of Mahendergarh District.



1.4 Soils

Light coloured arid soils are found in the major part of the district. These soils are calcareous and have lime nodules in the subsurface horizons. Most of the soils in district are medium textured. Loamy sand is the average texture in all the blocks of the district.

1.5 Geomorphology

The area forms the part of Indo - Gangetic plains and has vast alluvial and sandy tracts. It is interspersed with strike ridges which are occasionally covered by blown sands. South western part of the district is occupied by blown sand and alluvium. The sand dunes attain heights unto 30m but on an average they attain height of about 7m with respect to surrounding. The detailed geomorphology map has been prepared by Haryana Space Applications Centre (HARSAC), Hissar and is shown in fig 3.

The hill ranges are marked features of the district and are part of great Aravali chain. The Dhosi hill touches the height of 7090m amsl. The master slope of the area is north ward.

1.6 Topography

The topography values ranges between 216 to 425m amsl and has been plotted to prepare the elevation contour map (fig 4).

1.7 Land Use and Land Cover

The detailed land use and land cover map has been prepared by HARSAC, Hissar and is shown in fig 5. According to this map, the majority of the land is utilized in agriculture and in agri plantations followed by land with scrub and habitations.

Fig 2: Drainage Map

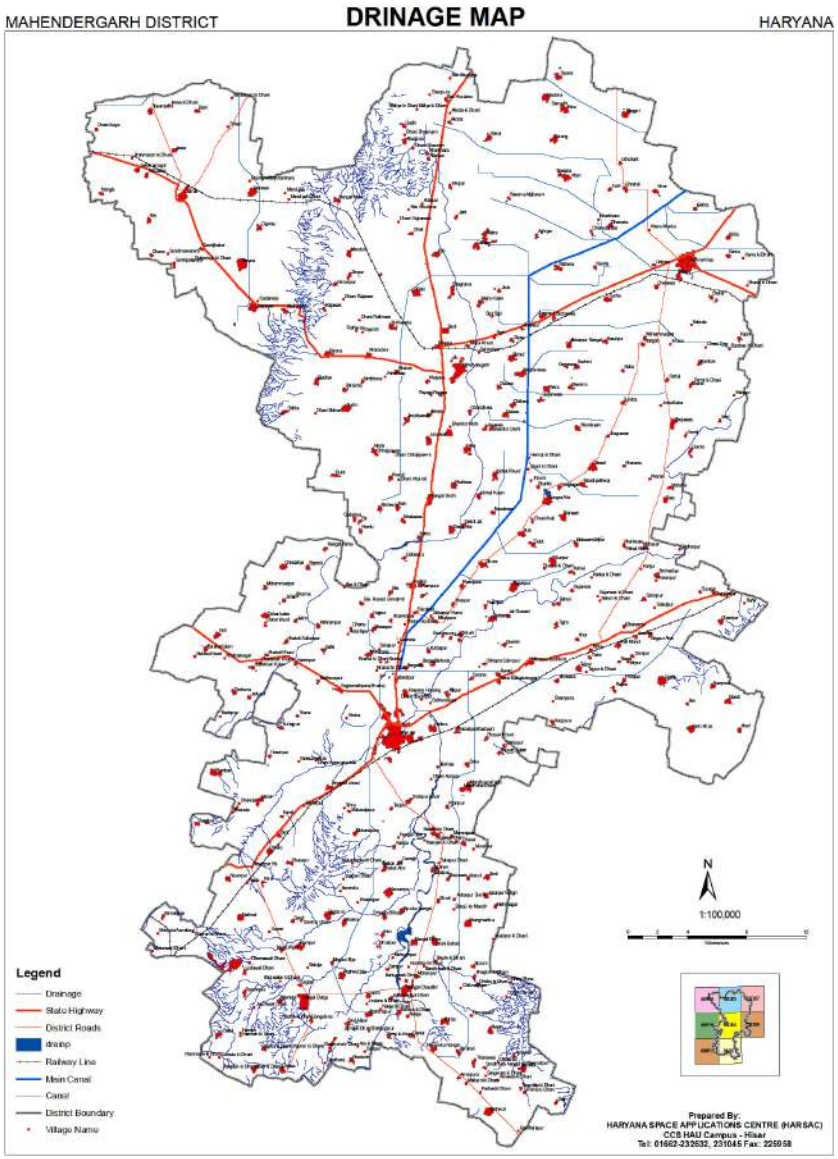


Fig 3: Geomorphology Map

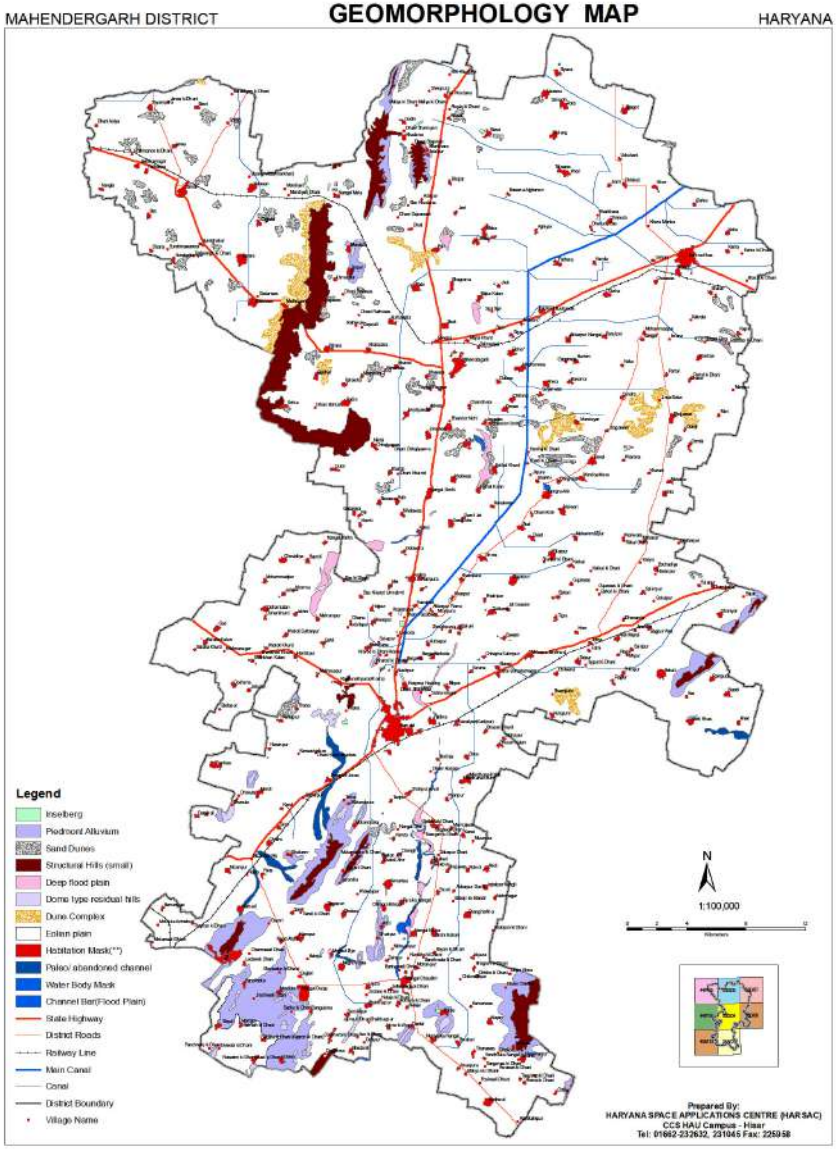


Fig 4: Elevation Contour Map – Mahendergarh district

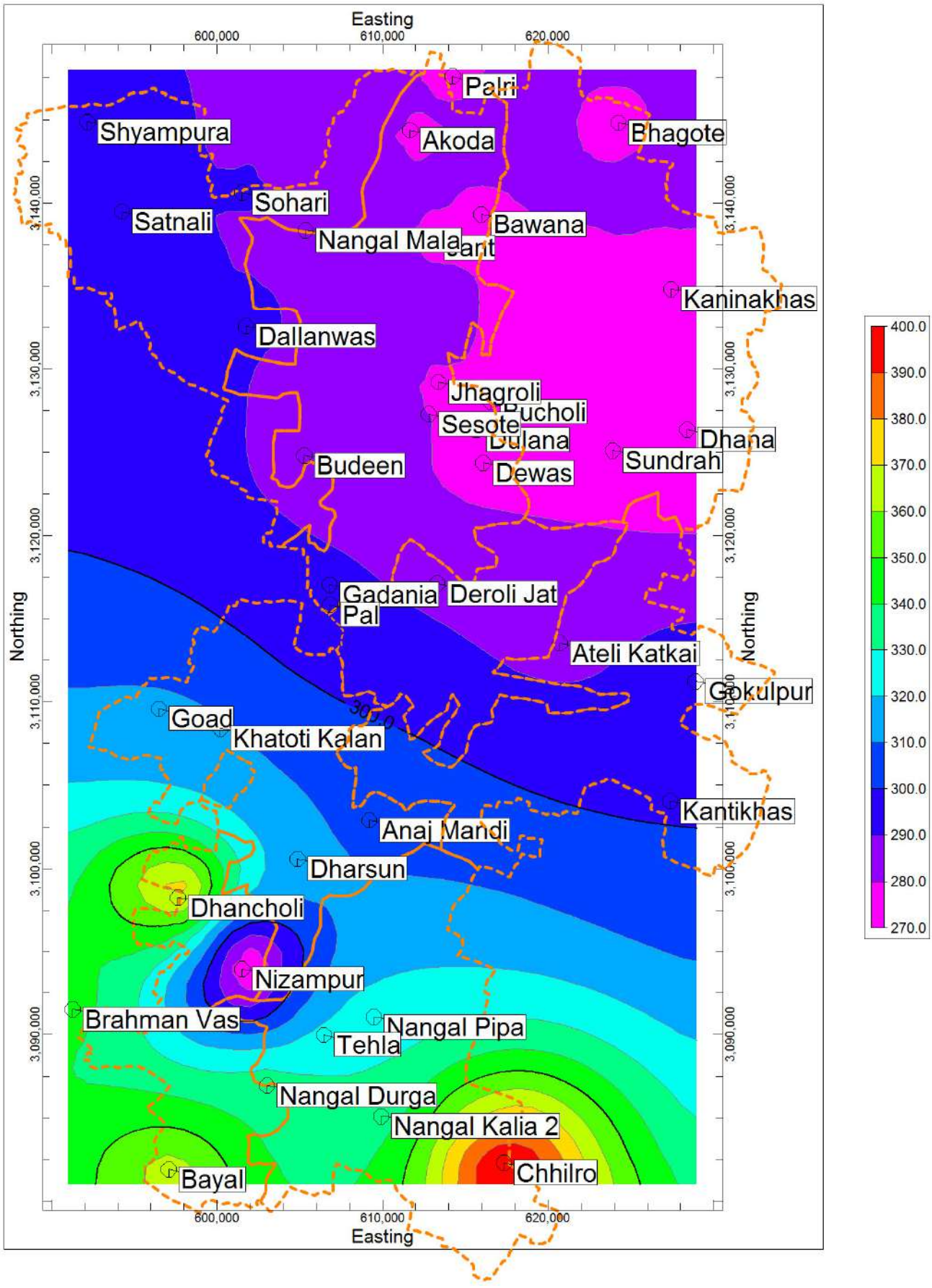
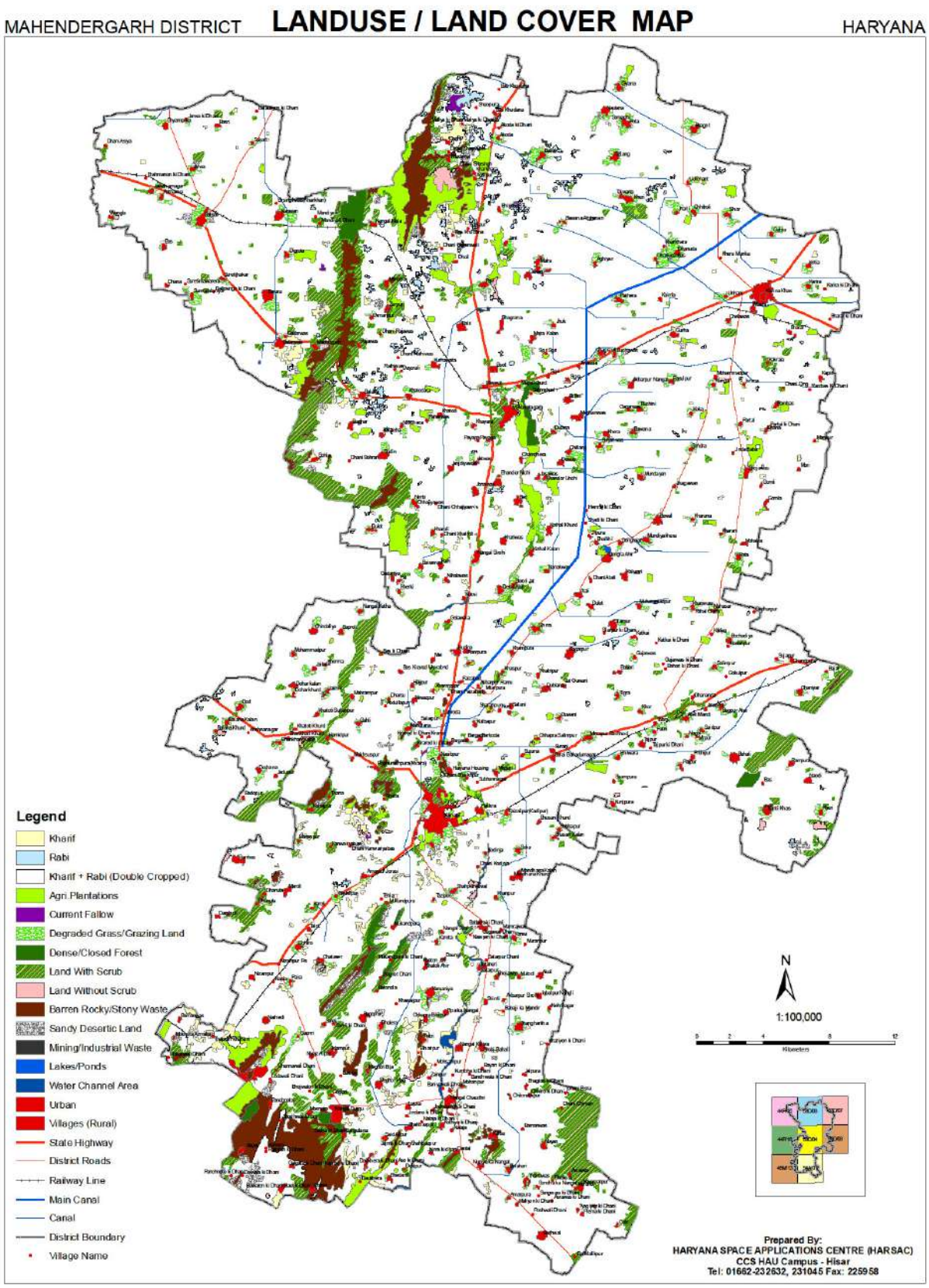


Fig 5: Land Use and Land Cover Map

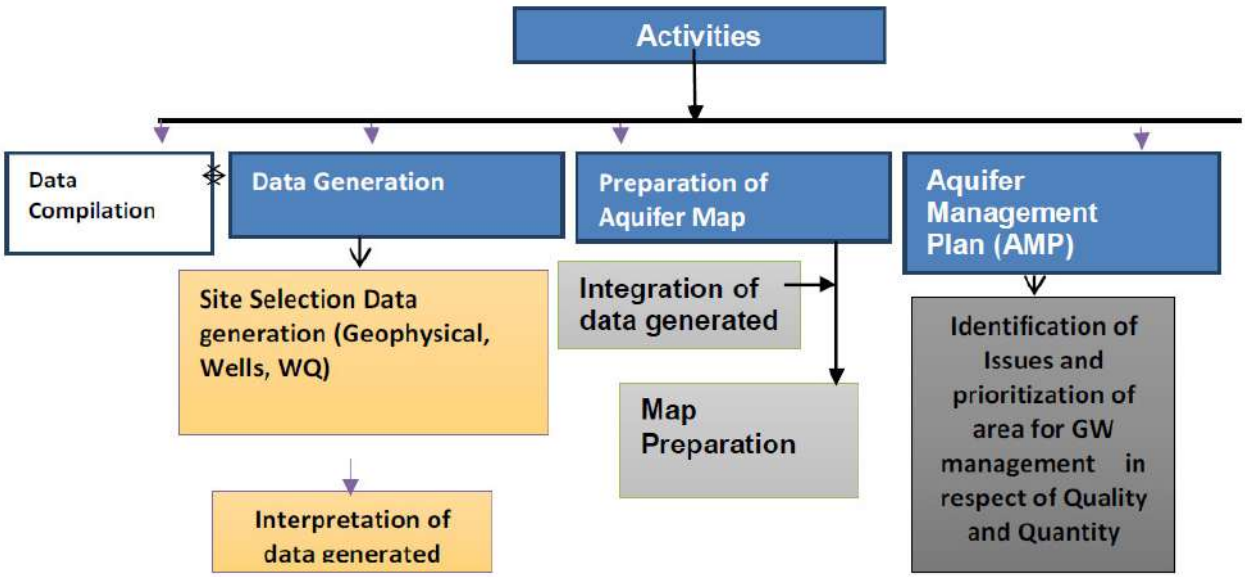


1.8 Objective, Scope of Study & Methodology

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders.

This is an activity where the Government and the Community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

Methodology: Various activities of NAQUIM are as follows:



1.9 Data Availability, Data Adequacy, Data Gap Analysis & Data Generation

The data of CGWB wells (Fig 7) and all the wells from PHED in the area are plotted on the map of 1:50000 scale with 5'X5'grid (9 x 9km) and is shown in fig 6 &7 respectively. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation.

Fig 6: Location of CGWB wells

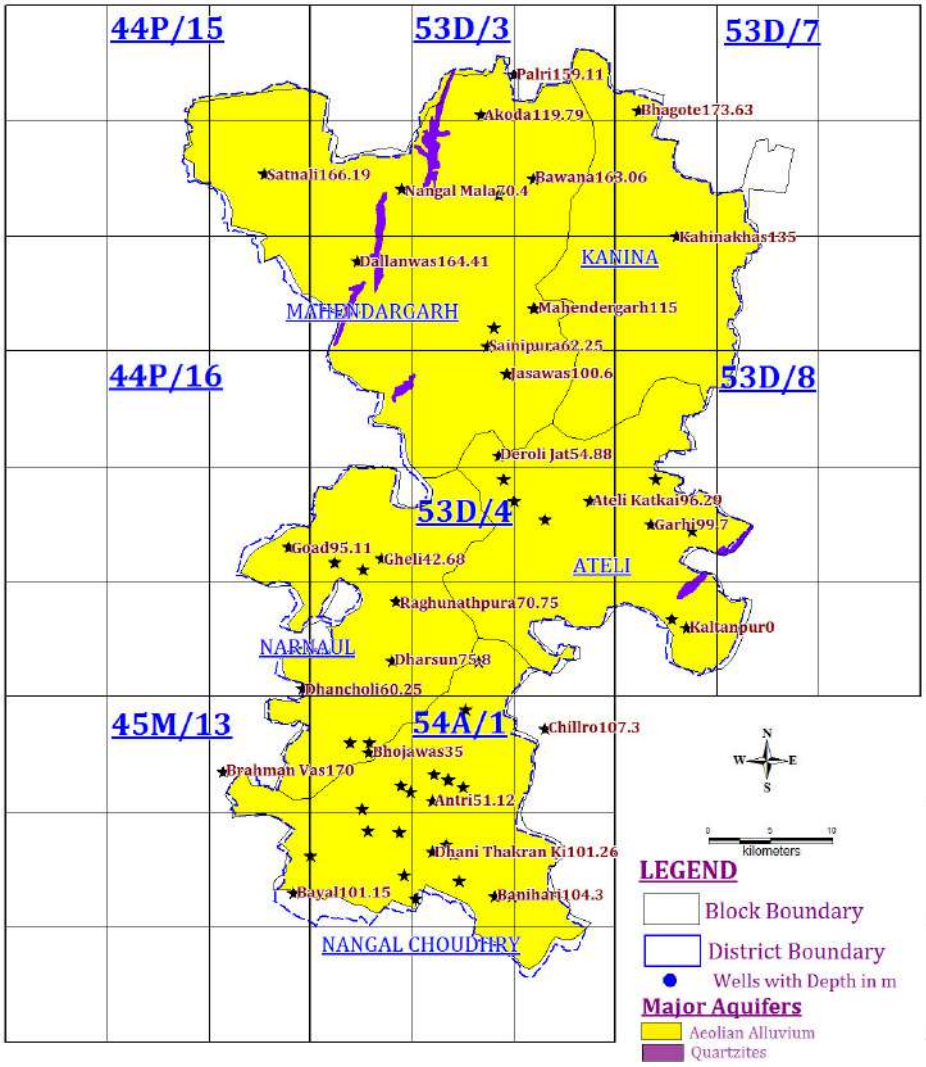
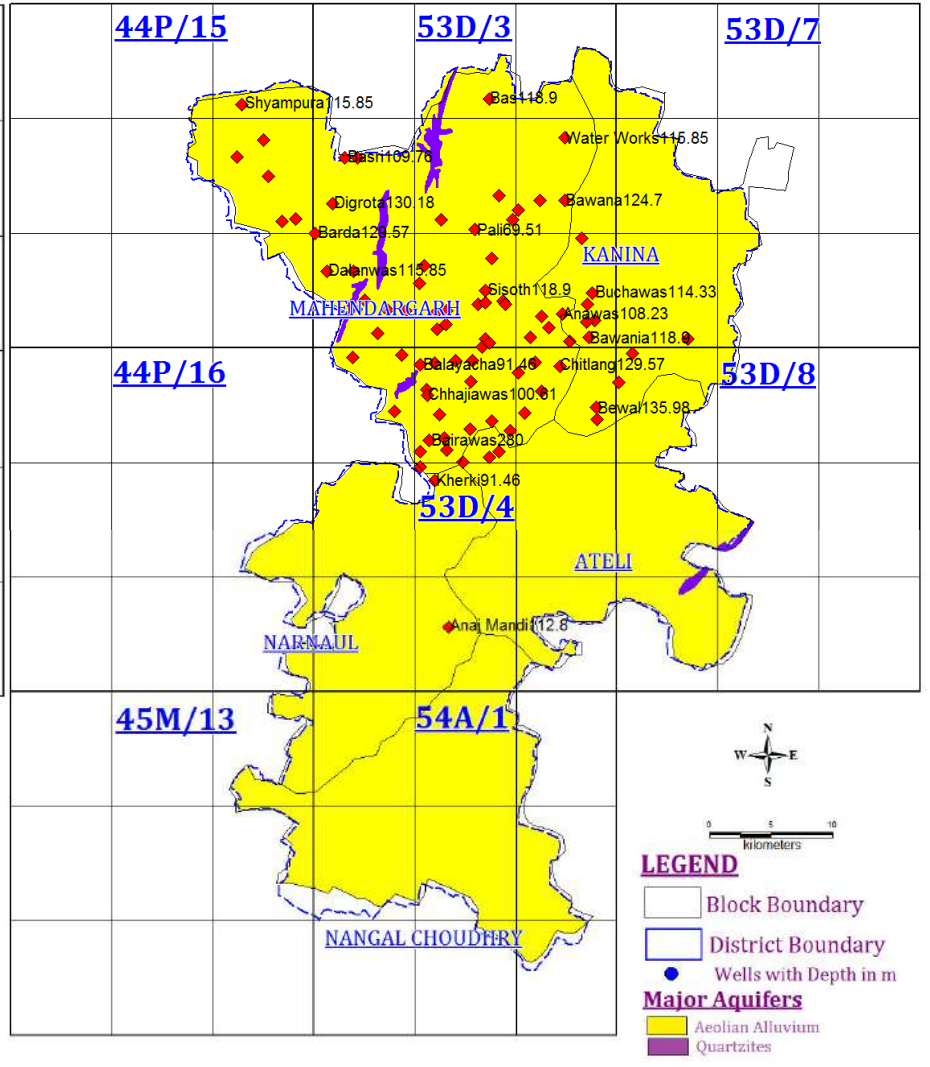


Fig 7: Location of PHED wells



2. DATA COLLECTION AND GENERATION

2.1 Hydrogeological Data

2.1.1 Geology of the Area

The district is underlain by alluvium and blown sand of Recent to sub recent age which are overlying the rocks of post Delhi and Delhi system. The alluvium in the area belongs to older alluvium stage comprising of sand, silt, clay and calcareous nodules. The alluvium is the fresh water deposit of Indo- Gangetic river system.

