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

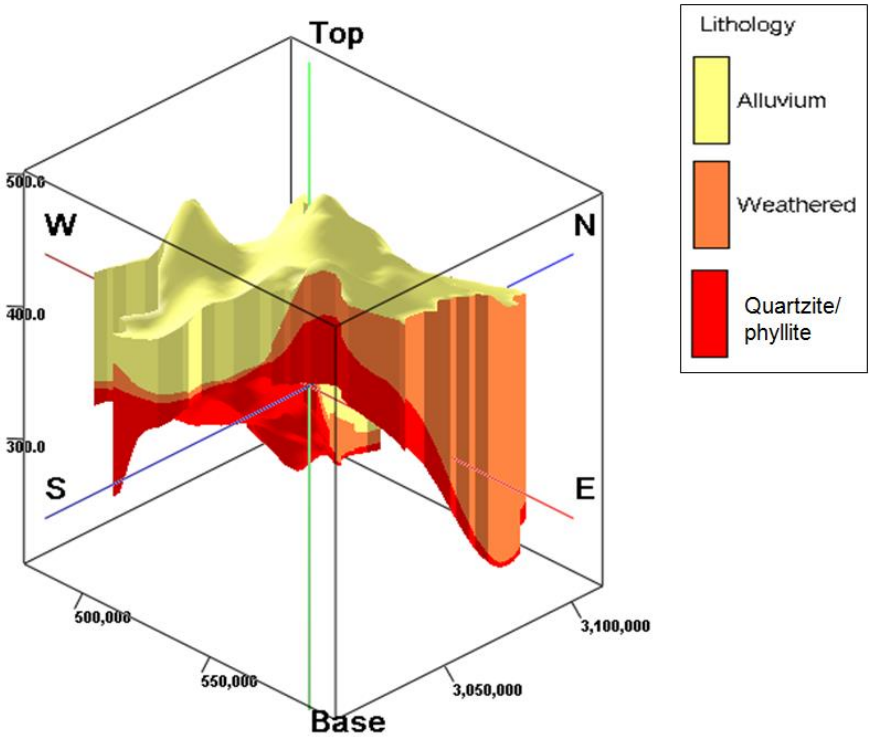
AQUIFER MAPPING AND GROUND WATER MANAGEMENT

Sikar District, Rajasthan

पश्चिमी क्षेत्र जयपुर

Western Region, Jaipur

Report on
AQUIFER MAPPING AND GROUND WATER MANAGEMENT
DISTRICT SIKAR, RAJASTHAN
(UNDER XII PLAN)



CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVANATION
GOVERNMENT OF INDIA
WESTERN REGION, JAIPUR

JULY, 2017

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District Sikar, Rajasthan

1. Introduction

Various developmental activities over the years have adversely affected the groundwater regime in the state. There is a need for scientific planning in development of groundwater under different hydrogeological situation and to evolve effective management practices with involvement of community for better ground water governance. In view of emergent challenges in the ground water sector in the state, there is an urgent need for comprehensive and realistic information pertaining to various aspects of groundwater resources available in different hydrogeological setting through a process of systematic data collection, compilation, data generation, analysis and synthesis. Hence, aquifer mapping of the study area is the need of the hour.

1.1 Purpose and Scope of the study

Aquifer mapping can be understood as a scientific process wherein a combination of geological, geophysical, hydrological, chemical fields and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. Aquifer mapping is expected to improve our understanding of the geological framework of aquifer, its hydrologic characteristics, water level in aquifer, changes in water level over time & space and the occurrence of natural & anthropogenic contaminants that affect the portability of groundwater. The results of these studies will contribute significantly to resource management tools such as long term aquifer monitoring network and conceptual & quantitative regional groundwater flow models to be used by planners, policy makers and other stake holders. Aquifer mapping at appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed at long term sustainability of our precious groundwater recourses, which in turn will help to solve drinking water scarcity, improved irrigation facilities and sustainability of water resources in the state.

As mentioned above, aquifer mapping is an attempt to integrate the geological, geophysical, hydrological and chemical laboratory analysis to characterize the quality, quantity and sustainability of groundwater in aquifer. Under the National aquifer Programme, it is proposed to generate Aquifer maps on 1:50000 scale, which basically aims at characterizing the aquifer geometry, behavior of groundwater levels and status of groundwater development in various aquifer systems to facilitate planning of their suitable management. The major activities involved in this process include compilation of existing data, identification of data gaps and generation of data for identified data gaps and preparation of different aquifer layers.

1.2 Location and Extent

Sikar district is located in the north eastern part of Rajasthan State and extends between north latitudes 27°07′ & 28°12′ and east longitudes 74°41′ and 76°05′ . It encompasses an area of 7732 sq. km. (forming about 2.25% of total area of the entire state and forms roughly the

crescent shape) and is covered in the Survey of India degree sheet nos. 45I, 45M, 54A, 44P and 44L. It is bounded on the north by Churu and Jhunjhunu districts of Rajasthan state and Mahendergarh district of Haryana state, on the west by Churu and Nagaur districts and on the south by Jaipur district of Rajasthan state. The index map of Sikar district is given in Figure 1.

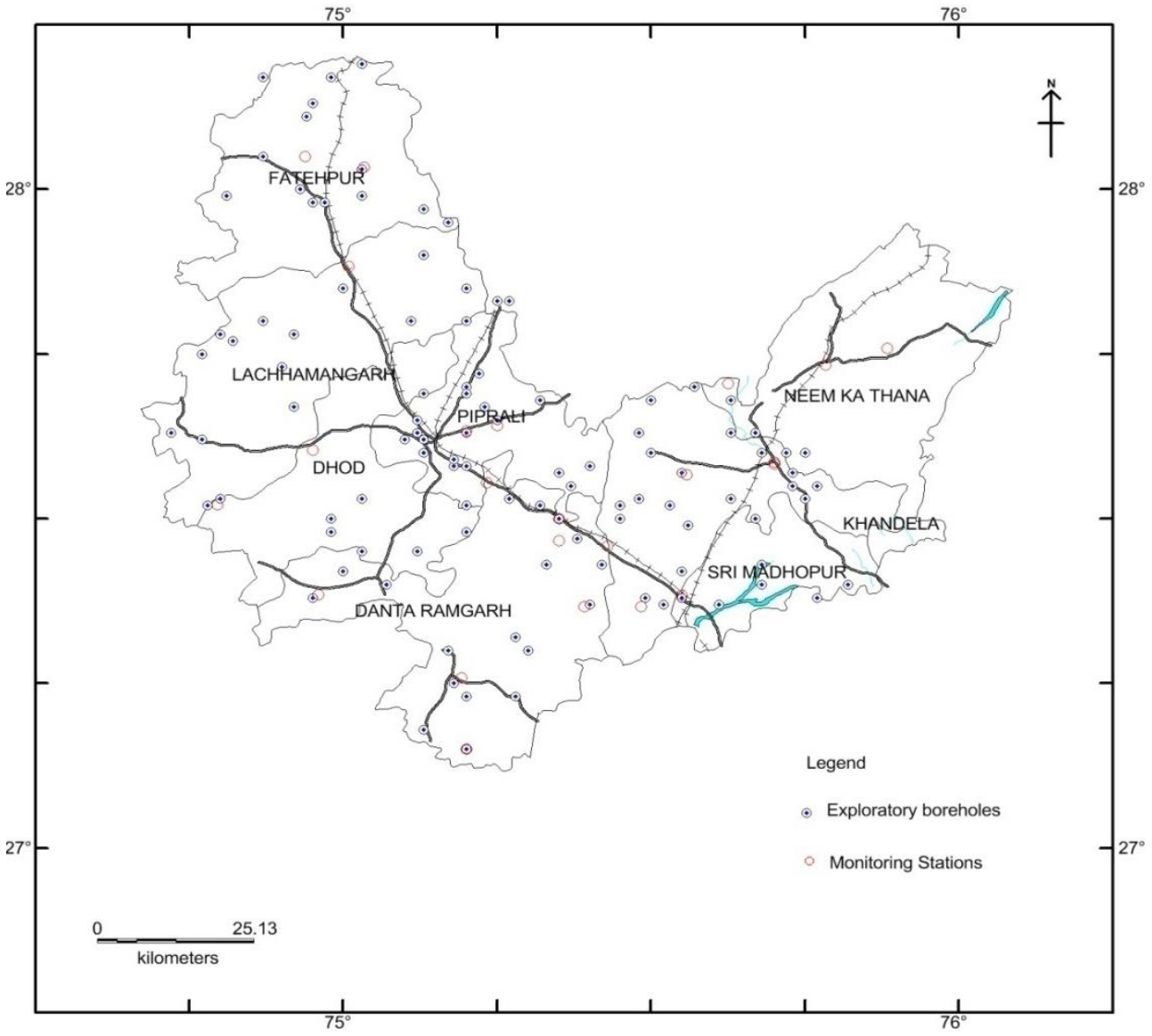

Figure 1: Index map of Sikar district, Rajasthan

1.3 Physiography and Drainage

Geomorphologically, the district comprises the following geomorphological units (Figure2):

Hilly area in the east, undulating area in the centre with hillocks, western desertic plain (major part of the villages and plains are sandy with development of dunes to the north of Sikar).