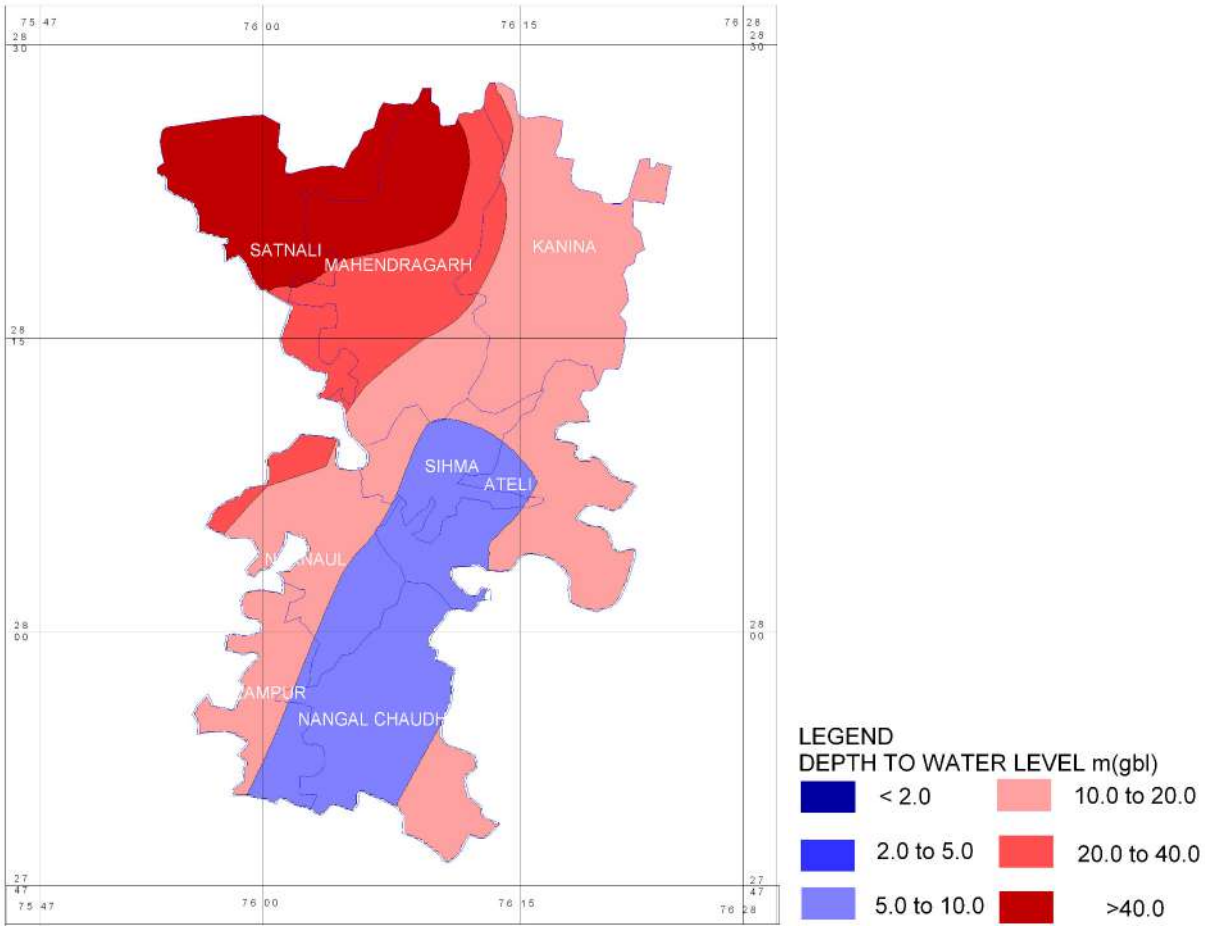
In alluvium the granular zones exist down to entire thickness, which is negligible near the out crop of Delhi system to about 150m in the northern part of district. The average thickness of the alluvium in the district is more than 50m. Exploratory drilling has been carried out at 19 exploratory sites in alluvial formation and 35 in Hard rock areas. In alluvial formations the successful exploratory tube well tapped aquifer zones down to the depth of 170m & 235 m yielding 220 lpm to 1200 lpm for 6 to 23m drawdown.

The transmisivity value ranges from 150 to 810 m^2/day in alluvial formations and between 370 and 1685 m^2/day in hard rocks. The lateral hydraulic conductivity ranges from 1.5 to 20 m/ day. In hard rock area the depth of bore holes ranges between 50 to 135 m and the water bearing zones in weathered fractured quartzite and limestone were tapped. The discharge of tube wells varies between 100 to 1325 lpm with 3 to 15m draw down in lime stone aquifers. The discharge of tube wells constructed in quartzite formation ranges between 22 and 820 lpm for reasonable drawdown.

2.1.2 Water Level Behaviour (2016)

The depth to water level ranges from 8.63m bgl at Narnaul to 99.50m bgl at Kultajpur during pre-monsoon (fig 8) and 6.11m bgl to 98.50m bgl during post-monsoon at Deroli Ahir1 and Kultajpur respectively. The water level fluctuation shows both rise and fall in the water level. During post-monsoon, the rise in the water level ranges from 0.10m at Bhojawas to 10.20m at Pachnota and fall in the water level ranges from 0.10m at Kheri to 1.30m at Barda. The depth to water level data and its fluctuation is given in Annexure I.

Fig 8: Depth to water level map (Post-monsoon, 2016).



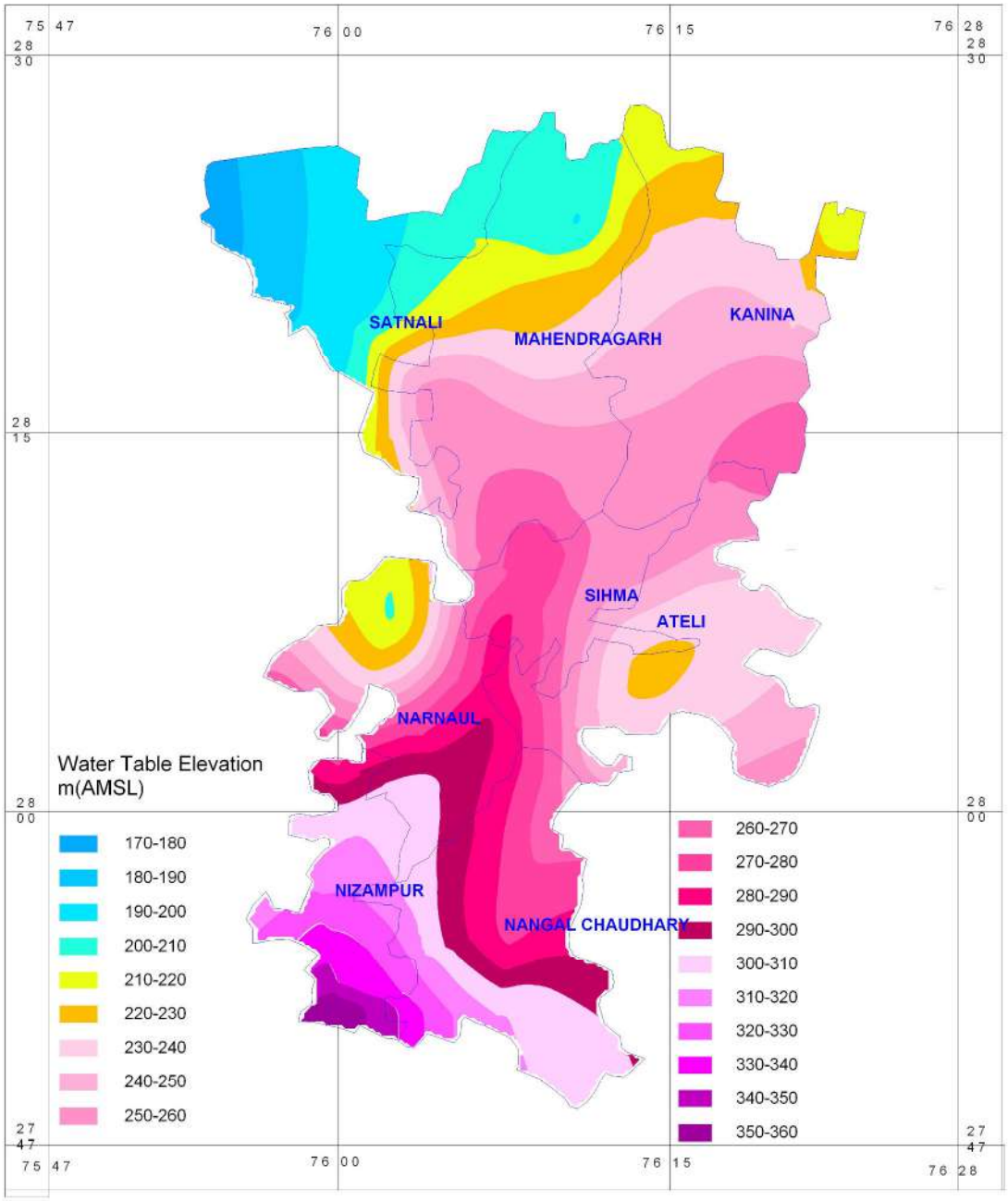
The long term trend in the water level reflected by water level hydrographs is indicative of the change in ground water storage in phreatic zone with time. The ground water observation wells (GWOW) which are indicating a rise in water level trend, this may be due to local hydrological conditions prevailing in the area. Whereas hydrographs showing declining water level trend may be due to over-exploitation of good quality ground water and these area require careful management of surface water and conjunctive use of surface water and ground water. Some of the hydrographs neither showing any substantial rise nor major decline thus indicating that the dynamic storage of phreatic aquifer is being maintained which is being utilized before the monsoon and gets recharged post monsoon.

2.1.3 Ground Water Flow

There is huge range of water table in the district and it ranges from 170 m amsl in the north western and western part to 360 m amsl in the southern part (Fig 9). Therefore, the major ground water flow is towards the north western part of the i.e. towards Mahendergarh

Block and at some parts in western and eastern boundary i.e. Narnaul and Ateli block respectively. This is due to high extraction rate in these blocks because of good quality of ground water at the shallow depths.

Fig 9: Water Table Map of Mahendergarh District (2016)



2.1.4 Exploratory & Geophysical Data

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB & Public Health and Engineering Department (PHED) have been collected and those supported electrical logs have been validate for aquifer map preparation. Deeper well data of

CGWB is available. The details are shown in table 1. The compromised logs derived from lithologs and geophysical well loggings have been taken as reliable data base.

Table 1: Data availability of Exploration Wells in Mahendergarh District

S. No.	Source	No. of wells	Depth (in mbgl)			
			0-100	100-200	200-300	>300
1	CGWB	77	30	46	1	0
2	PHED	100	14	76	10	0
Total		177	44	122	11	0

2.2 Geophysical Studies

Electrical logging has been carried out at 11 sites by CGWB, out of which 4 sites are having fresh ground water quality, 2 sites were having marginal quality of ground water and rest of the sites are having poor quality of ground water or saline. No VES has been conducted in the district.

Ground water quality (based on e-logging)	Location
Fresh water	Brahamanvas, Dallanwas, Kantikhas & Nangal Pipa
Marginal water	Palri & Satnali
Brackish/Saline water	Imlota, Mandola, Dadri, Chandanwas (below 60m) & Dawana

2.3 Hydrochemical

The pH value ranges from 7.96 at Narnaul to 8.76 at Mahendergarh indicating that the ground water is neutral to alkaline (weak base type in nature). Specific conductivity, which ranges from 752μS/cm at Mahendergarh to 4510μS/cm at Narnaul, indicates that ground water is moderate to highly saline in character. However at Deroli Ahir, well water is fresh with EC value as low as 414μS/cm. The total hardness value of ground water ranges widely 55 mg/l at Kanina Deroli Ahir to 691mg/l at Narnaul. The calcium concentrations are generally less than 100mg/l except at Khatand (204mg/l). Magnesium concentration varies from 5.0 mg/l at Jasawas to 108 mg/l at Narnaul. The sodium concentration varies from 45mg/l at Deoli Ahir to 800mg/l at Buchawas. The concentration of potassium is generally less than 50mg/l except at Narnaul (82mg/l) and it ranges from 0.6mg/l at Deorli Ahir to 16mg/l at Khatand.

Carbonate is found to be below the detection limit to 48 mg/l at Kheri Talwa and bicarbonate concentration ranges between 192mg/l at Khatand and 752 mg/l at Kheri Talwa. The chloride concentration in ground water varies broadly between 14mg/l at Deroli Ahir and 791mg/l at Narnaul with exceptionally high concentration of 1276mg/l at Khatand. The sulphate content ranges between 30mg/l at Deroli Ahir and 684mg/l at Buchawas. The nitrate levels vary from 1.1 mg/l at Deorli Ahir to 56 mg/l at Khatand. Exceptionally high level of 432 mg/l and 696 mg/l of nitrate are recorded at Narnaul. The fluoride values more than the permissible limit for drinking water (1.5mg/l) are only at Jassawas (1.83mg/l) , Mahendergarh (2.01mg/l) and ecxceptionally high value at Kheri Talwa(13.83 mg/l).

Trace Elements in Ground Water

Arsenic: As per the analytical data generated, it is observed that isolated case from Kheri Talwa has Arsenic concentration more than the desirable limit of >0.01mg/l(0.014 mg/l).

Iron: The concentration of iron (total) in ground water of the study area ranges from below detection limit to 0.6482 mg/l at Deorli Ahir. It is observed that none of the samples have iron concentration above BIS permissible limit of 1.0 mg/l for drinking water.

Type of Water

The analyzed data on the hydro-chemical facies of ground water in Mahendergarh district has been presented in trilinear diagrams (Fig 10) which indicate distribution of hydro-chemical types present in respective area. Among cations, sodium is the dominant cation and among anions, either chloride or bicarbonate is dominant. Ground water is mostly Na-Cl, Na-HCO3 or Na- mixed anion type.

Suitability for Drinking Purposes

Comparison with BIS assigned concentration values of chemical parameters indicates that most of the waters as per ground water monitoring stations of CGWB are not potable. High concentrations of NO_3 and F are mainly responsible for their non-suitability. Only 36% ground waters having all parameters within the permissible levels are potable.

Suitability for Irrigation Purposes

Plot in the USSL diagram (Fig 11) reveals that ground water falls under C2S1, C3S2, C3S3, C3S4 and C4S4 classes of irrigation rating. Continuous use of such waters in irrigation may cause medium to very high salinity problems and low to very high sodium hazards. Use of such water can best be made in conjunction with good quality water. Classification based on RSC indicates that 45.5% of the ground waters are safe, 9% marginal and the remaining unsafe for irrigational use under normal agricultural practices. However, these waters can be used on soils with adequate permeability and for growing salt tolerant crops.

The detailed water quality and ground water prospect maps prepared by HARSAC, Hissar and is shown in fig 12 & 13 respectively.

Fig 10: Hill Piper Diagram of Mahendergarh District

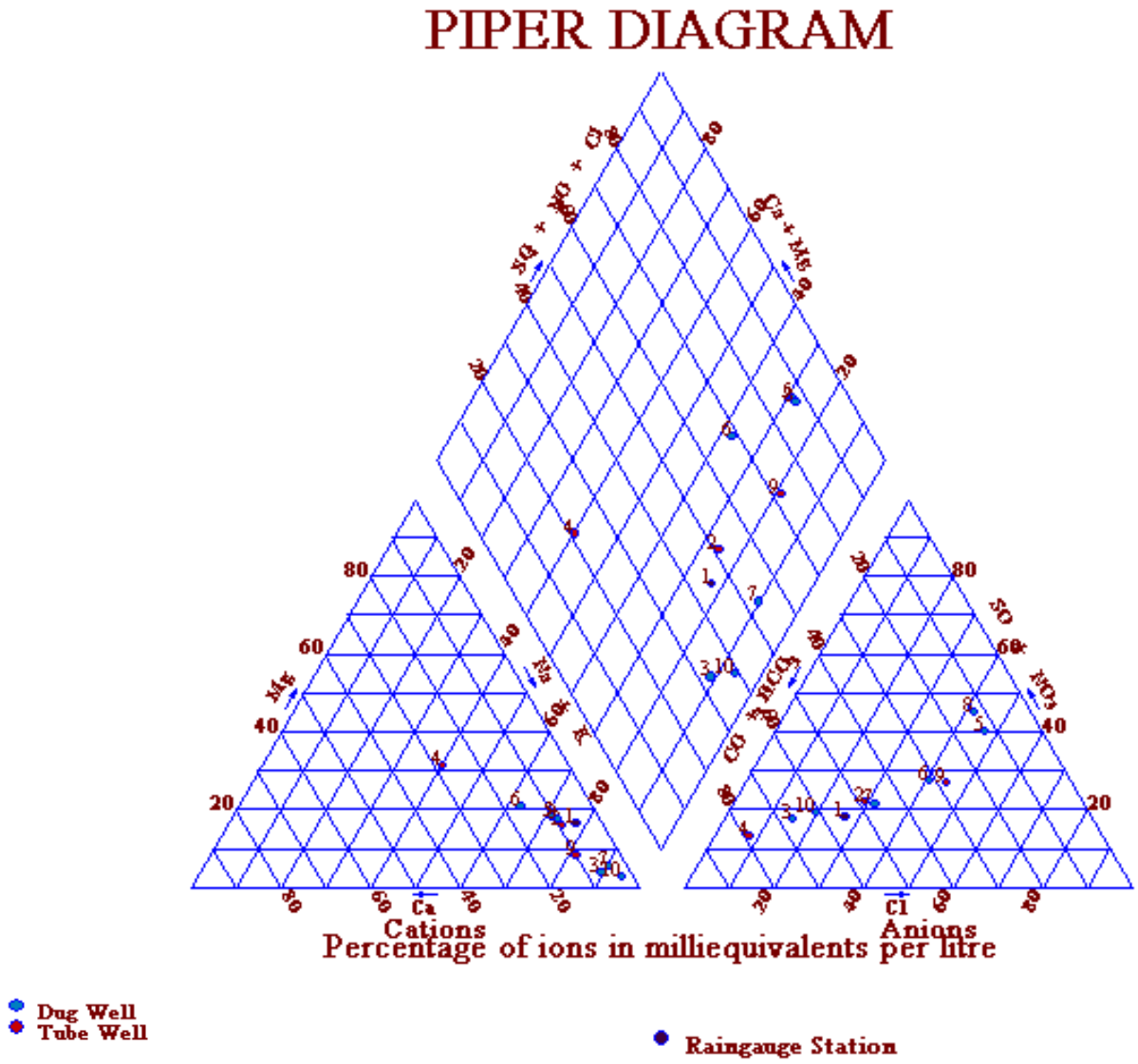


Fig11: US Salinity Diagram of Mahendergarh District

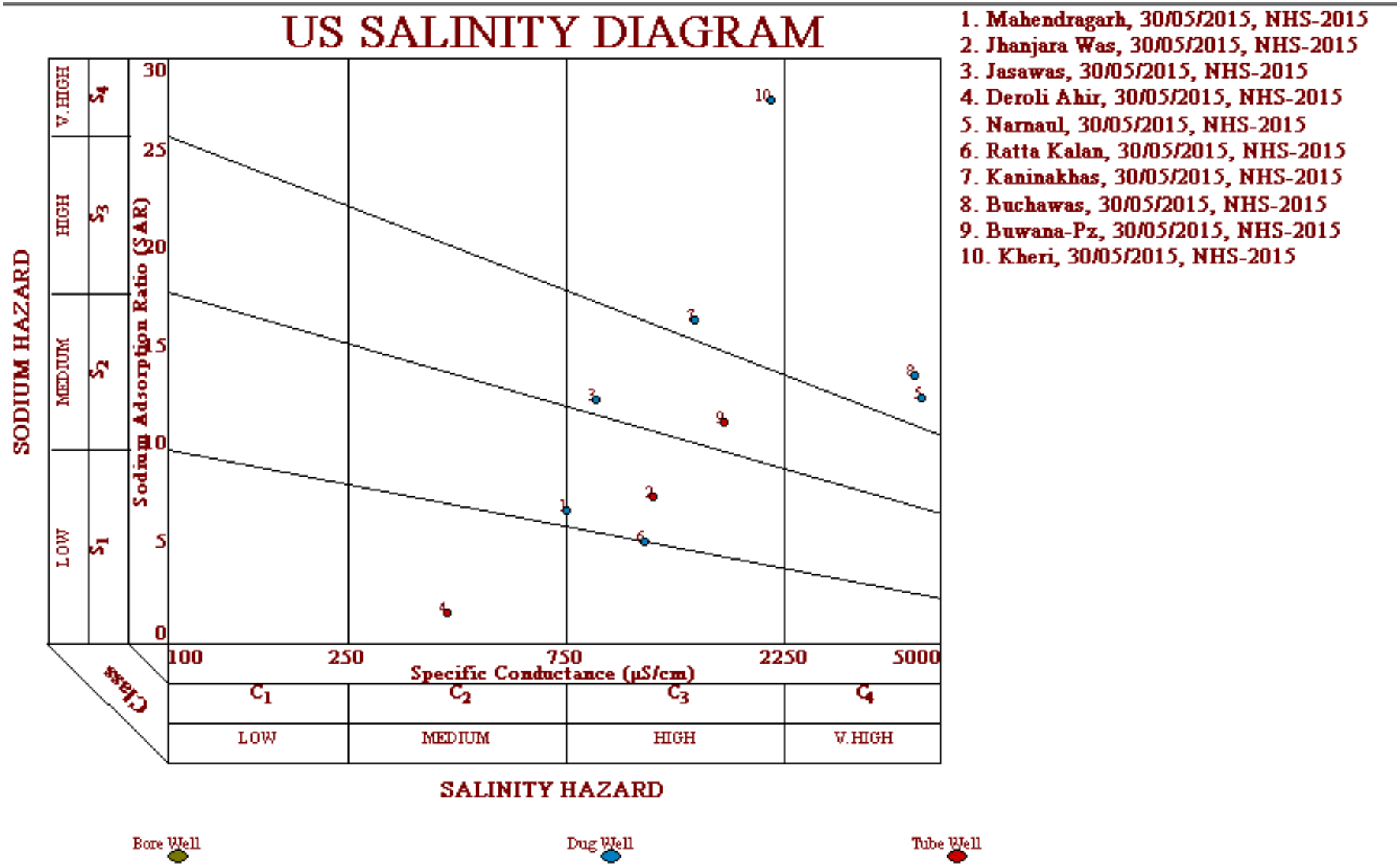


Fig 12: Ground Water Quality Map

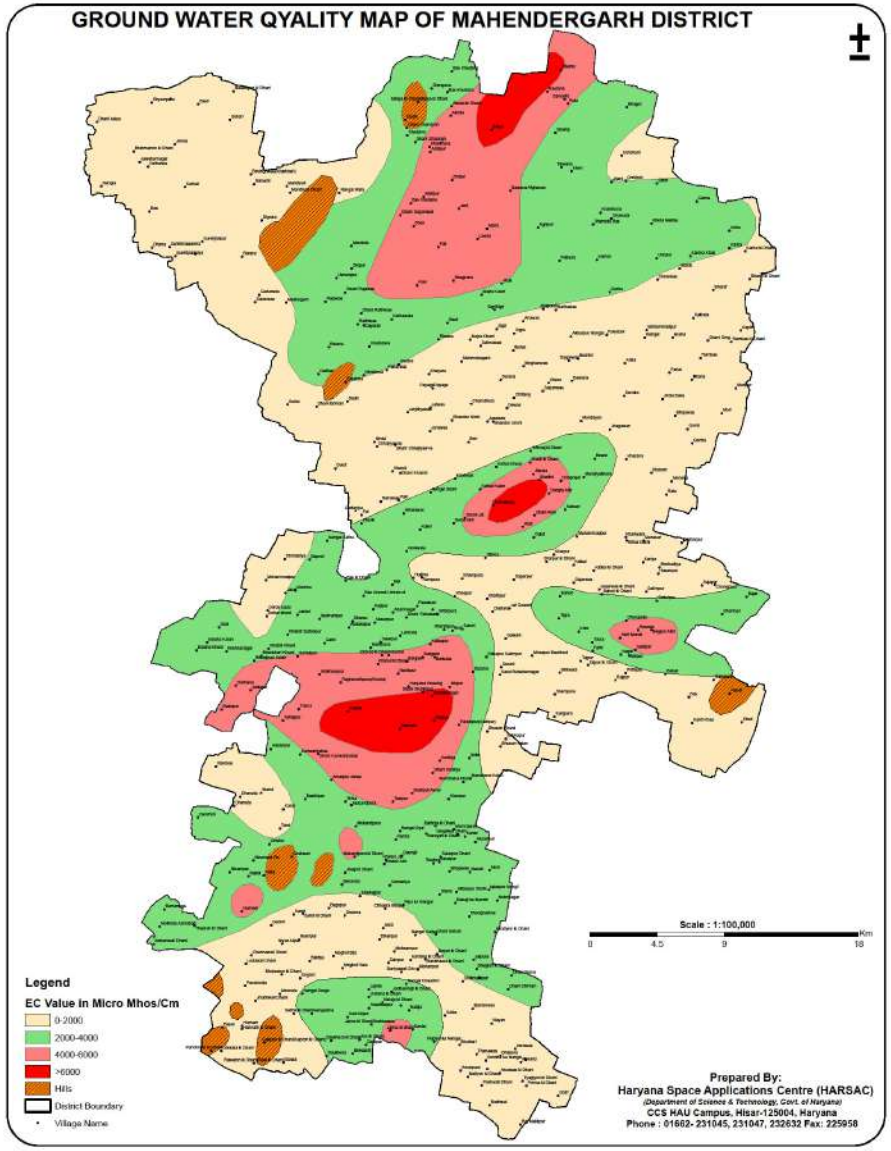
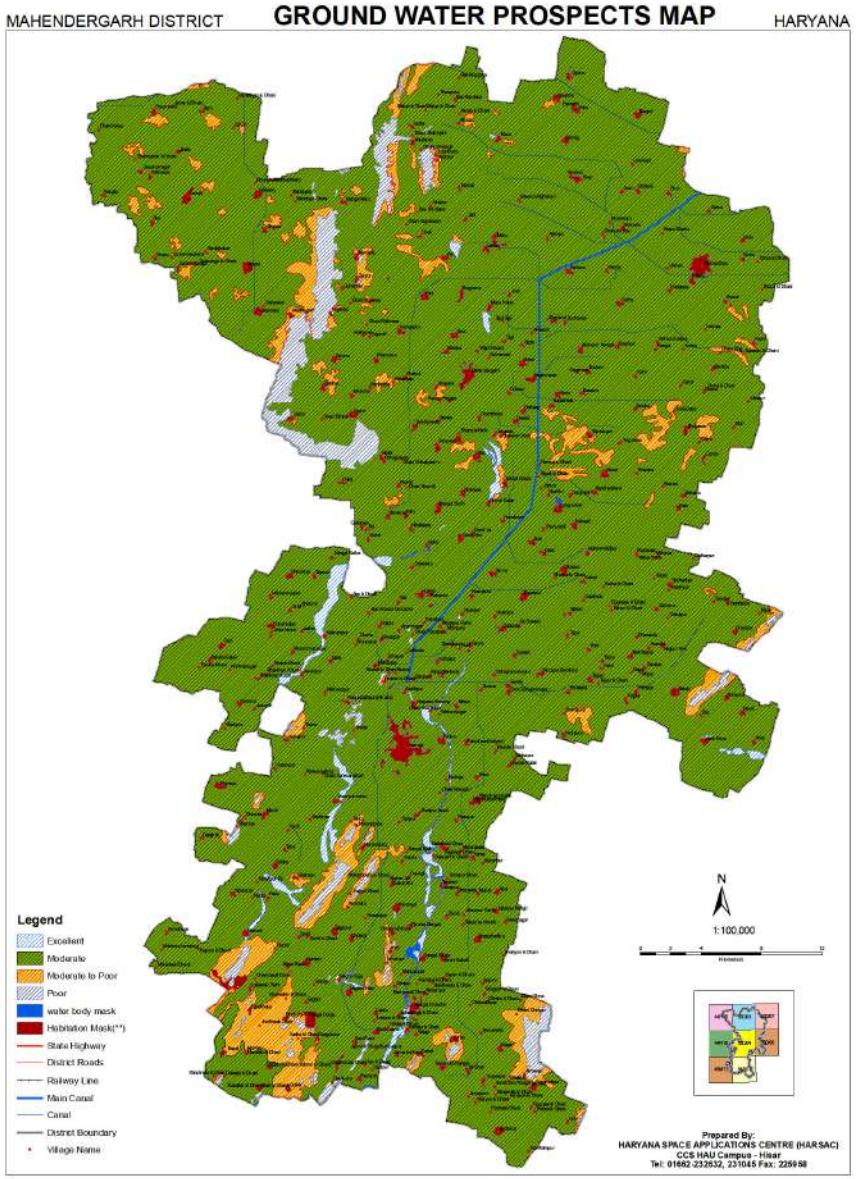


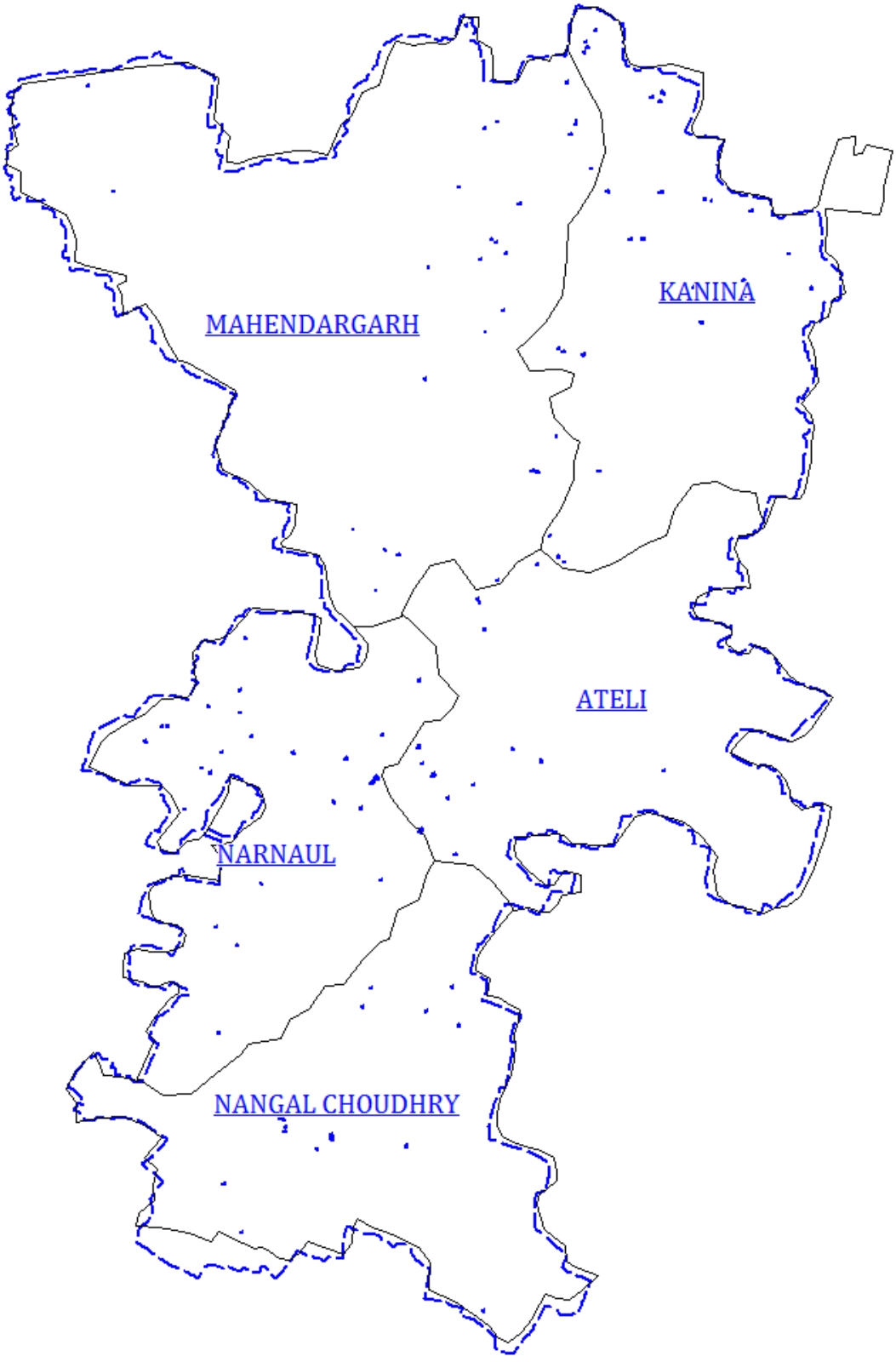
Fig 13: Ground Water Prospect Map



2.4 Water Bodies

There are total 125 water bodies exists in the whole district and their location is shown in fig 14.

Fig 14: Water bodies in Mahendergarh district.

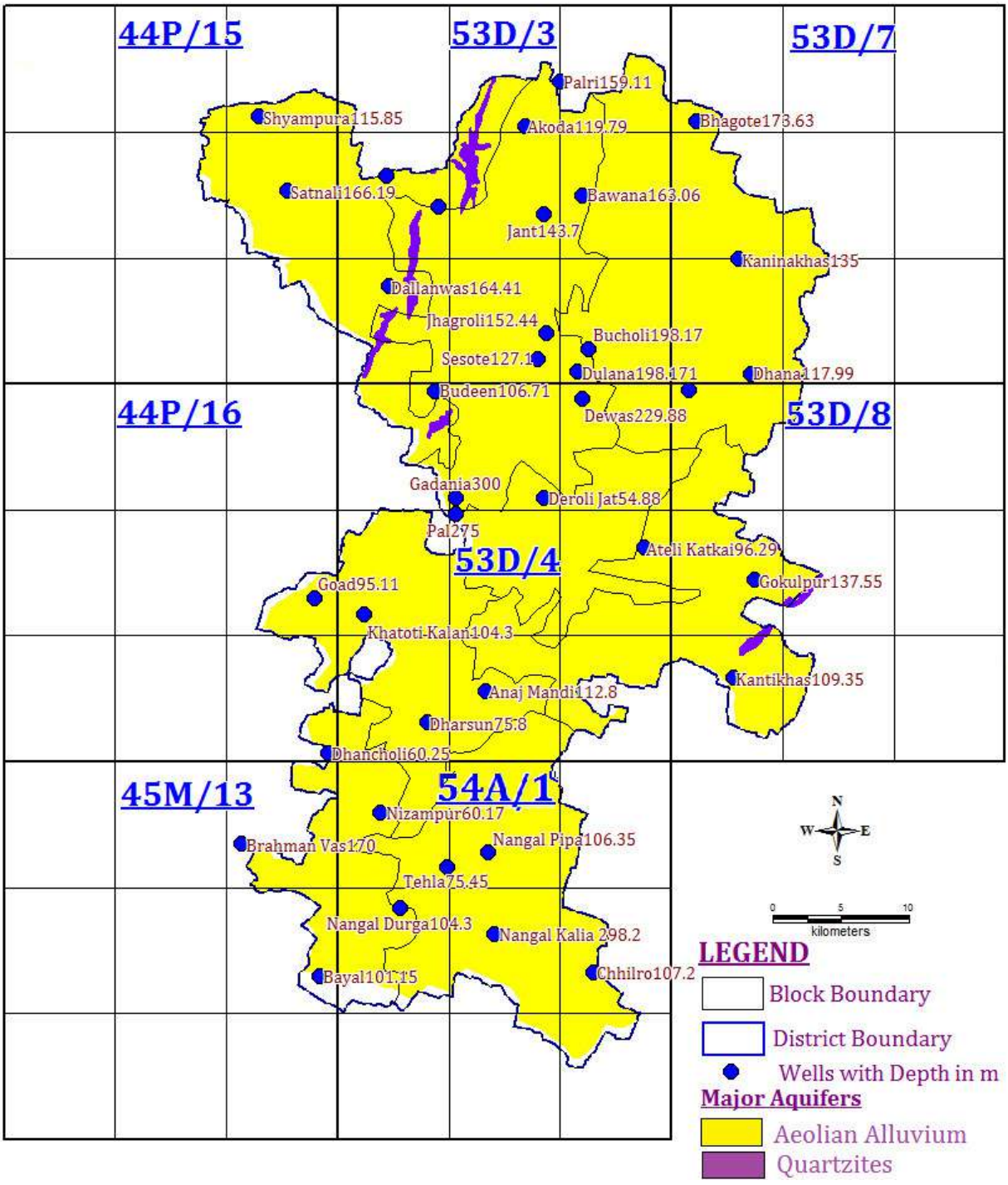


3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Hydrogeological Interpretation & Results

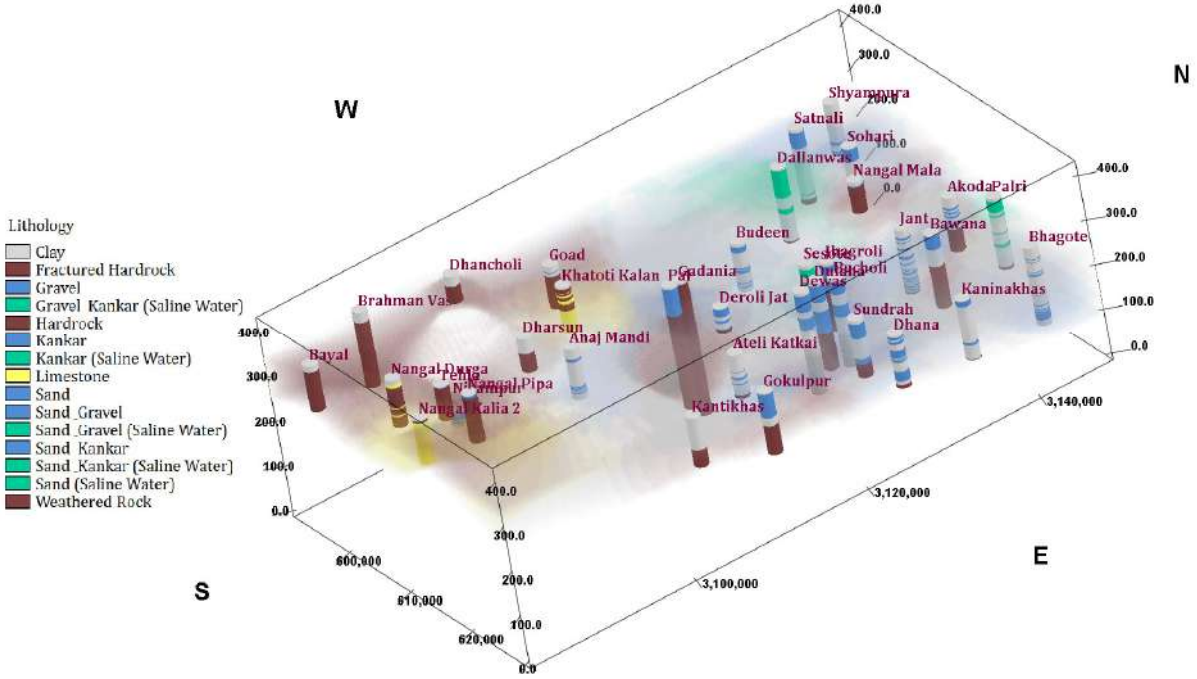
All the available data have been validated for consideration to generate aquifer map. The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig 15. Details are given in Annexure III.

Fig 15: Validated Exploration Data of Mahendergarh District



The locations of validated wells are plotted and litholog is shown in fig 16.

Fig 16: 3Dimension location of validated Exploratory Wells with litholog



Summarized details of the validated and optimized wells are given in table 2.

Table 2: Summary of optimized exploration wells

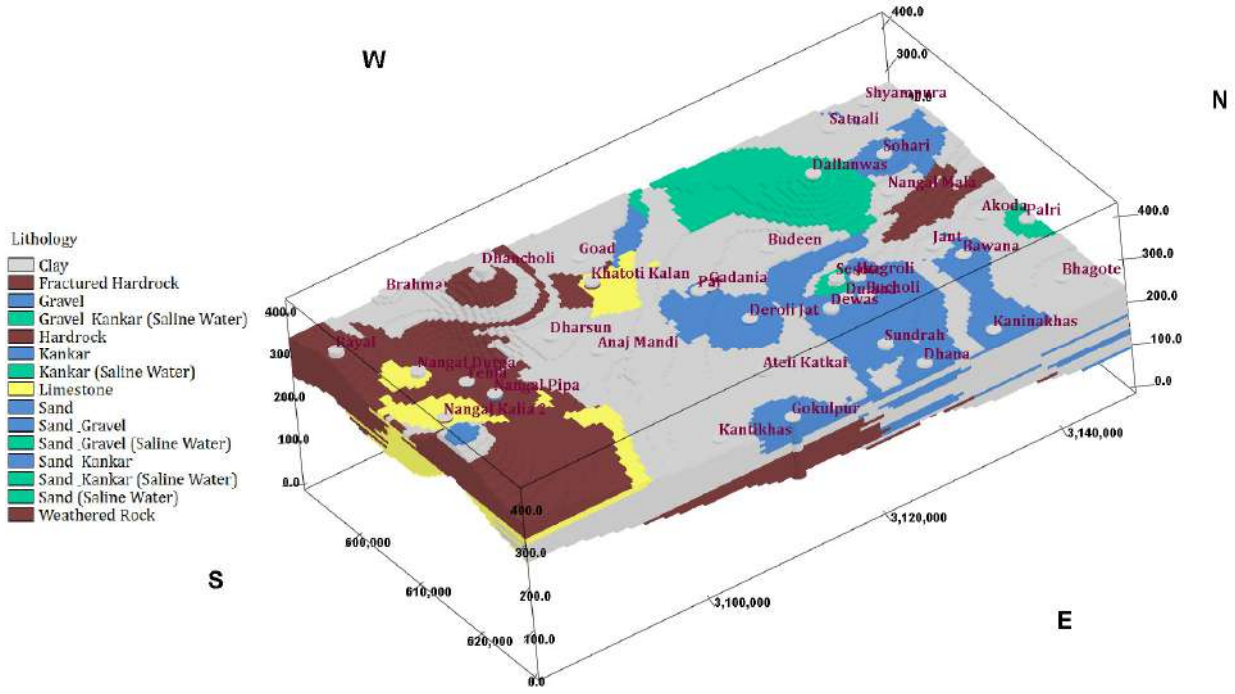
Block	Toposheet		Well Details & Depth			Remarks
			200-300	100-200	<100	
Ateli	53D/4	1B	-	-	1	Deroli Jat (54.88m)
		2B	-	-	-	-
		1C	-	-	-	-
		2C	-	-	1	Ateli Katkai (96.29m)
	53D/8	2A	-	1	-	Golkulpur (137.55m)
		3A	-	1	-	Kantikhas (109.35m)
Kanina	53D/3	2C	-	1	-	Bawana (163.06m)
		3C	-	2	-	Bucholi (198.17m) & Dulana (198.17m)
	53D/7	1A	-	1	-	Bhagote (173.63m)
		2A	-	1	-	Kaninakhas (135m)
		3A	-	1	-	Dhana (117.99m)
	53D/8	1A	-	1	-	Sundrah (128.96m)
Mahendergarh	44P/15	1C	-	1	-	Shyampura (115.85m)
		2C	-	1	-	Satnali (166.19m)
	53D/3	2A	-	1	1	Sohari (141.77) & Nangal Mala (70.4m)

		3A	-	1	-	Dallanwas (164.41m)
		1B	-	2	-	Palri (159.11m) & Akoda (119.79m)
		2B	-	1	-	Jant (143.7m)
		3B	-	2	-	Jhagroli (152.44m) & Sesote (127.1m)
	53D/4	1A	-	1	-	Budeen (106.71m)
		1B	1	-	-	Gadania (300m)
		1C	1	-	-	Dewas (229.88m)
Nangal Chaudhary	45M/13	1C	-	1	-	Brahman Vas (170m)
		2C	-	1	-	Bayal (101.15m)
	53A/1	1A	-	-	1	Tehla (75.45m)
		2A	-	1	-	Nangal Durga (104.3m)
		1B	-	1	-	Nangal Pipa (106.35m)
		2B	1	-	-	Nangal Kalia (298.2m)
		2C	-	1	-	Chhilro (107.2m)
Narnaul	44P/16	2C	-	-	1	Goad (95.11m)
		3C	-	-	1	Dhancholi (60.25m)
	53D/4	2A	-	1	-	Khatoti Kalan (104.3m)
		3A	-	-	1	Dharsun (75.8m)
		2B	1	-	-	Pal (275m)
		3B	-	1	-	Anaj Mandi (112.8m)
	54A/1	1A	-	-	1	Nizampur (60.17m)

3.1.1 Aquifer Geometry & Disposition

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 17. The 3D lithological fence diagram has been prepared using the lithology model and is shown in fig 18.

Fig 17: 3-Dimension Lithological Model of Mahendergarh District



According to the subsurface geology, there is large variability in the lithology as it is having alluvium as well as hardrock aquifers. The alluvium lithological units are sand, kankar, gravel, silt and clay which belongs to the alluvium deposits of recent and sub-recent age. The hardrock units are sandstone, chert, hematite, pegmatites, gneiss, granite, limestone, quartzite, micaschist and slates belongs to Delhi system.

The major aquifer material is sand, kankar and gravel and limestone aquifer also exists at some places. The non-aquifer material is majorly clay, sandstone, chert and granite. As the area is having alluvium as well as hardrock aquifers, its contacts has been plotted in the cross-sections along N-S and W-E directions and are shown in fig 19.