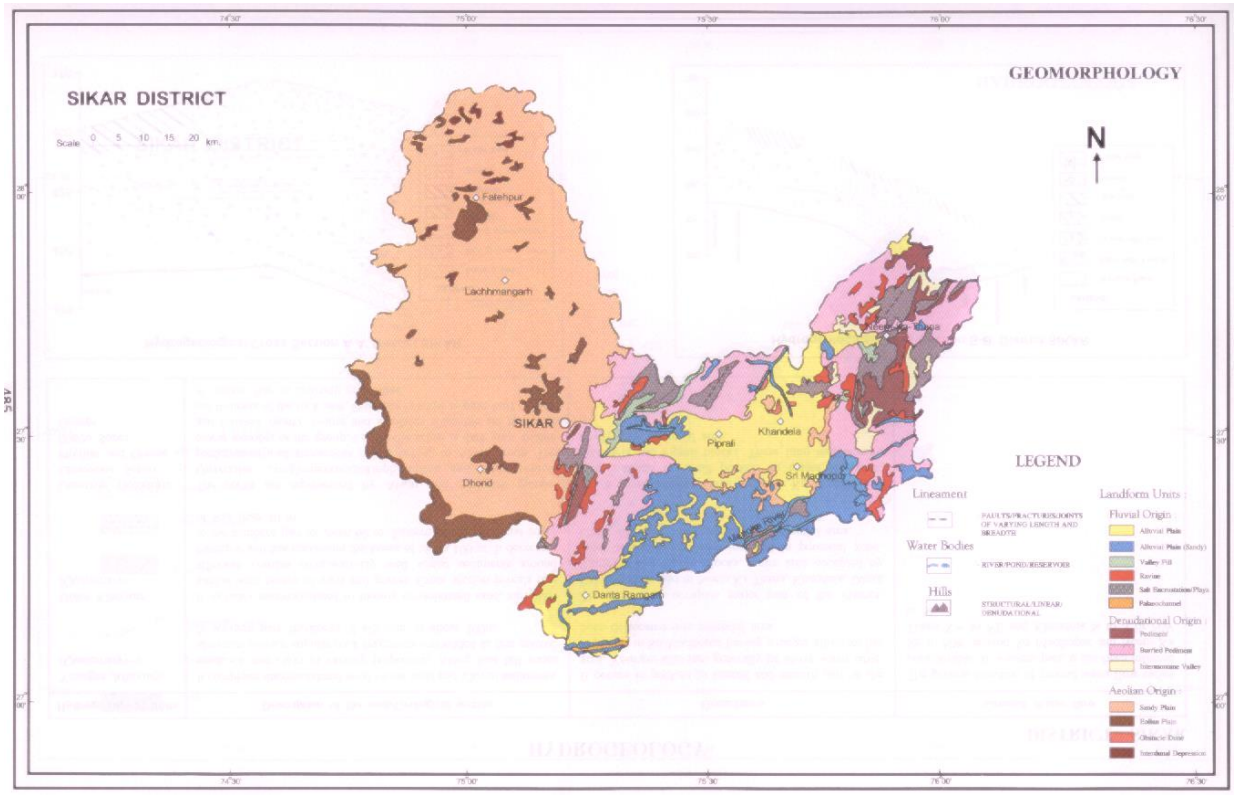

Figure 2: Geomorphological map of Sikar district

The hilly tract is part of the Aravalli range. A chain of hills passing through Sakarai Mata Ji lying east of Sikar divides the district almost into two east & west halves. The western part represents typical desertic topography. The altitude of the highest peak is about 1052 m amsl and that of other hills generally ranges between 350 and 700 m amsl. The plain area generally lies at altitude between 380 and 530 m amsl. The terrain in the north-west slopes towards west. The hill peaks which have attained considerable height in the hill system of the district are at Raghunathgarh, Harsh, Deogarh and Shyamgarh, all falling in Sikar tehsil. The central portion of the district can be called as watershed with the rivers and streams in the north flowing towards north, those in the south towards south and those in the east towards east.

There is no perennial river in the district. The most important rivers in the district are Mendha, Kantli, Dohan, Krishnawati and Sabi. Mendha river flowing in Danta Ramgarh and Sri Madhopur tehsils merges with the Sambhar lake. Kantli originates near Khandela in Sri Madhopur tehsil and flows out of the district in the northeasterly direction to district Jhunjhunu. Dohan River flows in the uppermost northeastern region of the district and covers a small portion of it. Krishnawati river originates from the hills in the southeast of Neem Ka Thana and flows out of the district in the northeastern direction. Sabi River flows only in Neem Ka Thana tehsil. In the western desertic plain, there is practically no surface drainage system. Apart from these, there are several minor streams or nallahs originating from the hills which flow for short distances and disappear in the sandy tract. There is natural lake near Pritampuri in the eastern part of the district. It is a small depression where rainwater accumulates and lasts for a few months. Similarly, there are no big tanks in the district. However, small tanks or pits are numerous in the area.

1.4 Rainfall & Climate

The mean annual rainfall (1971-2011) of the district is 463.0 mm whereas normal rainfall (1901-70) is lower than average rainfall and placed at 459.8. Almost 95% of the total annual rainfall is received during the southwest monsoon, which enters the district in the last week of June and lasts upto the middle of September. The climatology data of Sikar district is presented in Figure 3.