Fig 18: 3Dimension Lithological Fence of Mahendergarh District

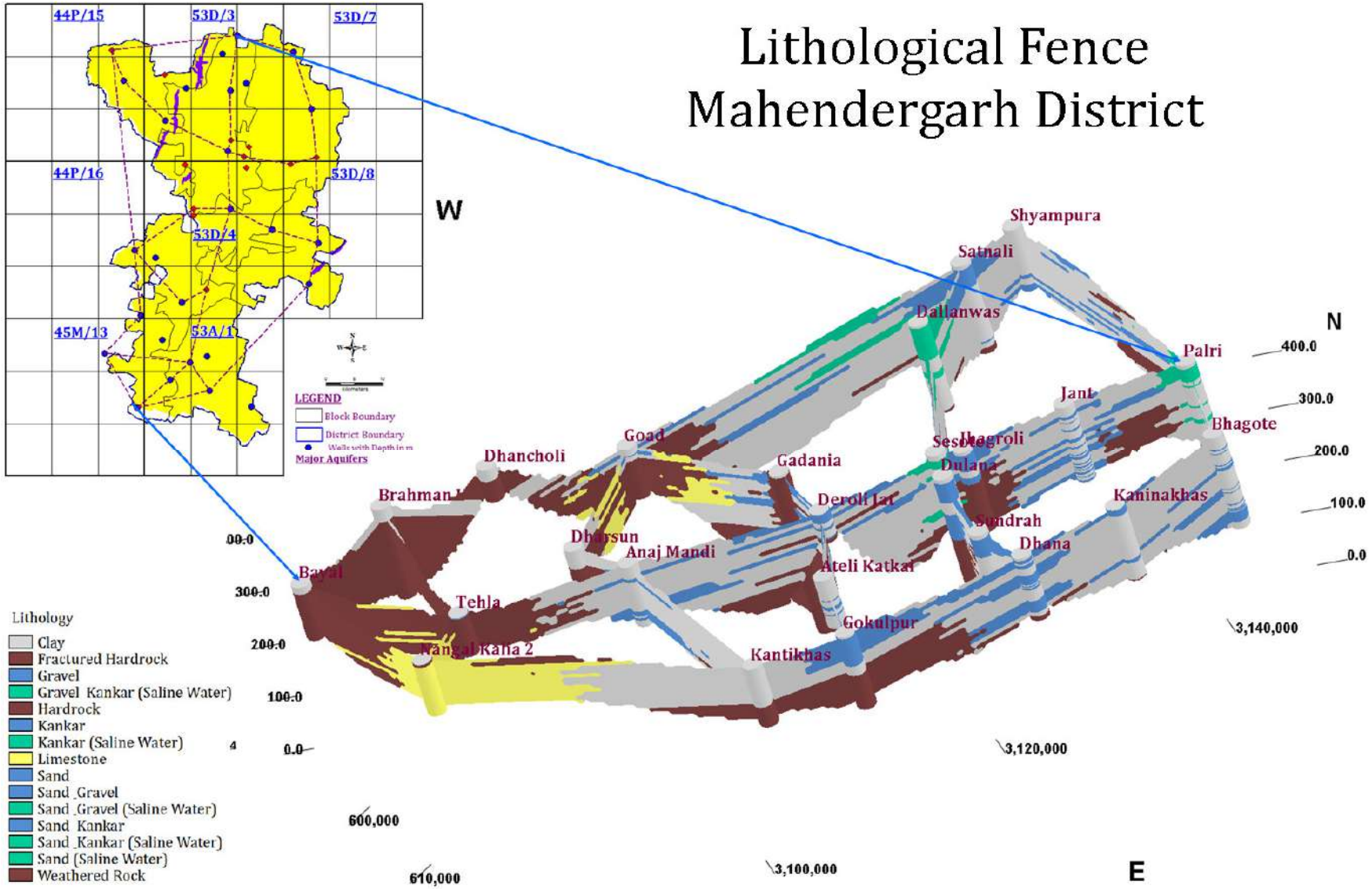
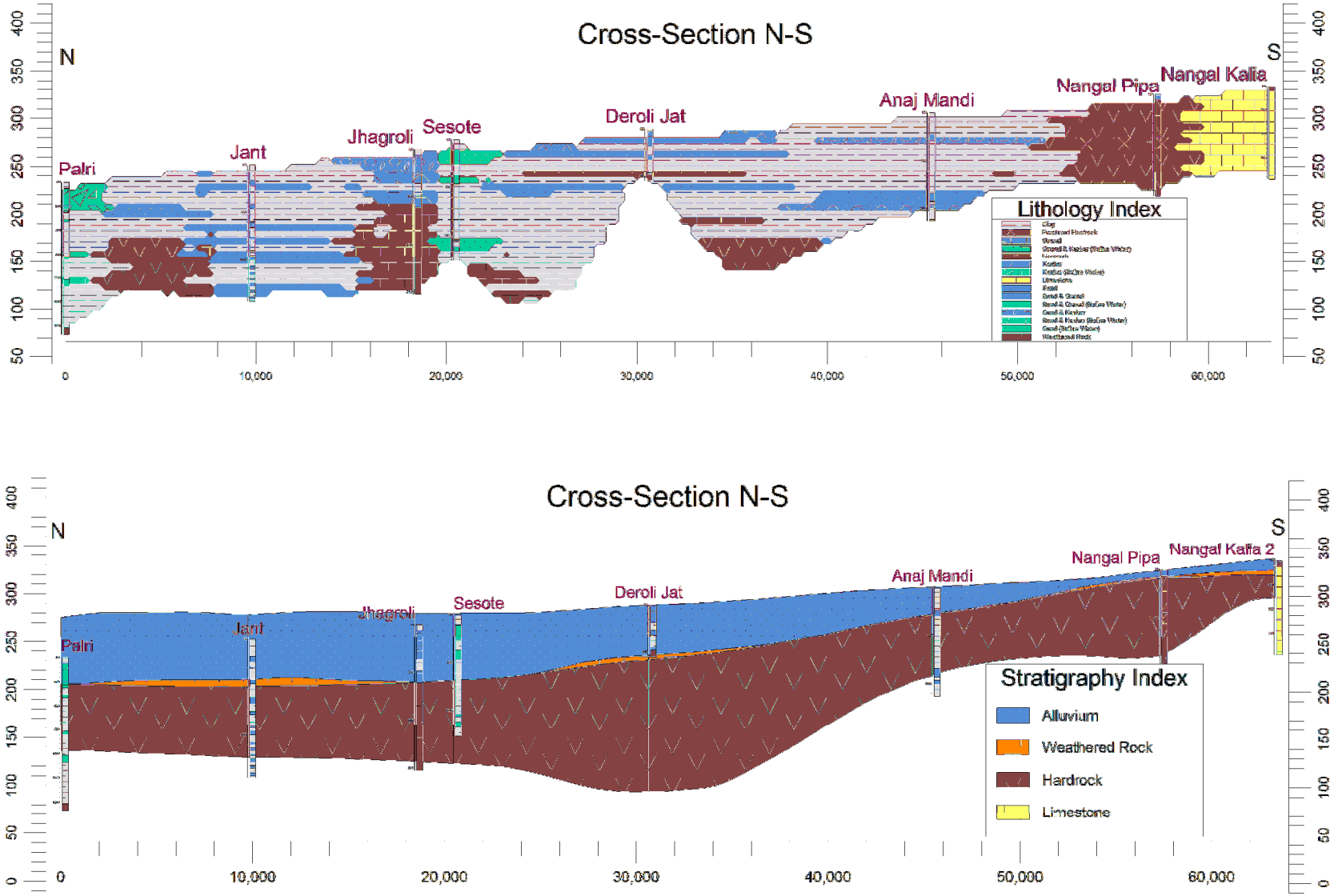
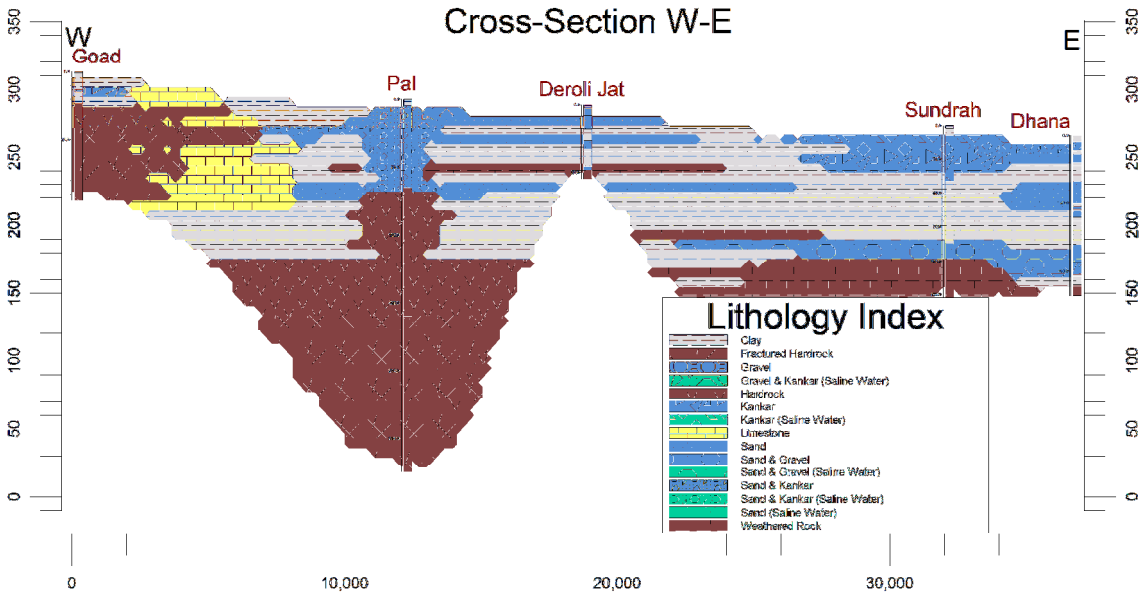


Fig 19: Cross sections along N-S and W-E direction showing the alluvium and hardrock interface along with the lithology

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Goad
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Deroli Jat
Sundrah
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Lithology Index
Clay
Fractured Hardrock
Gravel
Gravel & Kankar (Saline Water)
Hardrock
Kankar
Kankar (Saline Water)
Limestone
Sand
Sand & Gravel
Sand & Gravel (Saline Water)
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Weathered Rock
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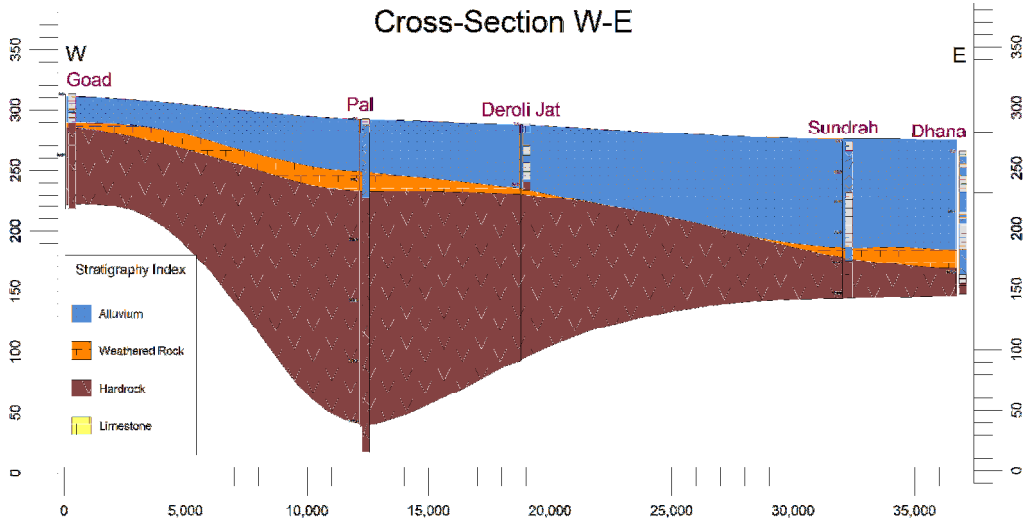
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Weathered Rock
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35,000

4. GROUND WATER RESOURCES

4.1 Ground Water Resources of Multiple Aquifer up to 300m Depth

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

The occurrence of potential aquifers (productive granular zones) up to 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 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.

4.1.1 Unconfined Aquifers-Dynamic Resources

The assessment of total availability of ground water resources encompasses two components namely dynamic resources and in-storage resources. Block wise dynamic resource figures so obtained based on GEC, 1997 norms have been taken as the 1st component for unconfined aquifer. Further in pursuance to the methodology recommended by CGWB to assess total availability of Ground Water Resources, the following procedure has been adopted to calculate in-storage resources and total availability of Ground Water Resources.

The block wise ground water resource potential in the district has been assessed as per GEC-97 as on March 2013. The stage of ground water development ranges between 21% (block-Narnaul) to 137% (block- Kanina). The net ground water availability and gross ground water draft is 256 and 226 mcm respectively. The stage of ground water development in the district is 86% (Table 3).

Table3: Dynamic Ground Water Resource&Development Potential of Mahendergarh District (as on 31.03.13)

Assessment Unit/ Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses	Provision for domestic, and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development
Ateli	**50.99**	37.45	1.34	38.79	3.58	9.96	76
Kanina	**63.84**	86.24	1.12	87.36	1.12	-23.52	137
Mahendragarh	**48.65**	40.38	0.90	41.28	6.81	1.46	85
Nangal Chaudary	**50.01**	43.76	1.29	45.05	7.83	-1.58	90
Narnaul	**42.81**	8.24	0.86	9.10	6.62	27.95	21
Total	**256.30**	**216.07**	**5.51**	**221.58**	**25.96**	**14.27**	**86**

*all the given figures are in mcm

4.1.2 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 20. 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 fresh and saline in-storage ground water resources up to 300m or maximum explored depth is given in table 4. Block wise total ground water resources are given in table 5.

Fig 20: Methodology for Resource Estimation in Aquifer System

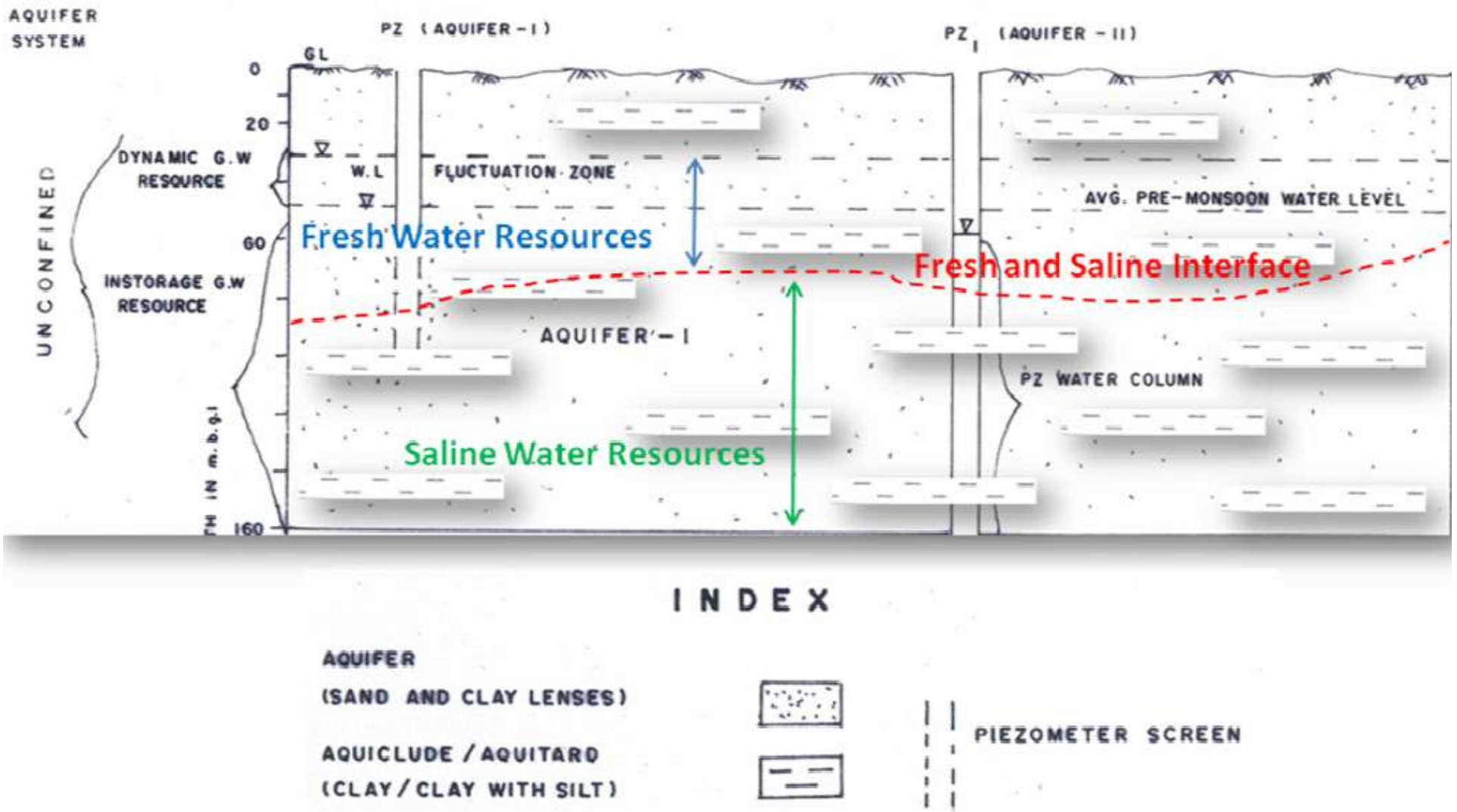


Table 4: Block Wise Instorage Ground Water Resources (up to 300m or max. explored depth)

Name of Assessment Unit	Type of rock formation	Total Areal extent (sq km)	Hilly Area (sq km)	Fresh Water Area (sq km)	Saline/ Brackish Water Area (sq km)	Average Pre-monsoon Water Level (m bgl)	Average Explored Depth (m bgl)	Thickness of the Granular Zone below water level (m)	Depth of bedrock (Min. - Max.) (mbgl)	Average Specific Yield	In-Storage Ground Water Resources [5*9*11] FRESH (mcm)	In-Storage Ground Water Resources [6*9*11] SALINE (mcm)
1	2	3	4	5	6	7	8	9	10	11	12	13
Ateli	Alluvium & Hardrock	318.40	9.08	293.47	15.85	27	138	16	84-99	0.072	338.08	18.26
Kanina		379.38	0.00	374.60	4.78	21	198	37	111-162	0.072	997.93	12.73
Mahendergarh		349.22	22.62	295.68	30.92	32	300	22	59-164	0.072	468.36	48.98
Nangal Chaudary		606.80	14.76	573.88	18.16	10	113	14	6-113	0.072	578.47	18.31
Narnaul		285.67	0.00	279.97	5.70	10	275	22	23-65	0.072	443.47	9.03
Dist. Total (sq.km.)		**1939.5**	**46.46**	**1817.6**	**75.41**						**2826.31**	**107.30**

Table 5: Block-Wise Total Ground Water Resources in Aquifer (in mcm up to 300m or max. explored depth)

Assessment Unit/District	Dynamic Ground Water Resources (As on 31st March 2013)	Fresh In-Storage Ground Water Resources	Saline In-Storage Ground Water Resources	Total Availability of Ground Water Resources (Fresh & Saline)	Volume of Unsaturated Granular Zones (above Water Level) for Natural Recharge (Considered below 2m bgl to WL)	Unsaturated Zone (in m)
Ateli	50.99	338.08	18.26	407.33	2.11	10
Kanina	63.84	997.93	12.73	1074.51	4.32	16
Mahendragarh	48.65	468.36	48.98	565.98	3.83	18
Nangal Chaudary	50.01	578.47	18.31	646.79	2.48	6
Narnaul	42.81	443.47	9.03	495.31	0.00	0
Total	**256.3**	**2826.31**	**107.30**	**3189.92**	**12.74**	**50**

5. GROUND WATER RELATED ISSUES

Ground water level decline is the major problem in the district. Though the ground water quality is not a major problem in the area, the declining water level is imposing a major problem in the district. In absence of any major canal network in the district almost complete dependence on ground water for all types of water needs is a major concern. Out of five blocks in the district two blocks namely Nangal Chaudhary and Narnaul have been notified by Central Ground Water Authority for ground water regulation up to the depth of 100 m bgl. Mahendragarh block of the district has been notified for registration of ground water abstraction structures. The declining water level trend can be seen in the hydrograph shown in fig 21 and plot for normal versus average annual rainfall is shown in fig 22.

Fig 21: Hydrographs of various sites in Mahendergarh district.

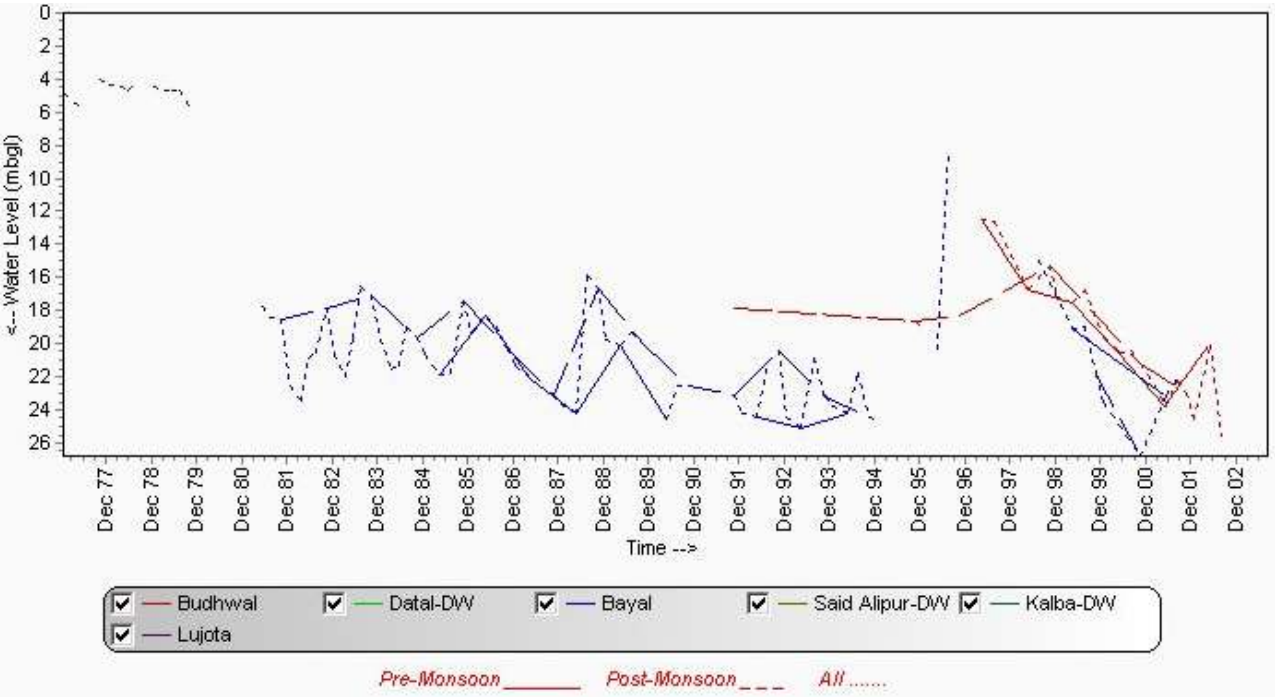
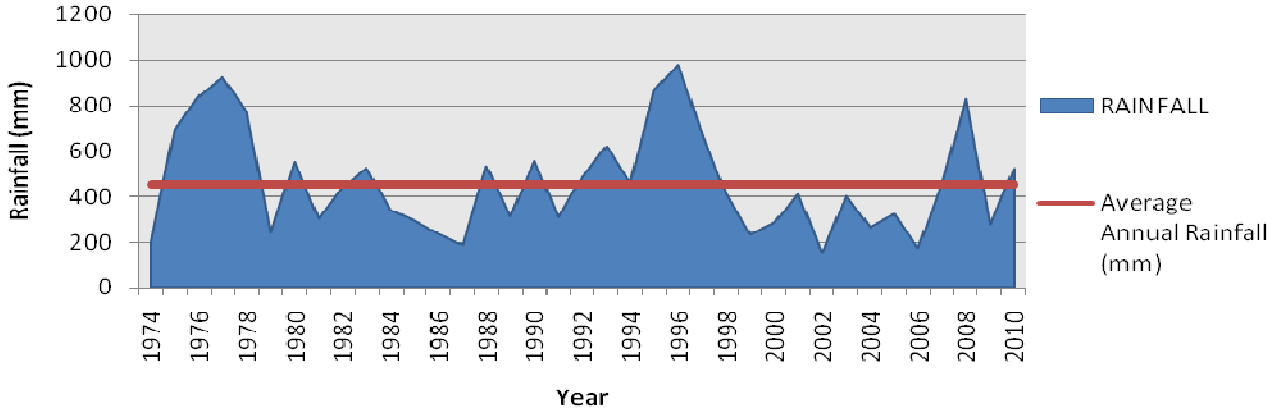


Fig 22: Normal Vs Average Annual Rainfall



5.1 Ground Water Irrigation Scenario

As per the data available from minor irrigation census 2006-07 the detailed number of shallow, deep, tube wells, lined, unlined water distribution system, land holdings of wells are given below in table 6, 7 and shown in fig 23.

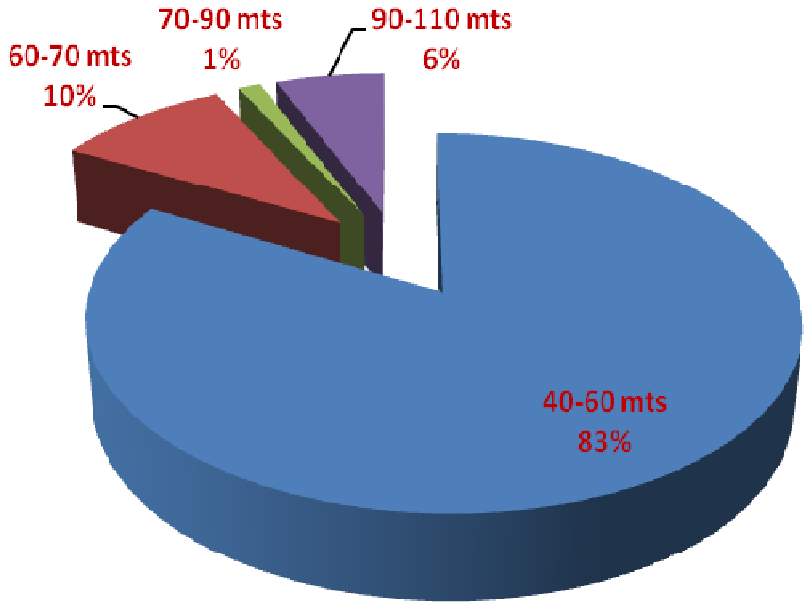
Table 6: Distribution of Tube wells According to Owner's land holding Size

Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Public	Group of Farmers	Total
98	1227	1745	146	566	16593	20375

Table 7: Type of Ground water distribution device

Open Water Channel		
Lined/pucca	Unlined/kutcha	Total
8348	12027	20375

Fig 23: Irrigation tubewells as per depth range.



6. AQUIFER MANAGEMENT PLAN

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

6.1 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. Artificial recharge plan for rural and urban areas, and through recharge pits of Over-Exploited blocks is given in Table 8, 9 & 10 respectively.

Table 8: Artificial Recharge in Rural Area

Name of CD block	Total households (2011 census)	No of Houses taken for Artificial Recharge (10% of total households)	Total No of AR Structures (one structure for 10 households)	Annual Rainfall runoff Available for recharge (MCM) (No of households x avg rooftop area(200 sqm) x runoff coefficient (80%) x rainfall, 228mm)
Ateli	28780	2878	2878	0.151
Kanina	29874	2987	2987	0.124
Mahendragarh	37318	3732	3732	0.159
Nangal Choudhury	26088	2609	2609	0.141
Narnaul	23238	2324	2324	0.214
Total	**145298**	**14530**	**14530**	**0.788**

Table 9: Artificial Recharge in Urban Area

Name of Block	Total Households	Households taken for Artificial Recharge (10%)	Total Roof Top Area (sqm)(=200 sq.mt per household)	Vol. of water available for recharge (mcm)
Ateli	1373	137	27460	0.010
Kanina	2393	239	47860	0.013
Mahendragarh	5402	1399	108040	0.031

Nangal Choudhury	1432	143	28640	0.010
Narnaul	13990	1399	279800	0.171
Total	**24590**	**2459**	**491800**	**0.137**

Table 10: Artificial Recharge through Recharge Pits in Farm

Block Name	Total Geographical Area (in Hectares)	10%of village area taken for farm recharge (sq m)	Total number of recharge pits (1 recharge pit / hector) for 10% area	Annual recharge (mcm)=(Area*Runoff 15%*Rainfall in mm/1000000)
Ateli	30052	30052000	3005	1.97
Kanina	37702	37702000	3770	1.95
Mahendragarh	30344	30344000	3034	3.49
Nangal Choudhury	33237	33237000	3324	2.24
Narnaul	56298	56298000	5630	3.00
Total	**187633**	**187633000**	**18763**	**12.64**

6.2 Potential of Enhancing The Ground Water Use Efficiency

The micro level transformation in the ground water management have vast impact potential to counter extensive ground water depletion faced by the state of Haryana, particularly in overexploited blocks. There are around 12027 (out of 20375) tubewells (59%) operated by farmers for irrigation through unlined/Katcha open channel system in Mahendergarh district where water from the tubewell is discharge to the agricultural field. In this process huge (up to 20 %) quantity of ground water is wasted in soil moisture and evaporation losses. Around 83% of the tube wells are of shallow depth (40- 60m) and remaining are deeper (60-110 m) depth. Thus majority of wells are tapping Aquifer group-1 which is under stress due to overexploitation.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in Mahendergarh district is estimated at 256 MCM. It is expected that around 25% of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby draft will be reduced up to 224 MCM assuming there is no crop diversification by the farmers. The benefit will lead to

saving of precious ground water resources in the area. The measure if implemented will bring down the stage of ground water development from 86% to 74%. The category of the blocks will also improve drastically resulting in boosting of agriculture and industrial development which may be otherwise not sustainable for future.

The tubewells also consume enormous electricity which is subsidized and government incurs significant revenue on this account. The measures therefore will result in saving of energy and money. Pollution impact will be reduced whenever diesel engines are used by the farmers. The environmental and ecological condition in the irrigated land will improve. Unwanted weed growth will also be controlled inside the farm land. This will also be useful in the waterlogged/ shallow water table areas as the seepage losses in these areas also aggravate the water logging. Government should make/launch a mission mode program for installing the underground pipe lines instead of having *katcha* channel in the entire Haryana. Heavy ground water overdraft can be reduced by these efforts. This will ensure more crop per drop. Reduction in stage of development after construction of Pucca channels in irrigated land is given in table 11.

6.3 Water Saving Potential from Crop Diversification

In Mahendergarh district, only Rabi crops can be diversified due to very limited or no paddy area exists in the district. Therefore, following methods can be adopted i.e. sprinkler/drip irrigation/mulching etc.

6.4 Water Saving Through 3/5 Pond System

The disposal of waste water in rural/villages is a major problem. The stagnant waste water smells bad and also acts as breading place for mosquitoes resulting in spread of diseases like Denguem, Malaria, Filaria etc. Therefore proper disposal and reuse of waste water wherever possible will help in controlling diseases as well as meting out scarcity of water. The waste water of households called the grey water collected from bathroom, washing of cloths and kitchen requires less treatment than black water and generally contains fewer pathogens. The treated water can be used for gardening, fodder raising and kitchen gardening.

Under water management for rural areas is that it is revealed that more than 90% of waste water generated in rural areas is grey water. For the treatment of waste water at village level by natural way, a system has been evolved called 3/5 pond system. The grey water of the

village collected through the drains/nallas collected at a common point and passed through the iron mesh of different sizes and then allowed to pass through large shallow basins or ponds. Its pathogenicity is reduced and stabilized water becomes reusable. The field photographs of this three and five pond systems adopted in different villages of Karnal district are given in figure 24.

There are 125 village ponds existed in Mahendergarh district and recharge to groundwater from few of village ponds are explained in sub-chapter-1.9. In addition to this Industrial sectors may also initiated to adopt the surrounding village ponds with a prime objective of artificial recharge to groundwater through rainwater runoff. Periodically desiltation and cleaning of ponds and plantation of trees along the pond banks improve the quality of water in the ponds and ultimately this water is used for irrigation and recharge to ground water.

Figure 24: A view of village tanks of five pond / three pond system of water treatment under natural process

The above mentioned waste water utility techniques of village ponds can be adopted for every village for ground water development. The utilization of waste water though ponds in Mahendergarh district is given in table 12. The domestic demand is taken as person is 70 lpcd and out of this 80% will be domestic effluent. The 80% of water i.e waste can be saved in the ponds; the pond water can be treated and can be used for irrigation purpose. These are ultimately reflected to reduce in the draft of groundwater from tube well and reductions in change of present stage of development.

Scope of quantitative impact on stage of development after applying various management strategies is given in Table 13 (Census data, 2011).

Table 11: Reduction in stage of development after construction of Pucca channels in irrigated land

Block	Net Annual Ground Water Availability (mcm)	Gross Irrigation Draft (present in mcm)	Gross Ground Water Draft for Domestic & industrial supply (mcm)	Percentage of unlined channel	Wastage through unlined channel, (mcm) [3*4*0.25]	Potential of Reduced irrigation overdraft (mcm) [2-5]	Gross draft after saving of water (mcm) [6+3]	Present Stage of Development (%)	Reduction in stage of development after constructing pucca channel [7/1*100]
	1	2	3	4	5	6	7	8	9
Ateli	50.99	37.45	1.34	59	5.52	31.93	33.27	76	65
Kanina	63.84	86.24	1.12	59	12.72	73.52	74.64	137	117
Mahendra garh	48.65	40.38	0.9	59	5.96	34.42	35.32	85	73
Nangal Chaudary	50.01	43.76	1.29	59	6.45	37.31	38.60	90	77
Narnaul	42.81	8.24	0.86	59	1.22	7.02	7.88	21	18
Total	**256.30**	**216.07**	**5.51**		**31.87**	**184.20**	**189.71**	**86**	**74**

Table 12: Reduction in stage of development after adopting 3/5 Pond System

Block	Net Annual Ground Water Availability (mcm)	Total draft (mcm)	Saving of water through waste water of pond	Gross draft after saving of water (mcm)	Existing stage of Development (%)	SOD after wards
Ateli Nangal	50.99	38.79	3.14	35.65	76	70
Kanina	63.84	87.36	3.20	84.16	137	132
Mahendra Garh	48.65	41.28	4.18	37.10	85	76
Nangal Chaudhary	50.01	45.05	3.07	41.98	90	84
Narnaul	42.81	9.1	2.55	6.55	21	15
Total	**205.31**	**182.79**	**12.99**	**169.80**	**86**	**83**

Table 13: Scope of Quantitative Impact on Stage of Development after applying various management strategies

Block (OE blocks)	Net Ground Water Availability (mcm)	Total Draft (mcm)	Present Stage of draft (SOD) (%) As per 2013	Reduction in draft by different water saving method			SOD afterwards (%)
				Replace water courses by UG Pipes (mcm)	Adopt artificial recharge (mcm)	Adopting 3 or 5 Pond system (mcm)	
Kanina	63.84	87.36	137	74.64	2.09	3.20	**12**

Table 13 shows reduction of ground water draft by various water saving methods and here is huge potential of irrigation overdraft by replacing water courses by underground pipelines. The rainfall in the area is low about 400mm/year; hence the adoption of artificial recharge measures will only save 13.57mcm whereas as adoption of 3/5 pond system can save up to 12.99mcm of groundwater.

7. BLOCK WISE AQUIFER MAPS

AND

MANAGEMENT PLAN

I. Ateli Block (318.40 sq km)

Population (2011)	Rural-153623 Urban-7619 Total-161242
Rainfall	Monsoon -320.80mm Non Monsoon-115.04mm
Average Annual Rainfall	435.84.6mm
Agriculture and Irrigation	Major Crops- Bajra, Wheat & Rabi Oilseeds Other crops-Gram, cotton & Barley Net Area Sown-253.36sqkm Total Irrigated Area-242.25sqkm
Water Bodies	17 nos.

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

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

Water level Behavior (2016):

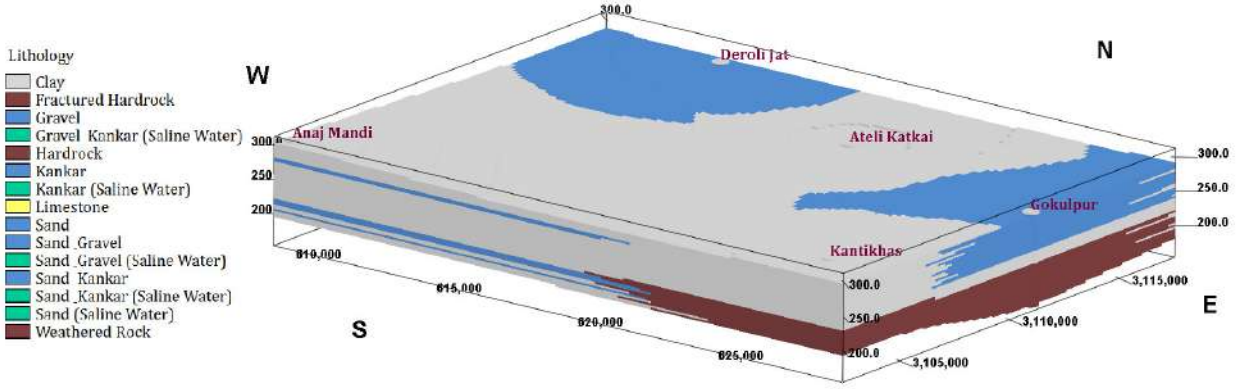
Pre Monsoon-22.4-66.5 mbgl & Post Monsoon-18.9-22.6 mbgl

Aquifer Disposition: Single Aquifer System

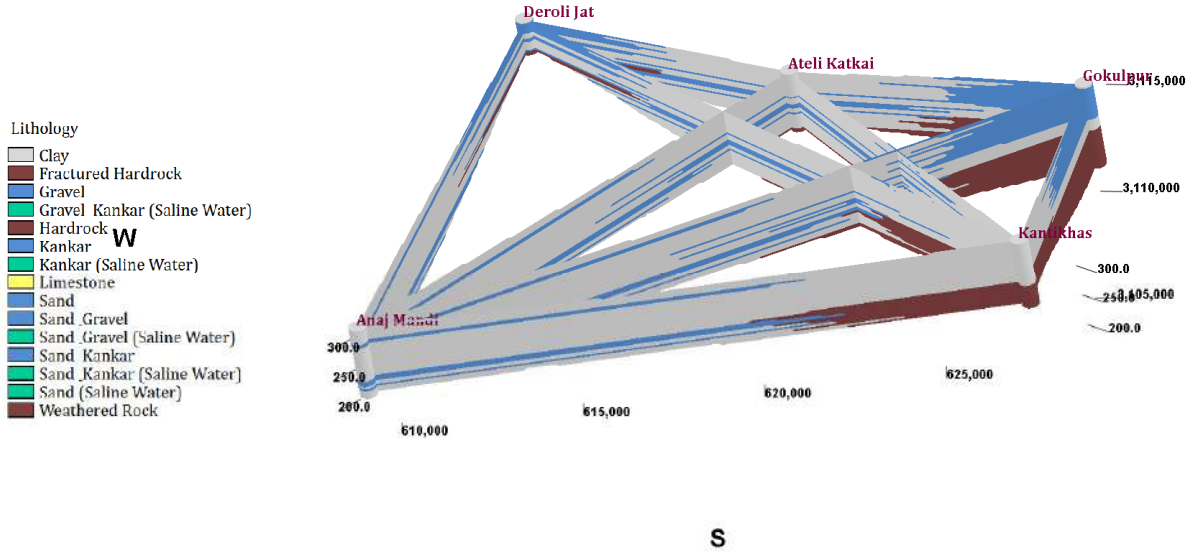
Aquifer comprises of fresh and saline water and the main aquifer formations are sand and mixture of sand with kankar. The non-aquifer material comprises of clay. The basement rock encountered at a depth of 73 mbgl with 10m thick weathered zone towards the NE part of the block.

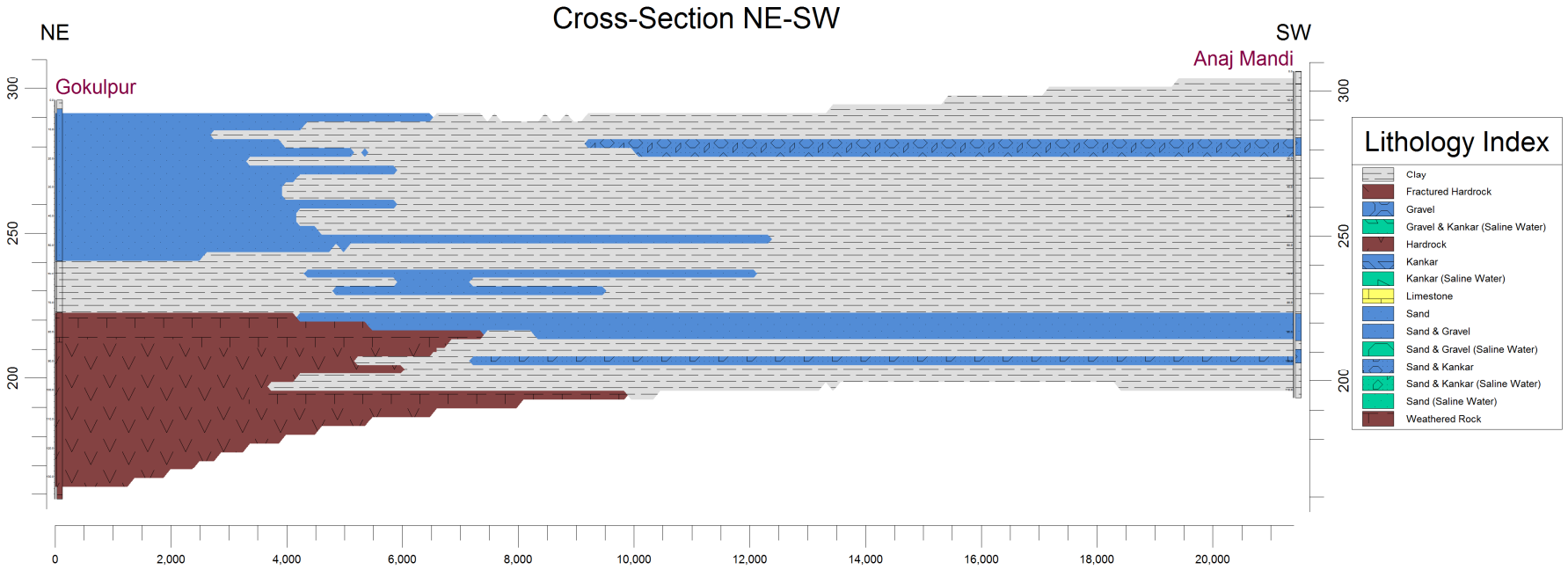
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (2-138m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	26	151-364	12	NA

3D Lithology model



3D Lithology Fence

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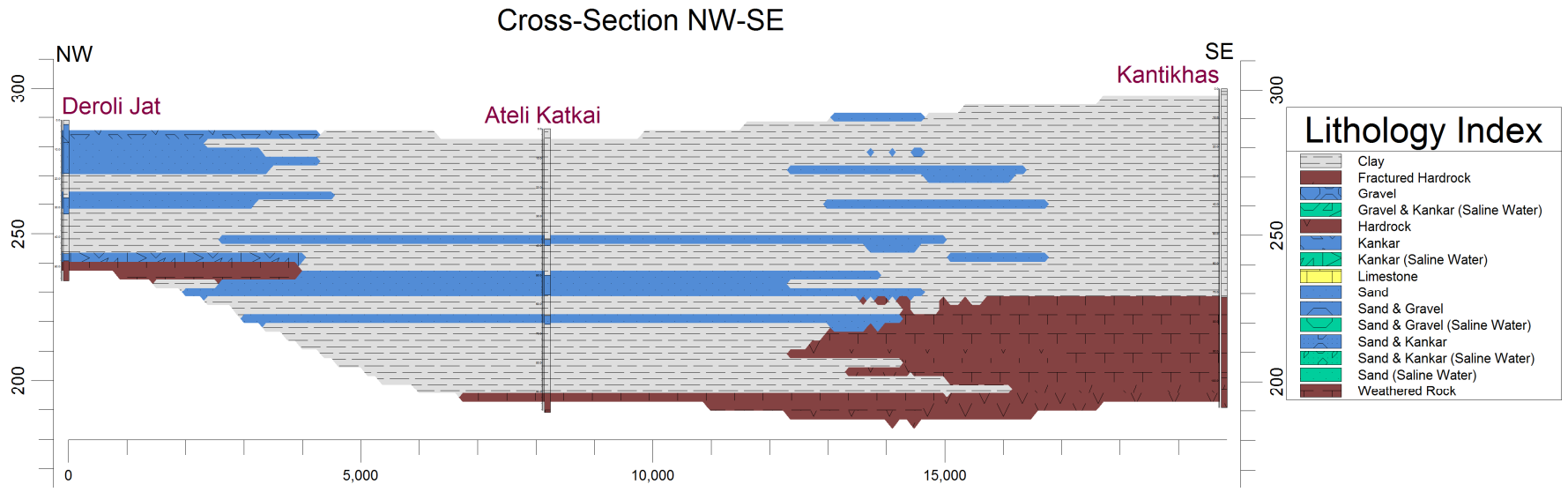
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Fractured Hardrock
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Limestone
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Sand & Gravel
Sand & Gravel (Saline Water)
Sand & Kankar
Sand & Kankar (Saline Water)
Sand (Saline Water)
Weathered Rock

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	50.99
	In-storage Aquifer I	356.34 (F=338.08, S=18.26)
	Total	407.33
Ground Water Extraction (mcm)	Irrigation (2013)	37.45
	Domestic & Industrial (2013)	1.34
Future Demand for domestic & Industrial sector (2025) (in mcm)		3.58
Chemical Quality of ground water		No quality problem (Details in ANNEXURE II)
Other issues		Declining ground water level trend (2.0-2.5m/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 (27m) is 2.11mcm.
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 5.52mcm volume of water wastage Adopt Sprinkler/drip irrigation/mulching etc
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

II. Kanina Block (379.38 sq km)

Population (2011)	Rural-156383
	Urban-12989
	Total-169372
Rainfall	Monsoon -265.40mm Non Monsoon-79.70mm
Average Annual Rainfall	345.1mm
Agriculture and Irrigation	Major Crops- Bajra, Wheat & Rabi Oilseeds
	Other crops-Gram, cotton & Barley
	Net Area Sown-328.52sqkm
	Total Irrigated Area-325.72sqkm
Water Bodies	33 nos.