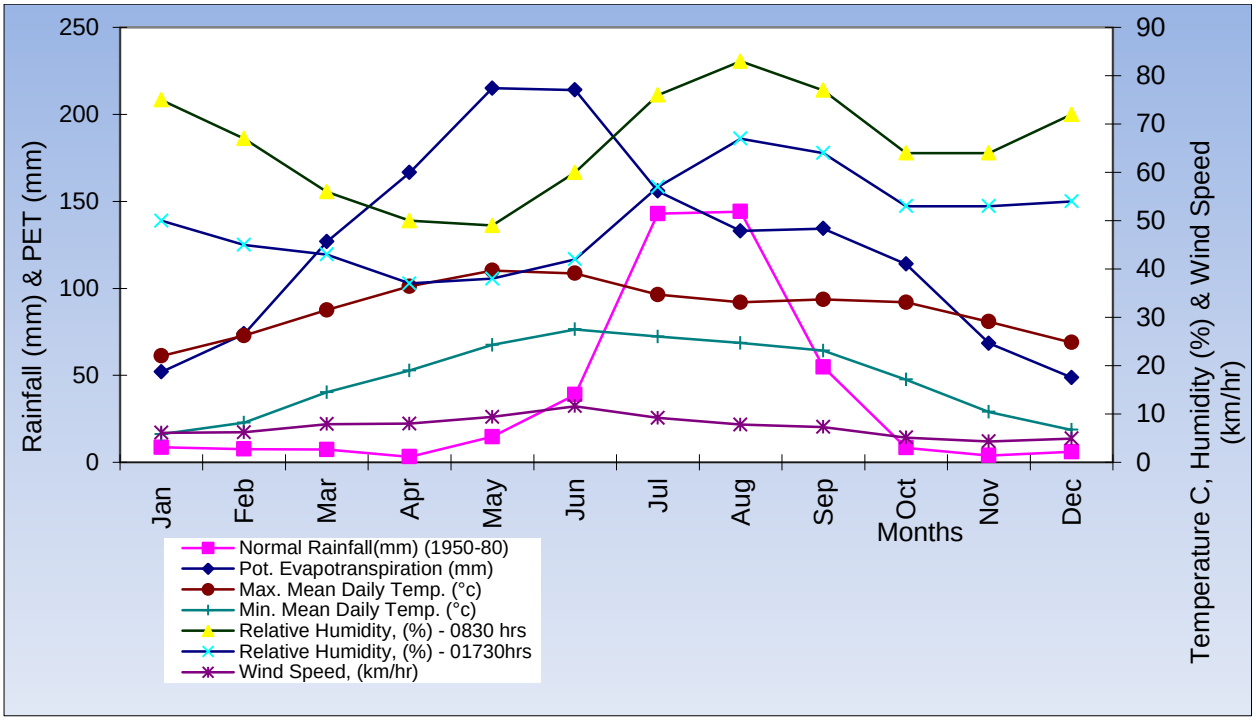

Figure 3: Climatology data of Sikar district

The mean annual rainfall is highest (536.6 mm) in Neem Ka Thana, which is located in the south eastern part of the district. It is lowest in Fatehpur (407.8 mm), which lies near north western boundary of the district. The climate of the district is generally dry except during the monsoon period. The humidity is highest in month of August with mean daily relative humidity of 80%.

1.5 Soils, Land Use & irrigation

1.5.1 Soils

The soils of the district have been broadly classified into the following categories by Agriculture Department, Govt. of Rajasthan.

- Desertic soil
- Red desertic soil
- Serozems
- Saline soil
- Lithosols
- Regosols

- Older alluvium

1.5.2 Land use

The socio-economic factors have significant influence on land use both in rural and urban areas. Land form, slope, soils and natural resources are some of the important factors which control the land use pattern of the district. About 67.95% of the total area of district was under cultivation during the year 2011-12 (Table 1). The uncultivable area comprises of forest land (9.09%), uncultivable land (5.77%), pasture land (5.20%), cultivable waste (0.49%), Barren land (1.15%) and fallow land (10.12%). Trees, groves, orchards etc. constitute only 0.0018% of the total area.

Table 1: Land use of the district

Tehsil	Geographical area (ha)	% of Study area	Forest & Hills	Barren land	Non agriculture use	Pasture & grass land	Cultrable waste-land	Trees & grooves	Fellow land	Net sown area
Fatehpur	107070	9.13	4616	1	4062	5289	0	0	26212	66747
Lachhmangarh	121893	36.77	1700	0	4716	7401	27	0	18213	89819