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

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

Water level Behavior (2016):

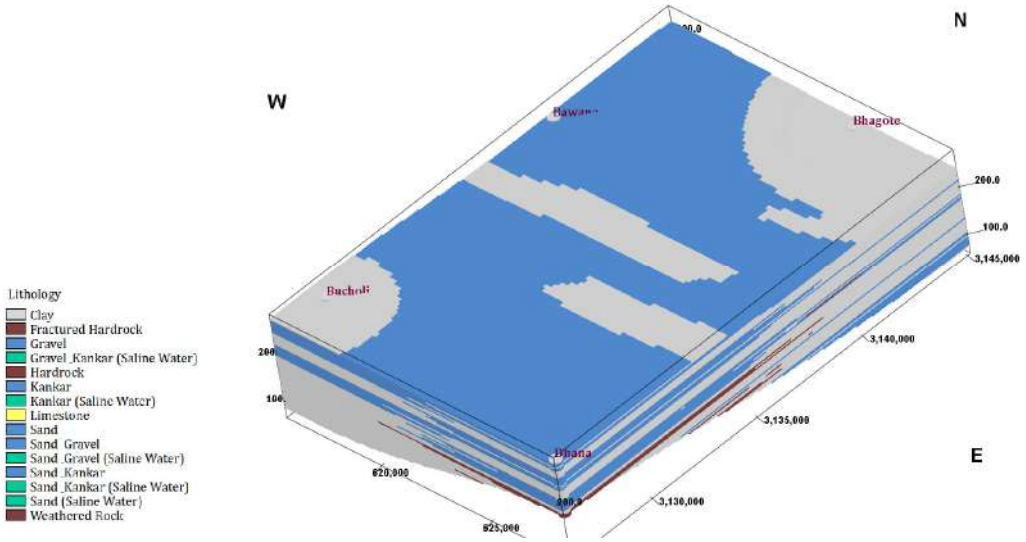
Pre Monsoon-17.7-38.5 mbgl & Post Monsoon-- mbgl

Aquifer Disposition: Single Aquifer System

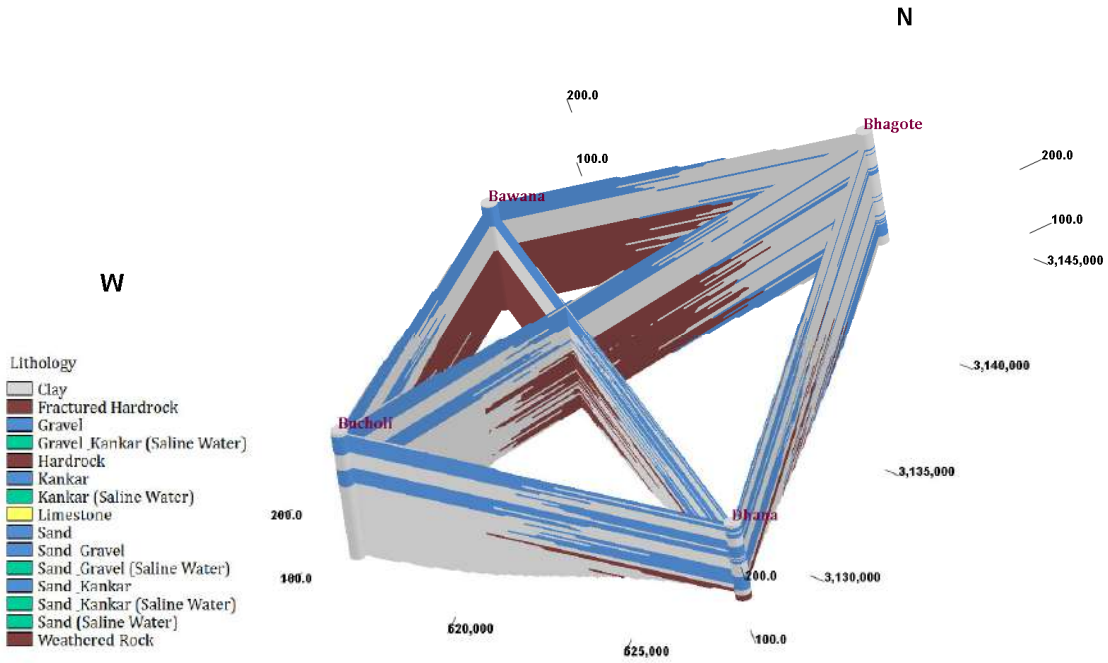
Aquifer comprises of fresh and saline water and the main aquifer formations are sand and mixture of sand with kankar/gravel. The non-aquifer material comprises of clay. The basement rock encountered at a depth of 69 mbgl with approx. 30m thick weathered zone towards the western part of the block.

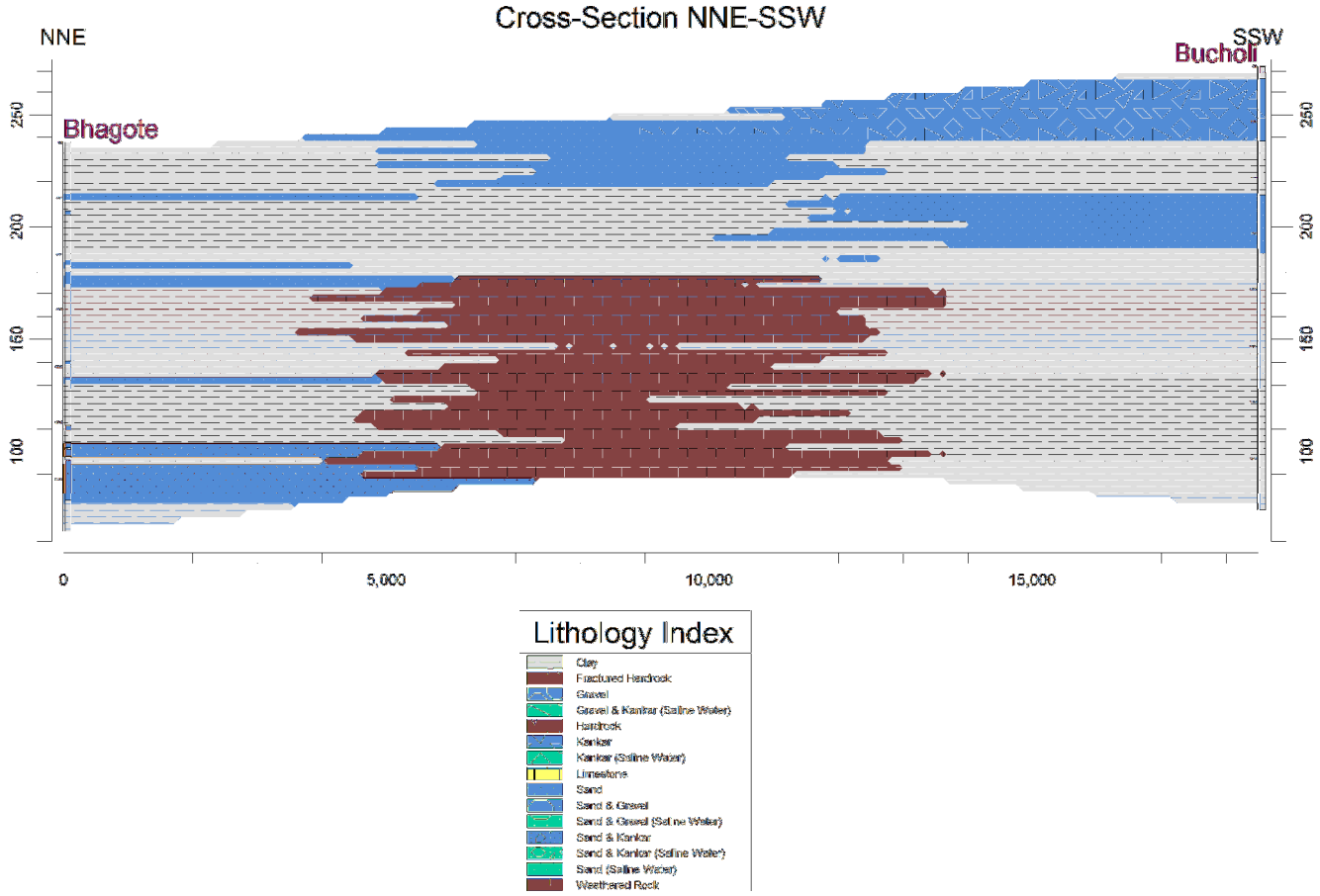
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (2-198m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	53	-	12	NA

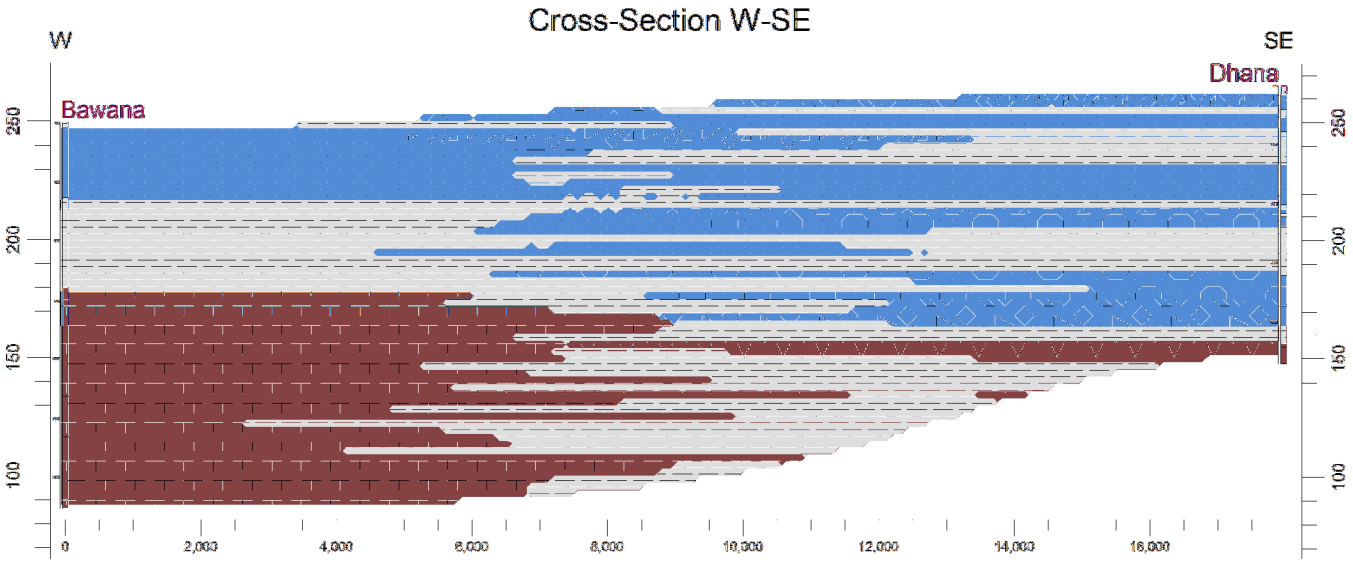
3D Lithology model



3D Lithology Fence




Cross-Section NNE-SSW
NNE
SSW
Bhagote
Bucholi
250
200
150
100
0
5,000
10,000
15,000
Lithology Index
Clay
Fractured Hardrock
Gravel
Gravel & Kankar (Saline Water)
Hardrock
Kankar
Kankar (Saline Water)
Limestone
Sand
Sand & Gravel
Sand & Gravel (Saline Water)
Sand & Kankar
Sand & Kankar (Saline Water)
Sand (Saline Water)
Weathered Rock


Cross-Section W-SE
W
SE
Bawana
Dhana
250
200
150
100
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	63.84
	In-storage Aquifer I	1010.66 (F=997.93, S=12.73)
	Total	1074.51
Ground Water Extraction (mcm)	Irrigation (2013)	86.24
	Domestic & Industrial (2013)	1.12
Future Demand for domestic & Industrial sector (2025) (in mcm)		1.12
Chemical Quality of ground water		No quality problem (Details in ANNEXURE II)
Other issues		Declining ground water level trend (67.5-72.2cm/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 (21m) is 4.31mcm.
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 12.72mcm volume of water wastage Adopt Sprinkler/drip irrigation/mulching etc
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

III. Mahendragarh Block (349.22 sq km)

Population (2011)	Rural-204370
	Urban-29128
	Total-233498
Rainfall	Monsoon -263.80mm Non Monsoon-91.60mm
Average Annual Rainfall	355.4mm
Agriculture and Irrigation	Major Crops- Bajra, Wheat & Rabi Oilseeds
	Other crops-Gram, cotton & Barley
	Net Area Sown-449.93sqkm
	Total Irrigated Area-422.67sqkm
Water Bodies	30 nos.

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

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

Water level Behavior (2016):

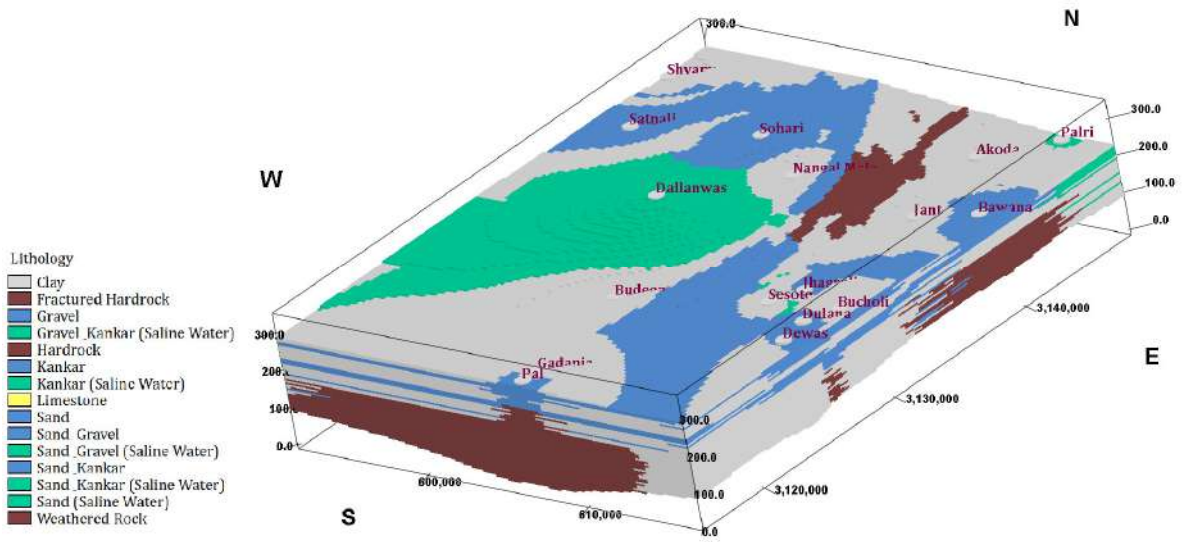
Pre Monsoon-12.1-84.7 m bgl & Post Monsoon-12.6-84.0 m bgl

Aquifer Disposition: Single Aquifer System

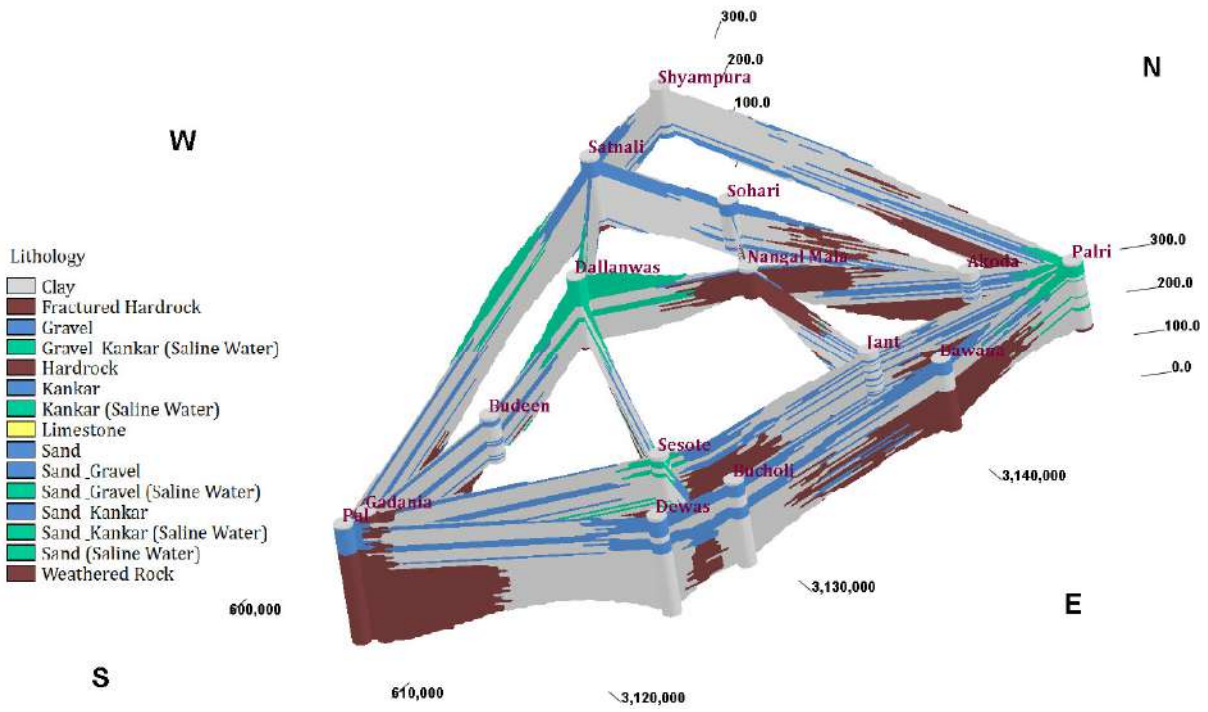
Aquifer comprises of fresh and saline water and the main aquifer formations are sand, kankar and mixture of sand with kankar/gravel. The non-aquifer material comprises of clay. The basement rock encountered shallowest at 5 mbgl and deepest at of 160 mbgl with weathered zone thickness ranges from 6 to 46m.

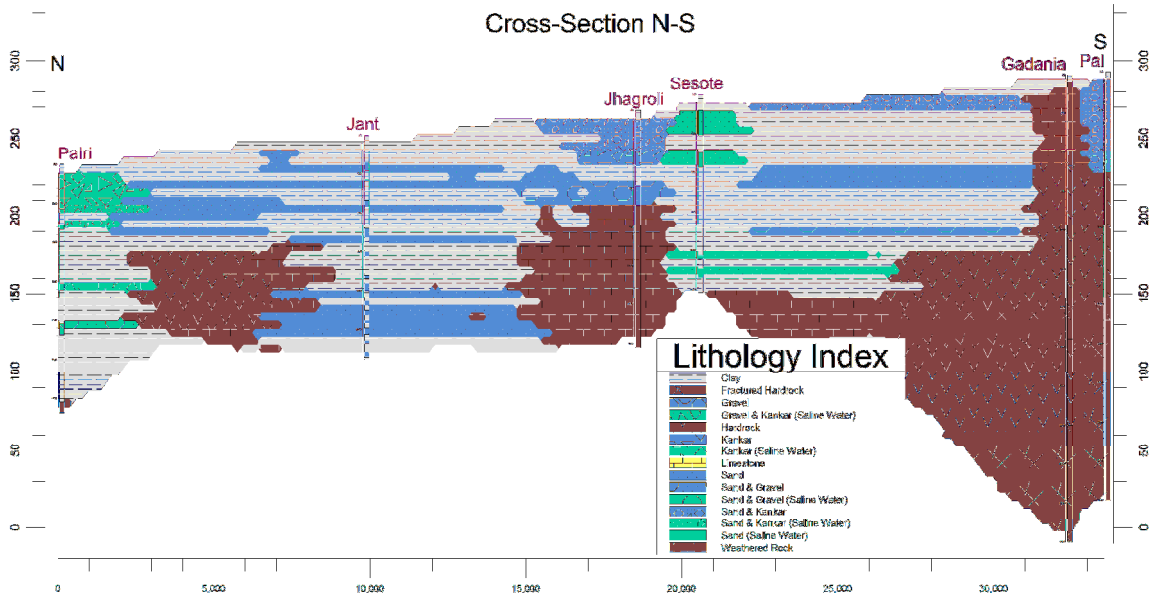
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (2-160m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	40	352-548	12	NA

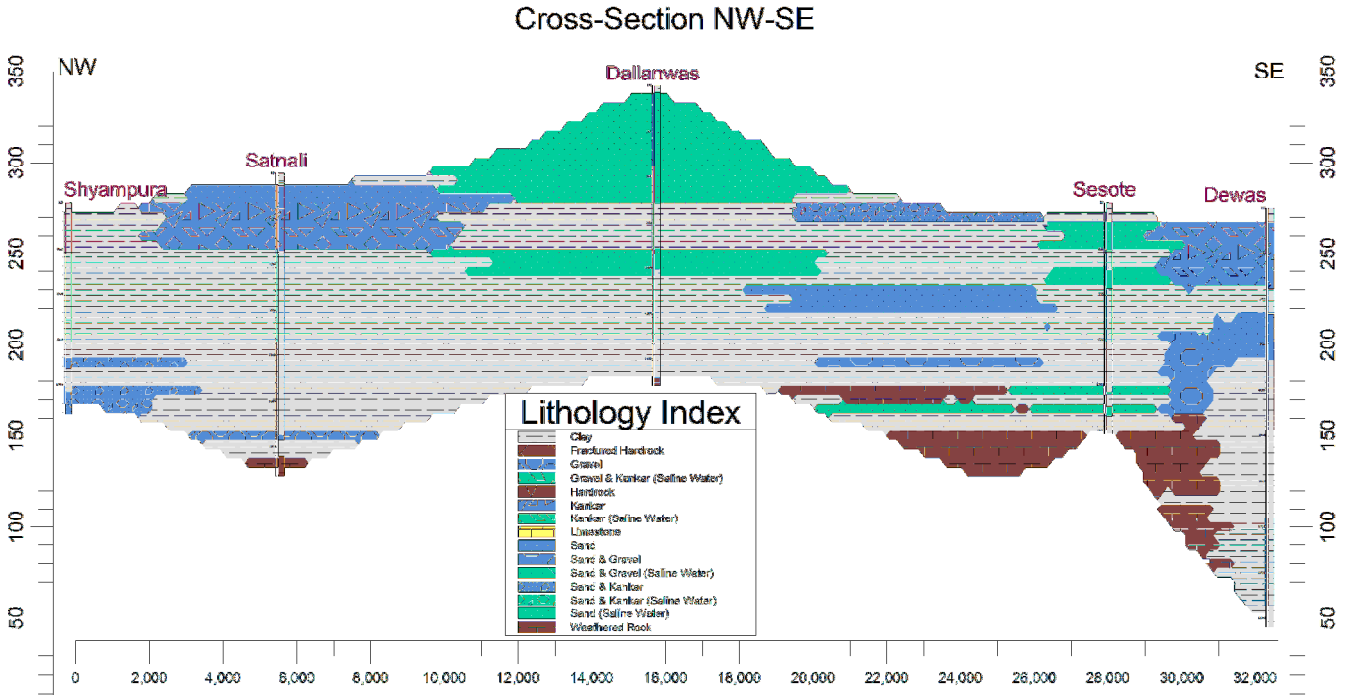
3D Lithology model



3D Lithology Fence




Cross-Section N-S
N
S
Palri
Jant
Jhagroli
Sesote
Gadania
Pal
Lithology Index
Clay
Fractured Hardrock
Gravel
Gravel & Kankar (Saline Water)
Hardrock
Kankar
Kankar (Saline Water)
Limestone
Sand
Sand & Gravel
Sand & Gravel (Saline Water)
Sand & Kankar
Sand & Kankar (Saline Water)
Sand (Saline Water)
Weathered Rock


Cross-Section NW-SE
NW
SE
Dallarwas
Satnali
Shyampura
Sesote
Dewas
Lithology Index
Clay
Fractured Hardrock
Gravel
Gravel & Kankar (Saline Water)
Hardrock
Kankar
Kankar (Saline Water)
Limestone
Sand
Sand & Gravel
Sand & Gravel (Saline Water)
Sand & Kankar
Sand & Kankar (Saline Water)
Sand (Saline Water)
Weathered Rock

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	48.65
	In-storage Aquifer I	517.34 (F=468.36, S=48.98)
	Total	565.98
Ground Water Extraction (mcm)	Irrigation (2013)	40.38
	Domestic & Industrial (2013)	0.90
Future Demand for domestic & Industrial sector (2025) (in mcm)		6.81
Chemical Quality of ground water		Salinity problem in some parts (Details in ANNEXURE II)
Other issues		Declining ground water level trend (23-27cm/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 (32m) is 3.83mcm.
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 5.96mcm volume of water wastage Adopt Sprinkler/drip irrigation/mulching etc
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	No (Not Notified)
Other interventions proposed, if any	-

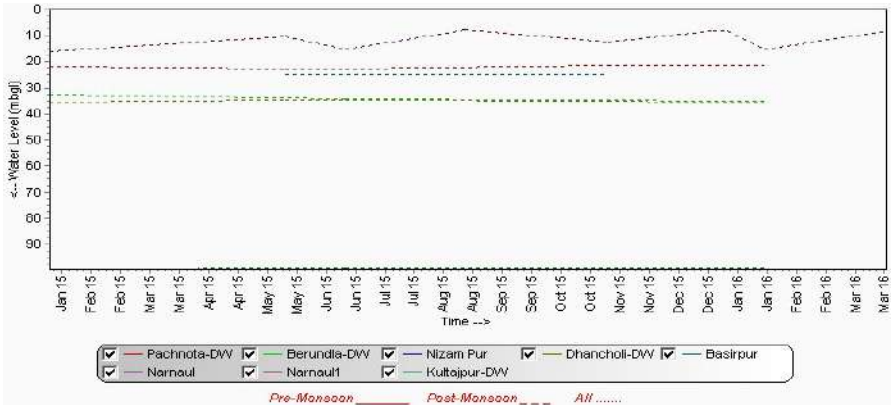
IV. Narnaul Block (285.67 sq km)

Population (2011)	Rural-124621 Urban-74581 Total-199202
Rainfall	Monsoon -517.24mm Non Monsoon-248.54mm
Average Annual Rainfall	765.78mm
Agriculture and Irrigation	Major Crops- Bajra, Wheat & Rabi Oilseeds Other crops-Gram, cotton & Barley Net Area Sown-236.09sqkm Total Irrigated Area-89.43sqkm
Water Bodies	27 nos.

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

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

Water level Behavior (2016): Pre Monsoon-8.6-99.5 mbgl & Post Monsoon-12.6-92.6 mbgl

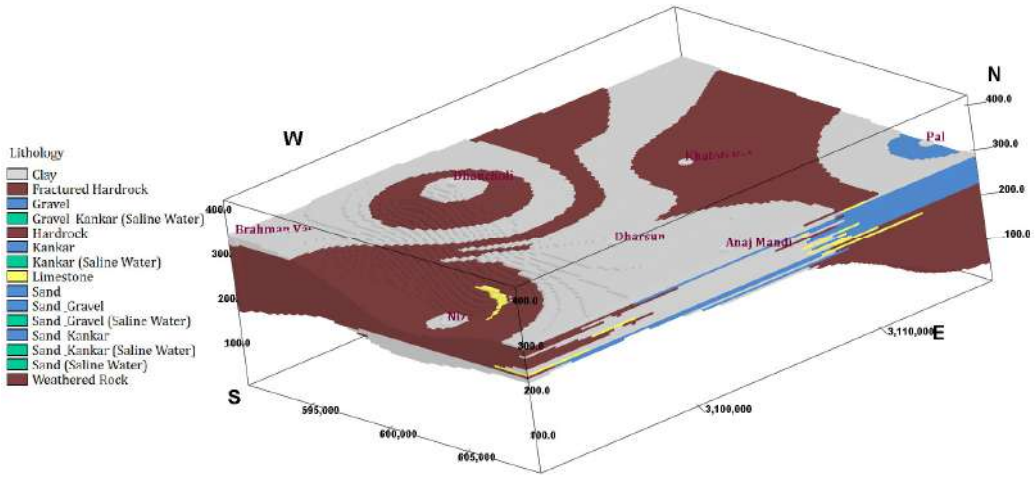


Aquifer Disposition: Single Aquifer System

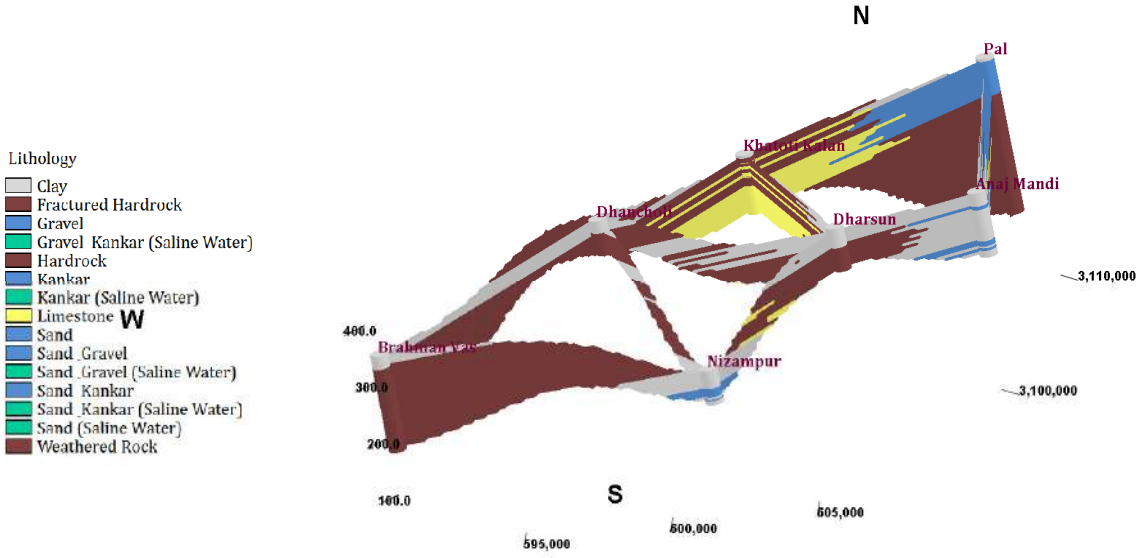
Aquifer comprises of fresh and saline water and the main aquifer formations are sand, kankar and mixture of sand with kankar. In this block, limestone aquifer also exists at different depths. The non-aquifer material comprises of clay. The basement rock encountered shallowest at a depth of 5 mbgl and deepest at 65 mbgl. The weathered zone of 5m encountered at one site.

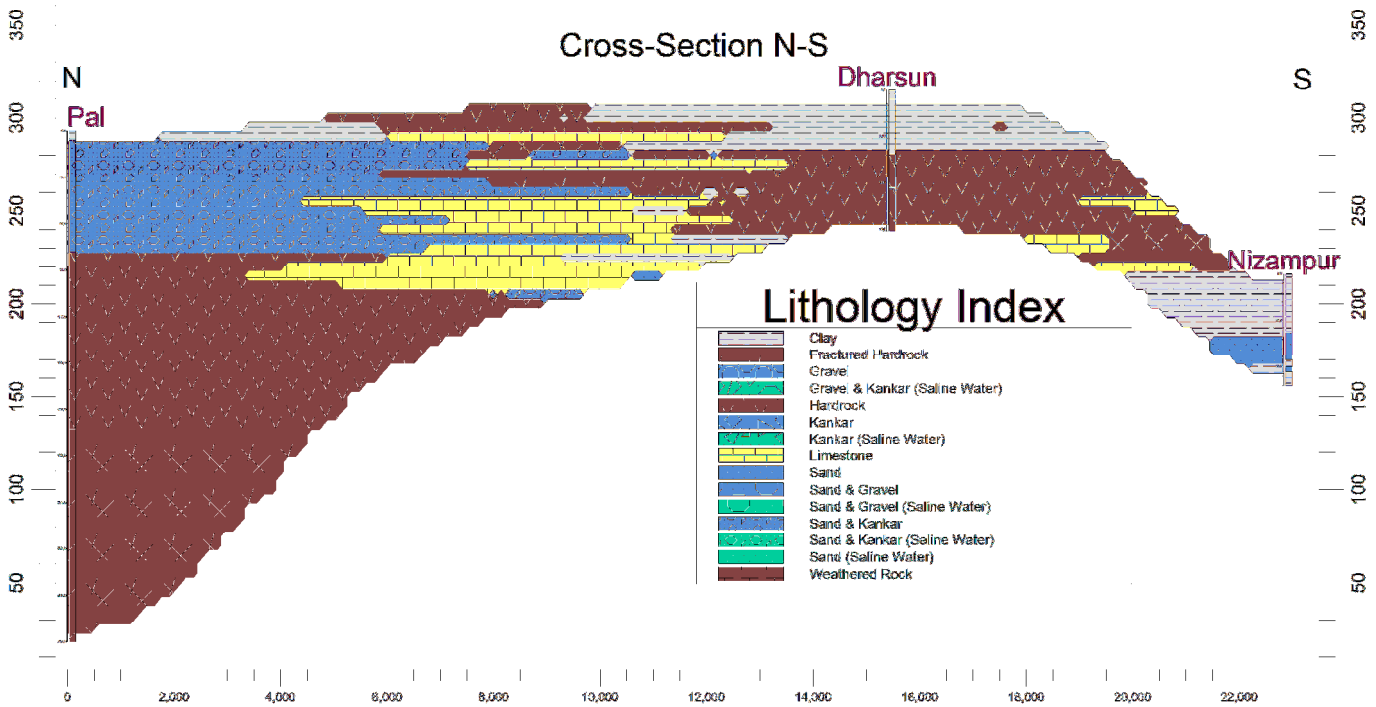
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (5-113m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	22	997-1047	0.0072	0.072

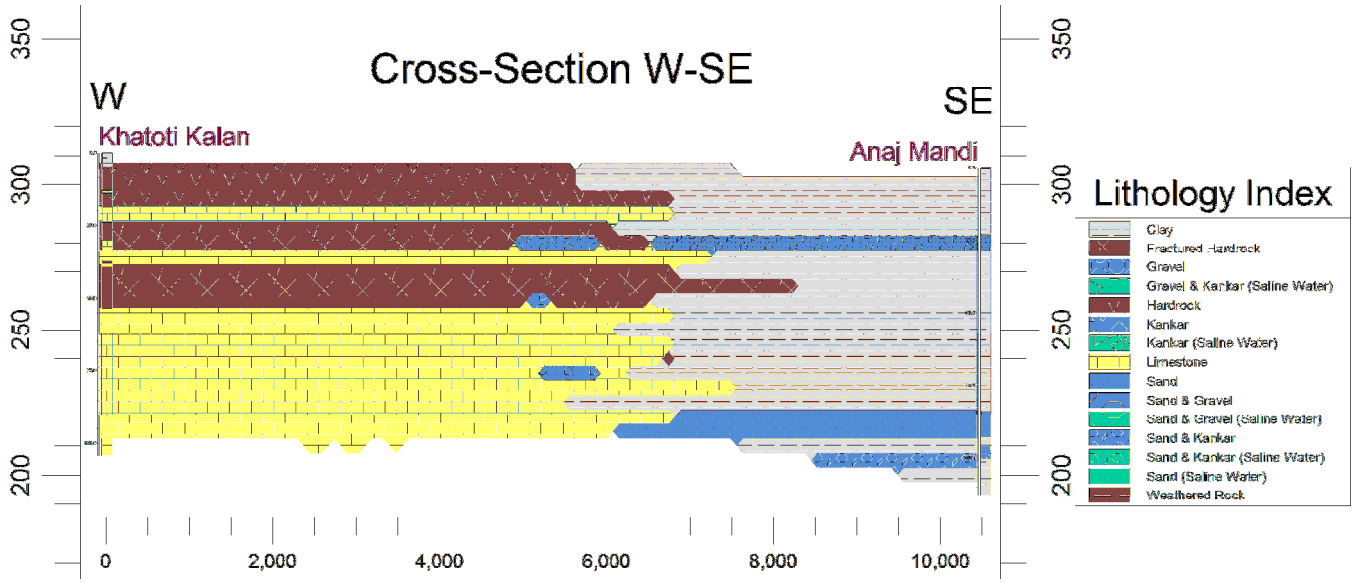
3D Lithology model



3D Lithology Fence




Cross-Section N-S
N
S
Pal
Dharsun
Nizampur
Lithology Index
Clay
Fractured Hardrock
Gravel
Gravel & Kankar (Saline Water)
Hardrock
Kankar
Kankar (Saline Water)
Limestone
Sand
Sand & Gravel
Sand & Gravel (Saline Water)
Sand & Kankar
Sand & Kankar (Saline Water)
Sand (Saline Water)
Weathered Rock
350
300
250
200
150
100
50
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000


Cross-Section W-SE
W
SE
Khatoti Kalan
Anaj Mandi
Lithology Index
Clay
Fractured Hardrock
Gravel
Gravel & Kankar (Saline Water)
Hardrock
Kankar
Kankar (Saline Water)
Limestone
Sand
Sand & Gravel
Sand & Gravel (Saline Water)
Sand & Kankar
Sand & Kankar (Saline Water)
Sand (Saline Water)
Weathered Rock
350
300
250
200
0
2,000
4,000
6,000
8,000
10,000

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	42.81
	In-storage Aquifer I	452.5 (F=443.47, S=9.0)
	Total	495.31
Ground Water Extraction (mcm)	Irrigation (2013)	8.24
	Domestic & Industrial (2013)	0.86
Future Demand for domestic & Industrial sector (2025) (in mcm)		6.62
Chemical Quality of ground water		Salinity problem in deeper aquifers
Other issues		Water logging

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 (10m) is 0mcm. (based on limit data available)
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 1.22 mcm volume of water wastage
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	Notified
Other interventions proposed, if any	-

V. Nangal Chaudhary Block (606.80sq km)

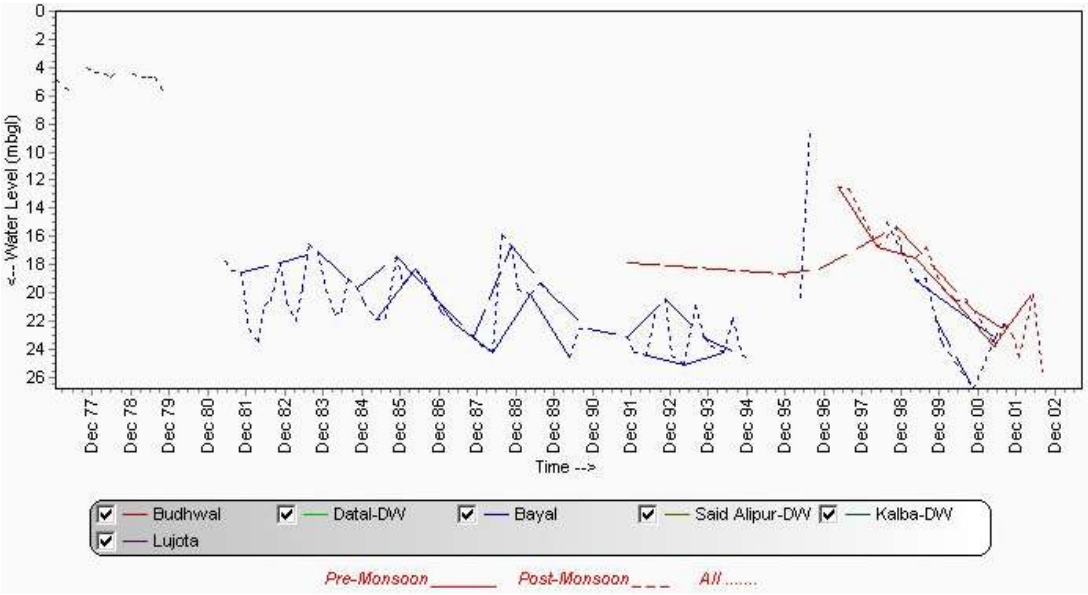
Population (2011)	Rural-150236
	Urban-8538
	Total-158774
Rainfall	Monsoon -318.90mm Non Monsoon-131.50mm
Average Annual Rainfall	450.40mm
Agriculture and Irrigation	Major Crops- Bajra, Wheat & Rabi Oilseeds
	Other crops-Gram, cotton & Barley
	Net Area Sown-235.81sqkm
	Total Irrigated Area-132.58sqkm
Water Bodies	18 nos.

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

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

Water level Behavior (2016):

Pre Monsoon-26.8-51.7 m bgl & Post Monsoon-24.4-51.6 mbgl

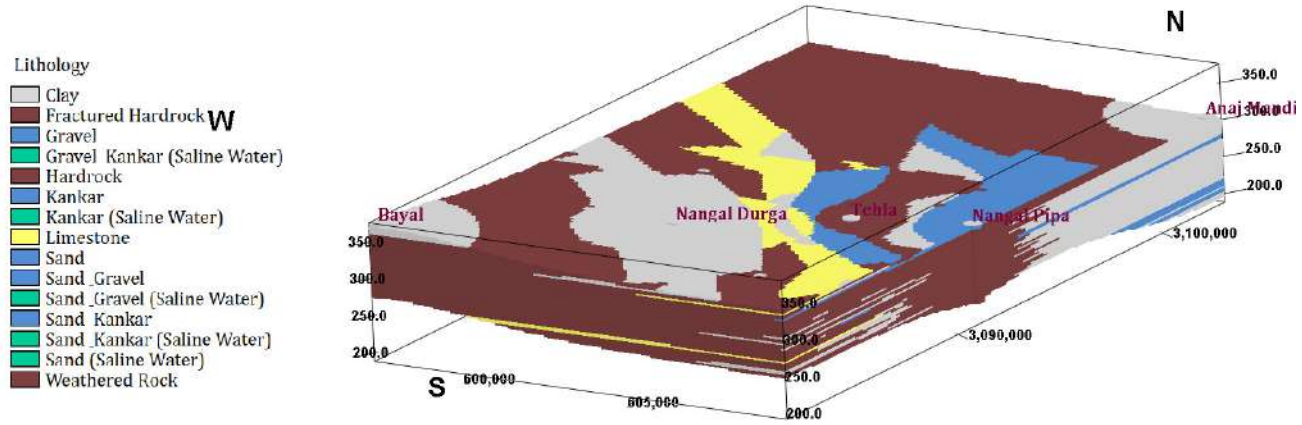


Aquifer Disposition: Single Aquifer System

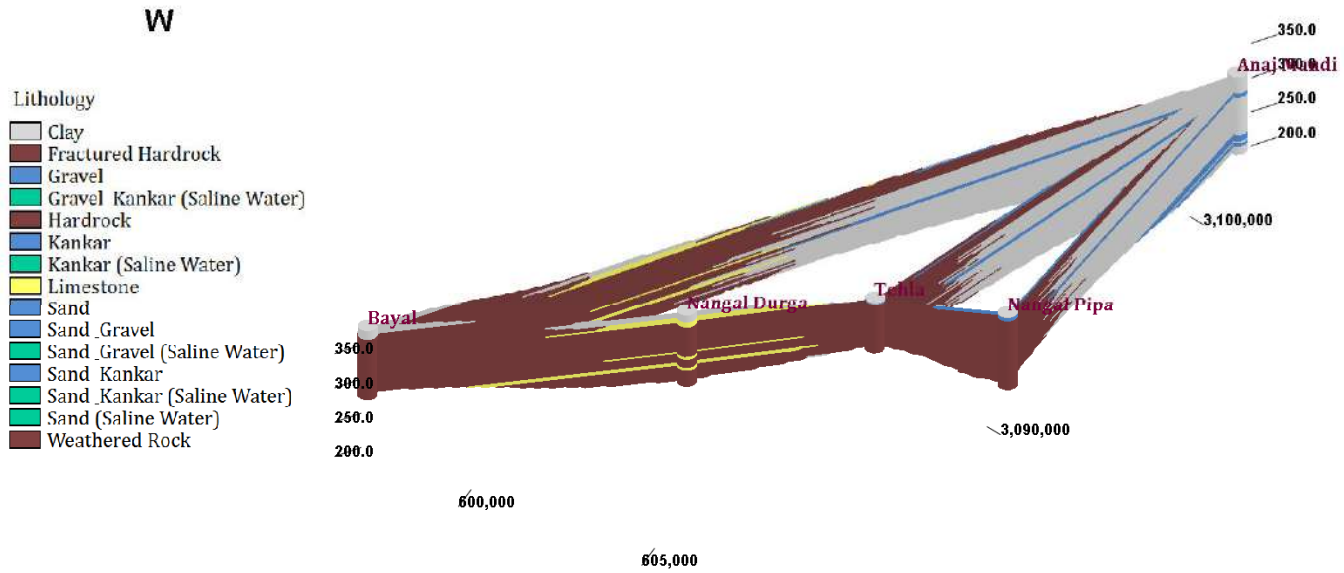
Aquifer comprises of fresh and saline water and the main aquifer formations are sand, kankar and mixture of sand with kankar. In this block, limestone aquifer also exists at different depths. The non-aquifer material comprises of clay and hard rock. The basementrock encountered shallowest at a depth of 1 mbgl and deepest at 40 mbgl.