Sikar	151534	10.24	10235	775	7778	6665	671	0	10686	113736
Danta Ramgarh	137117	0.00	5262	1731	6673	6590	44	0	15065	100642
Sri Madhopur	137807	0.00	9957	3266	7413	7999	1197	14	5865	99411
Neem Ka Thana	118822	2.57	38609	3142	5183	6341	1907	0	2342	55753
Total	774243	9.45	70379	8915	35825	40285	3846	14	78383	526108
Area in ha as per village records (2011-12)										

The major Kharif crops are bajra, jowar, pulses, maize and groundnut. Main Rabi crops are wheat, barley, gram and oilseeds. Cotton is an important cash crop that is grown in the district.

1.5.3 Irrigation

The Net area under irrigation of the district is 37.98% of the total geographical area. There is no major irrigation project. Dug wells & tube wells are the main source of irrigation. Irrigated area and number of structures according to sources are given in Table 2.

Table 2: Irrigated area by various sources, Sikar District

S. No.	Tehsil	Area as per village records	Tube wells	Wells	Total irrigated area
1	Fatehpur	107070	2157	1590	3747
2	Lachhmangarh	121893	19098	12705	31803

3	Sikar	151534	76716	15858	92574
4	Danta Ramgarh	137117	57338	14086	71424
5	Sri Madhopur	137807	50183	19902	70085
6	Neem Ka Thana	118822	9815	15558	25373

1.6 Data availability

The Data for Groundwater availability, monitoring (water level and chemical quality) and exploration carried out by CGWB and state Ground water Department has been collected for Sikar district. A total of 36 No. of wells are being monitored by CGWB and nearly 85 observation wells by State Ground Water Department. A total of134 Exploratory and Observation wells have been constructed by CGWB in Sikar district and around 37 by State Ground Water Department.

1.7 Data Adequacy

The data collected from State GWD and CGWB have been compiled and analyzed. It has been observed that validation and georeferencing of the location coordinates, lithologs and hydrogeological data are needed. Geophysical data collected needs georeferencing of the hydrogeological interpretations. It has been observed that available data are limited largely to State highways and main roads only. Hence, to get a clear 3D hydrogeological geometry of the aquifer system and its behaviour, we need to generate data by Groundwater Exploration and to establish more numbers of monitoring stations for better understanding of the groundwater regime behavior in terms of both quantity and quality.

1.8 Data Gap Analysis

Data collected from State GW agencies and CGWB has been brought to a standard format and integrated location maps have been prepared related to groundwater monitoring, exploration, surface water and agriculture data. Based on these maps, hydrogeological conditions in the area and on the basis of various analyses performed on the collected data from several departments, it is observed that Sikar District further needs generation of data in the gap areas. The details of data gap for monitoring and exploration are given in appendix.

2. Aquifer System

The availability, occurrence and movement of groundwater are mainly controlled by the topographic features, physical characteristics and structural features present in the geological formations. Groundwater occurs under unconfined to semi-confined condition in the district. The principal aquifer in the area is Quaternary sediments covering major part of the district in western and central parts whereas quartzite, schist, phyllite, limestone and dolomitic limestone of Delhi Supergroup also constitute important aquifers in the eastern and north central parts of the district (mainly in Neem ka Thana, Khandela, Danta Ramgarh and part of Piprali blocks). The principal aquifer map of Sikar district is given in figure 3.

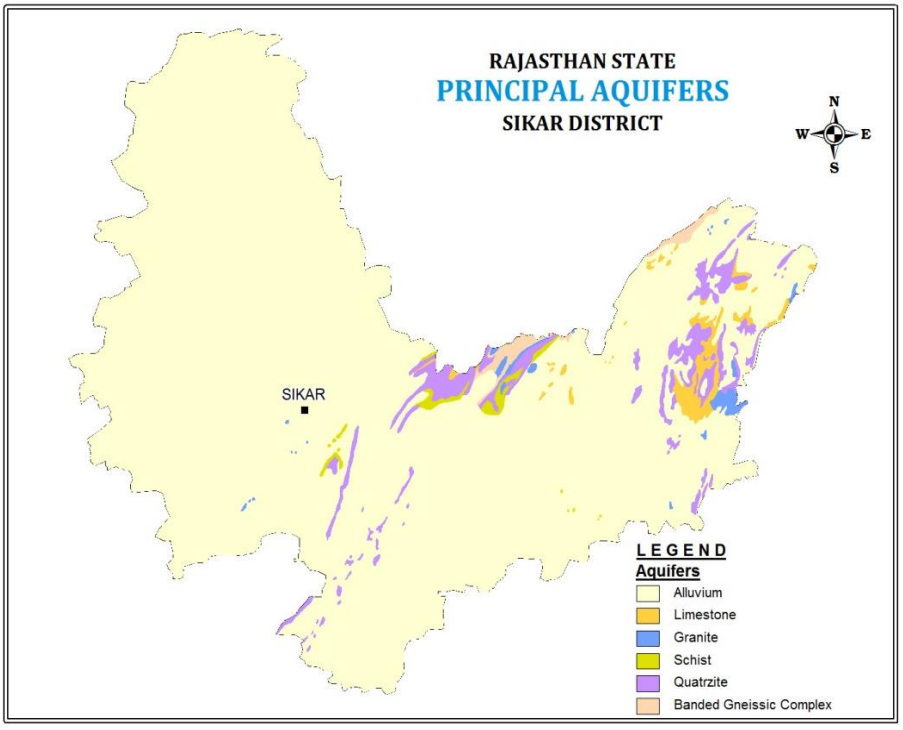

Figure 3: Principal aquifer map of Sikar district

Groundwater occurs in the pore spaces and interstitial openings of Quaternary alluvium while in hard rock formations, occurrence and movement of ground water is controlled by secondary porosity i.e. through the bedding planes, fissures, joints, fractures, solution cavities and other structurally weaker planes. Hydrogeological map of the area is depicted in figure 4.