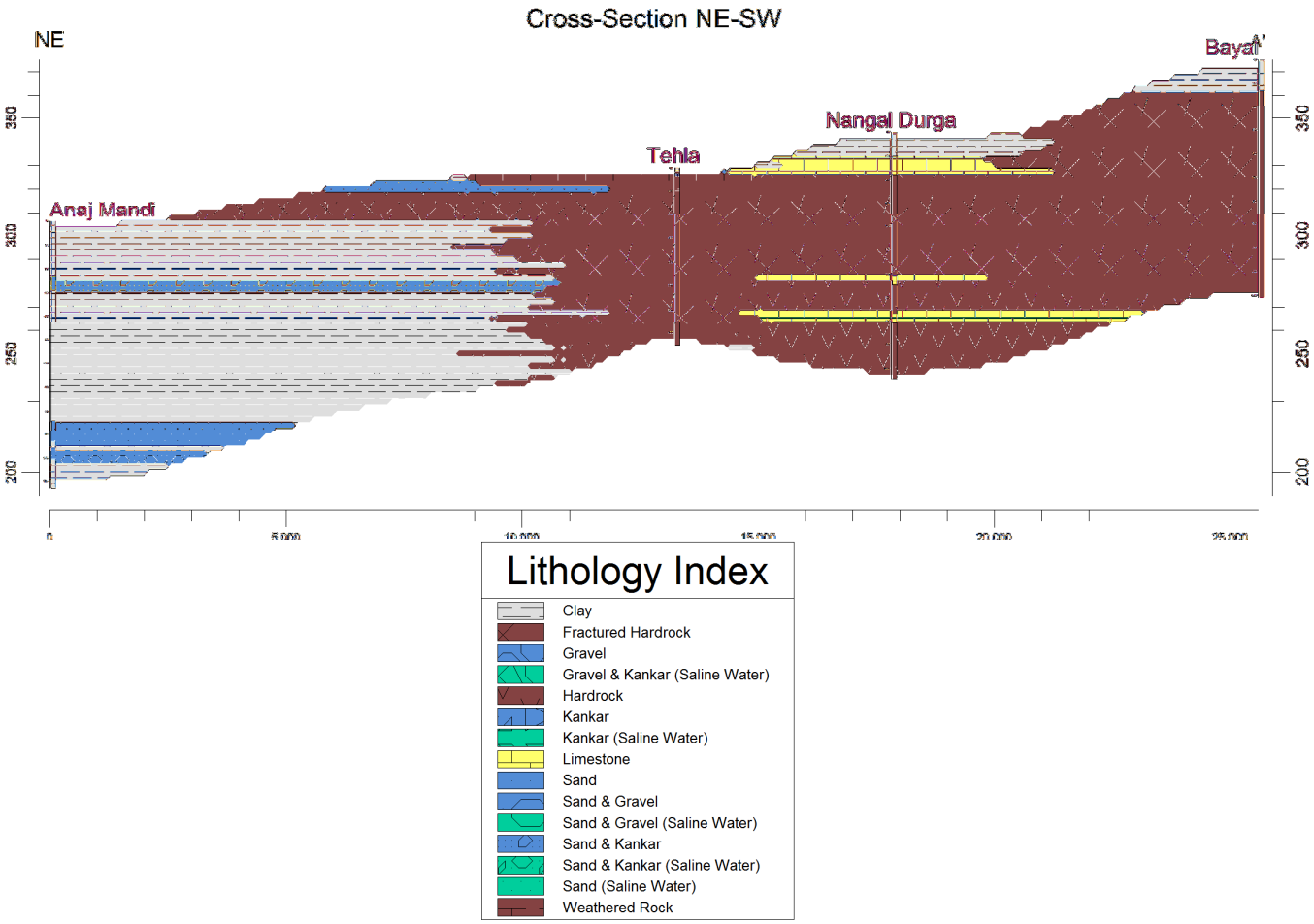
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
I (2-113m)	Quaternary Alluvial deposits	Unconfined to Semi-confined	20	373-1684	12	0.1415

3D Lithology model



3D Lithology Fence





Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resources (in mcm) (2013)	Dynamic Aquifer I	50.01
	In-storage Aquifer I	596.78 (F=578.471, S=18.30)
	Total	646.78
Ground Water Extraction (mcm)	Irrigation (2013)	43.76
	Domestic & Industrial (2013)	1.29
Future Demand for domestic & Industrial sector (2025) (in mcm)		7.83
Chemical Quality of ground water		Salinity problem in deeper aquifers
Other issues		Declining water level trend (31-56cm/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 (10m) is 2.48mcm.
Other interventions proposed	NA

Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 6.45mcm volume of water wastage
Change in cropping pattern	NA
Alternate water sources	Tanks, ponds and canals
Regulation and Control	Notified
Other interventions proposed, if any	-

8. CONCLUSIONS

- Mahendragarh district occupies the southern extremity of the Haryana state jointly with Rewari and Gurgaon districts of Haryana with a total geographical area of 1776 sq km. It falls between Latitudes $27^0$48'10" and $28^0$8'30" and Longitudes $75^0$54' 00" and $76^0$51' 30".
- The climate of Mahendragarh district can be classified as tropical steppe, semi-arid and hot. The normal annual rainfall and the normal monsoon rainfall of the district are 500 which are unevenly distributed over the area 26 days.
- The area forms the part of Indo - Gangetic plains and has vast alluvial and sandy tracts. It is interspersed with strike ridges which are occasionally covered by blown sands. The hill ranges are marked features of the district and are part of great Aravalli chain. The Dhosi hill touches the height of 7090m amsl
- The main streams of the district are Dohan & Krishnawati which flow from south to north. The land use and land cover map indicates that the majority of the land is utilized in agriculture and in agri plantations followed by land with scrub and habitations .
- Geophysical investigation in terms of electrical logging has been carried out at 11 sites by CGWB, out of which 4 sites are having fresh ground water quality, 2 sites were having marginal quality of ground water and rest of the sites are having poor quality of ground water or saline.
- The depth to water level ranges from 1.6 to 63.50m bgl during pre-monsoon and 1.53 to 67.87m bgl during post-monsoon. The major ground water flow is towards the north western part of the district i.e. towards Satnali block.
- The ground water is alkaline in nature. In most of the samples, the EC concentration is > 1000 µS/cm indicating the saline water.
- Arsenic concentration is within the permissible limit of BIS 2012 whereas Iron concentration is more than the permissible limit at two sites with a value of 0.48 - 0.64mg/l.
- The district is underlain by alluvium and blown sand of Recent to sub recent age which are overlying the rocks of post Delhi and Delhi system. The alluvium in the area belongs to older alluvium stage comprising of sand, silt, clay and calcareous nodules. The alluvium is the fresh water deposit of Indo- Gangetic river system.
- According to the present NAQUIM study, it has been found that there is large variability in the lithology as it is having alluvium as well as hardrock aquifers. The

alluvium lithological units are sand, kankar, gravel, silt and clay which belongs to the alluvium deposits of recent and sub-recent age. The hardrock units are sandstone, chert, hematite, pegmatites, gneiss, granite, limestone, quartzite, micaschist and slates belongs to Delhi system.

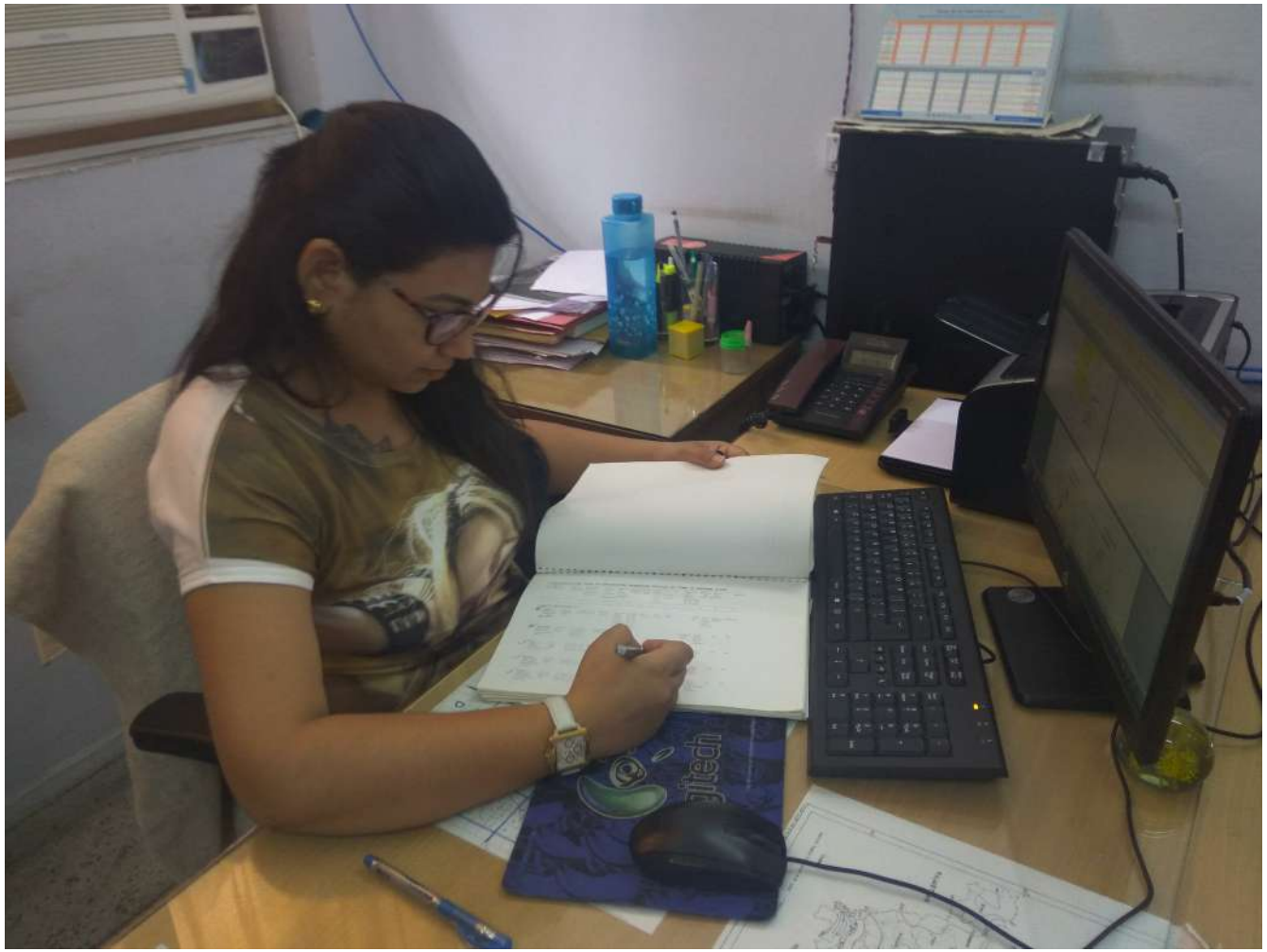
- As per Ground water resource estimation as on March 2013, the stage of ground water development ranges between 21% (block- Narnaul) to 137% (block- Kanina). 2 of the blocks are notified i.e. Narnaul and Nangal Chaudhary.
- The net ground water availability is 256 mcm, and existing gross ground water draft for all uses is 222 mcm and net ground water availability for future irrigation development is 14mcm. The stage of ground water development in the district is 86.
- The district belongs to single aquifer system upto a depth of 300m. Dynamic & In-storage ground water resources has also been carried for the same for fresh as well as saline.
- There are around 12027 (out of 20375) tubewells (59%) operated by farmers for irrigation through unlined/Katcha open channel system in Mahendergarh district where water from the tubewell is discharge to the agricultural field. In this process huge (up to 20 %) quantity of ground water is wasted in soil moisture and evaporation losses.
- Around 83% of the tube wells are of shallow depth (40- 60m) and remaining are deeper (60-110 m) depth. Thus majority of wells are tapping Aquifer group-1 which is under stress due to overexploitation.
- There is water level decline as well as water quality problem in the district and due to absence of major canal network, it is suggested that proposed artificial recharge measures, conserving ground water through laying of underground water pipe line and 3/5Pond system will save 13.57, 189.71 &12.99 mcm of ground water respectively.

9. PHOTOGRAPHS

Water Level Monitoring

Key-in & Validation of data

Preparation of the report



ANNEXURE I: Depth to water level of GWOW (2016)

S. No.	Location	Depth to Water Level (mbgl)		Fluctuation
		May-16	Nov-16	
1	Atali-DW	23.75	24.00	-0.25
2	Barda-DW	84.70	86.00	-1.30
3	Basirpur	24.85	25.50	-0.65
4	Bayal	26.75	18.50	8.25
5	Berundla-DW	35.20	34.50	0.70
6	Bhojawas-DW	38.20	38.10	0.10
7	Buwana-Pz	51.80	51.25	0.55
8	Chandpura-Pz	-	68.10	-
9	Chelawas-DW	38.50	37.10	1.40
10	Datal-DW	-	34.90	-
11	Deroli Ahir	12.12	12.85	-0.73
12	Deroli Ahir1	-	6.11	-
13	Dhancholi-DW	36.30	36.15	0.15
14	Faizabad-DW	22.35	21.90	0.45
15	Kalba-DW	31.70	29.50	2.20
16	Kaninakhas1	-	26.70	-
17	Kharkara Bas-DW	17.65	15.65	2.00
18	Kheri	18.97	19.84	-0.87
19	Kheri-Pz	55.50	55.60	-0.10
20	Kultajpur-DW	99.50	98.50	1.00
21	Lukhi	18.39	-	-
22	Nagal Kalia-DW	51.72	51.58	0.14
23	Narnaul	8.63	8.43	0.20
24	Pachnota-DW	22.50	12.30	10.20
25	Pali-Pz	35.08	35.50	-0.42
26	Pathera-DW	32.10	29.80	2.30
27	Said Alipur-DW	36.40	-	-
28	Shelang-DW	34.50	33.00	1.50
29	Tazpur-Pz	66.50	67.00	-0.50

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

S. No	Location	Block	pH	EC in µS/cm at 250C	CO3	HCO3	Cl	SO4	NO3	F	PO4	Ca	Mg	Na	K	SiO2	T.H as CaCO3	As	Fe
					(----------mg/l----------)														
1	Kheri Talwa	Mahendergarh	**8.63**	**2110**	48	752	165	204	12	**13.83**	1.6	13	8.4	522	6.8	20	67	0.014	0.1278
2	Bnana		8.25	1667	Nil	312	302	207	**47**	0.74	0.03	36	19	335	6.5	22	166	BDL	0.0413
3	Buchawas		8.02	**4360**	Nil	351	708	**684**	**432**	0.56	0.04	89	103	800	6.5	21	**644**	BDL	BDL
4	Kanina khas	Kanina	**8.63**	1446	26	410	186	152	28	0.93	0.05	13	11	335	4.3	16	78	0.001	BDL
5	Rattakalan		8.02	1115	Nil	244	192	140	42	0.21	0.02	40	32	182	5	10	233	BDL	0.1933
6	Narnaul	Narnaul	7.96	**4510**	Nil	352	791	375	**693**	0.93	0.02	98	108	760	82	17	**691**	BDL	**0.4879**
7	Deroli Ahir	Mahendergarh	**8.55**	414	6.5	215	14	30	1.1	0.46	0.03	27	19	45	0.6	10	144	0.003	**0.6482**
8	Jaswas		8.48	877	6.5	390	55	72	19	**1.83**	0.03	13	5	212	2.5	17	55	0.001	BDL
9	Jhanjriawas		8.43	1173	6.5	383	142	121	28	0.57	BDL	24	25	222	3.2	35	164	BDL	BDL
10	Khatand		8.04	**4400**	Nil	192	**1276**	**406**	**56**	0.53	BDL	**204**	27	779	16	39	**619**	BDL	0.0455
11	Mahendergarh		**8.76**	752	26	240	85	51	36	**2.01**	BDL	10	18	153	1.6	35	97	BDL	BDL

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

ANNEXURE III: Lithological data of optimized wells.

Well Name	Zones		Lithology	Thickness
	From	To		
Akoda	0	22	Clay	22
	22	27	Sand	6
	27	31	Clay	4
	31	36	Sand	5
	36	39	Clay	3
	39	45	Sand	6
	45	53	Clay	8
	53	55	Sand	2
	55	58	Clay	3
	58	60	Sand	2
	60	61	Clay	2
	61	63	Sand	2
	63	69	Clay	7
	69	120	Hardrock	51
Ateli Katkai	0	38	Clay	38
	38	40	Sand	2
	40	50	Clay	10
	50	57	Sand	7
	57	64	Clay	7
	64	67	Sand	3
	67	91	Clay	24
	91	97	Weathered Rock	7
Bawana	0	2	Clay	2
	2	31	Sand	30
	31	69	Clay	38
	69	162	Weathered Rock	93
	162	163	Hardrock	1
Bayal	0	13	Clay	13
	13	101	Fractured Hardrock	88
Bhagote	0	24	Clay	24
	24	26	Sand	3
	26	31	Clay	5
	31	33	Sand	2
	33	53	Clay	20
	53	55	Sand	3
	55	58	Clay	3
	58	64	Sand	7
	64	98	Clay	34
	98	99	Sand	1

	99	105	Clay	6
	105	106	Sand	2
	106	127	Clay	21
	127	129	Sand	2
	129	134	Clay	5
	134	136	Sand	2
	136	137	Clay	1
	137	140	Sand	3
	140	142	Clay	2
	142	160	Sand	19
	160	174	Clay	14
Brahman Vas	0	23	Clay	23
	23	170	Fractured Hardrock	147
Chhilro	0	2	Clay	2
	2	12	Clay	10
	12	15	Kankar	3
	15	22	Clay	7
	22	23	Sand	1
	23	30	Clay	7
	30	40	Weathered Rock	9
	40	41	Hardrock	1
	41	46	Hardrock	5
	46	89	Fractured Hardrock	43
	89	107	Hardrock	18
Dallanwas	0	4	Clay	4
	4	65	Sand (Saline Water)	61
	65	88	Clay	24
	88	101	Sand (Saline Water)	12
	101	160	Clay	60
	160	163	Weathered Rock	3
	163	164	Hardrock	1
Deroli Jat	0	2	Clay	2
	2	8	Kankar	6
	8	18	Sand	11
	18	27	Clay	9
	27	32	Sand	5
	32	46	Clay	13
	46	48	Kankar	2
	48	55	Weathered Rock	7
Dhancholi	0	3	Clay	3
	3	21	Clay	18

	21	26	Weathered Rock	5
	26	42	Fractured Hardrock	16
	42	58	Hardrock	16
	58	60	Fractured Hardrock	2
Dharsun	0	34	Clay	34
	34	53	Hardrock	18
	53	54	Fractured Hardrock	1
	54	76	Hardrock	22
Goad	0	8	Clay	8
	8	13	Clay	5
	13	15	Kankar	2
	15	23	Clay	8
	23	42	Hardrock	19
	42	95	Fractured Hardrock	53
Gokulpur	0	3	Clay	3
	3	55	Sand	52
	55	73	Clay	18
	73	84	Weathered Rock	10
	84	138	Hardrock	54
Jant	0	18	Clay	18
	18	23	Sand	6
	23	29	Clay	6
	29	30	Sand	2
	30	42	Clay	12
	42	46	Sand	4
	46	60	Clay	14
	60	66	Sand	6
	66	75	Clay	9
	75	78	Sand	3
	78	90	Clay	12
	90	92	Sand	2
	92	95	Clay	3
	95	100	Sand	5
	100	107	Clay	7
	107	110	Sand	3
	110	113	Clay	3
	113	116	Sand	3
	116	119	Clay	3
	119	121	Sand	2
	121	124	Clay	3
	124	128	Sand	4
	128	132	Clay	4

	132	134	Sand	2
	134	139	Clay	5
	139	142	Sand	3
	142	144	Clay	2
Kaninakhas	0	2	Clay	2
	2	13	Sand	12
	13	95	Clay	82
	95	102	Sand	7
	102	133	Clay	31
	133	135	Hardrock	2
Kantikhas	0	1	Clay	1
	1	72	Clay	71
	72	99	Weathered Rock	27
	99	103	Fractured Hardrock	4
	103	109	Hardrock	6
Khatoti Kalan	0	5	Clay	5
	5	13	Hardrock	8
	13	14	Limestone	1
	14	19	Hardrock	5
	19	24	Limestone	5
	24	30	Fractured Hardrock	6
	30	37	Limestone	7
	37	38	Fractured Hardrock	1
	38	39	Limestone	1
	39	53	Fractured Hardrock	14
	53	104	Limestone	51
Nangal Durga	0	10	Clay	10
	10	18	Limestone	8
	18	61	Fractured Hardrock	43
	61	65	Limestone	4
	65	77	Hardrock	12
	77	81	Limestone	4
	81	104	Hardrock	23
Nangal Kalia 2	0	1	Clay	1
	1	6	Weathered Rock	5
	6	98	Limestone	92
Nangal Mala	0	9	Clay	9
	9	12	Sand	3
	12	53	Weathered Rock	42
	53	70	Hardrock	17
Nangal Pipa	0	1	Clay	1
	1	6	Sand	5

	6	22	Hardrock	16
	22	45	Hardrock	22
	45	56	Fractured Hardrock	11
	56	106	Hardrock	50
Nizampur	0	31	Clay	31
	31	46	Sand	15
	46	50	Clay	4
	50	53	Sand	3
	53	60	Clay	8
Palri	0	6	Clay	6
	6	28	Kankar	22
	28	31	Sand & Kankar	3
	31	38	Clay	7
	38	41	Sand & Kankar	3
	41	77	Clay	35
	77	80	Gravel & Kankar	3
	80	102	Clay	22
	102	109	Sand & Gravel	8
	109	152	Clay	43
	152	159	Weathered Rock	7
Satnali	0	5	Clay	5
	5	7	Clay	2
	7	19	Sand	12
	19	43	Kankar	23
	43	144	Clay	101
	144	147	Gravel	3
	147	155	Clay	9
	155	164	Weathered Rock	9
	164	166	Hardrock	2
Sesote	0	10	Clay	10
	10	26	Sand	16
	26	37	Clay	11
	37	47	Sand	10
	47	104	Clay	56
	104	105	Sand	2
	105	112	Clay	6
	112	117	Sand	5
	117	127	Clay	10
	0	2	Clay	2
	2	4	Kankar	2
	4	10	Weathered Rock	6
	10	75	Fractured Hardrock	66
Anaj Mandi	0	5	Clay	5

	5	23	Clay	18
	23	29	Sand & Kankar	6
	29	84	Clay	55
	84	93	Sand	9
	93	96	Clay	3
	96	101	Sand & Kankar	5
	101	113	Clay	12
Budeen	0	8	Clay	8
	8	20	Sand & Kankar	12
	20	53	Clay	34
	53	58	Sand	5
	58	59	Clay	2
	59	66	Sand	6
	66	87	Clay	21
	87	90	Sand	3
	90	94	Clay	4
	94	97	Sand & Gravel	3
	97	107	Clay	10
Bucholi	0	6	Clay	6
	6	34	Kankar	27
	34	58	Clay	24
	58	84	Sand	26
	84	198	Clay	114
Dewas	0	8	Clay	8
	8	44	Kankar	37
	44	58	Clay	14
	58	84	Sand	26
	84	230	Clay	146
Dhana	0	5	Clay	5
	5	11	Sand & Kankar	6
	11	14	Clay	3
	14	20	Sand	6
	20	34	Clay	14
	34	50	Sand	17
	50	52	Clay	2
	52	55	Kankar	2
	55	56	Clay	2
	56	60	Sand & Gravel	4
	60	80	Clay	20
	80	93	Sand & Gravel	13
	93	102	Kankar	9
	102	110	Clay	8
	110	111	Weathered Rock	1

	111	118	Hardrock	7
Dulana	0	8	Clay	8
	8	44	Kankar	37
	44	66	Clay	21
	66	114	Sand & Gravel	49
	114	198	Weathered Rock	84
Jhagroli	0	6	Clay	6
	6	27	Sand & Kankar	21
	27	37	Kankar	9
	37	49	Clay	12
	49	61	Sand & Gravel	12
	61	152	Weathered Rock	91
Gadania	0	5	Clay	5
	5	59	Weathered Rock	54
	59	150	Hardrock	91
	150	170	Fractured Hardrock	20
	170	225	Hardrock	55
	225	300	Fractured Hardrock	75
Pal	0	5	Clay	5
	5	65	Sand & Kankar	60
	65	160	Hardrock	95
	160	275	Fractured Hardrock	115
Shyampura	0	64	Clay	64
	64	85	Clay	21
	85	91	Sand & Kankar	6
	91	104	Clay	12
	104	116	Sand & Kankar	12
Sundrah	0	8	Clay	8
	8	41	Kankar	34
	41	87	Clay	46
	87	98	Sand & Gravel	11
	98	129	Weathered Rock	31
Sohari	0	3	Clay	3
	3	30	Sand & Gravel	27
	30	82	Clay	52
	82	87	Sand & Kankar	5
	87	102	Clay	15
	102	111	Sand & Kankar	9