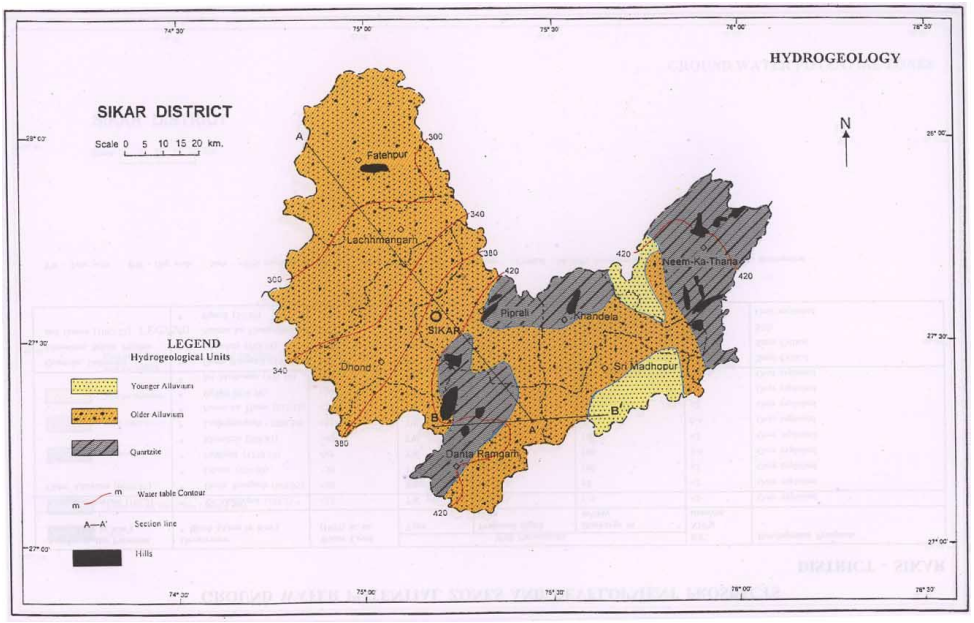

Figure 4: Hydrogeological Map of Sikar District

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a. Groundwater in Quaternary sediments

Quaternary sediments, generally unconsolidated, form the principal and most promising aquifer system. These are windblown sand and are comprised of sand, gravel, pebbles and clay with 'Kankar'. The Quaternary sediments form aquifer in the western and central parts of the district mainly in Fatehpur, part of Lachhmangarh, Dhod and part of Piprali and Sikar blocks and occupy about 75% of the district area. Ground water occurs under unconfined condition. In Sikar basin, silt and fine sand form the main aquifer. The coarse sediments mostly occur in the eastern part of the district in the proximity of rivers and streams originating from the hilly areas. Semi-confined conditions have developed locally due to occurrence of silty clay layer or clayey lenses. However, different water bearing lithological units of the Quaternary deposits are inter-connected and behave like a single hydrogeological unit.

In the western part of the district in Sikar basin area, the aquifer is quite extensive and fairly thick. Generally, its thickness lies between 30 and 80 m. In the central and eastern parts, the thickness of aquifer is controlled by bed rock topography and is highly variable. Thickness of saturated zone generally varies from 10 to 50m. Aquifers are mainly under unconfined and semi-confined conditions but at some places, confined conditions have also been observed. Average discharge of wells in alluvium ranges from 40m3/day to 90m3/day. Water is generally fresh and potable in all the blocks except in Fatehpur and parts of Lachhmangarh block where it is saline.

b. Groundwater in hard rock formations

In hard rock formations, groundwater occurs under unconfined condition in weathered mantle and in joints and fractures etc. However, semi-confined conditions may occur in deep seated fracture zones. These form aquifer in eastern part of the district in Neem Ka Thana, Khandela blocks, parts of Danta Ramgarh and Piprali blocks (figure 4). The hard rock aquifer is constituted by quartzite, schist, phyllite, gneiss and amphibolite of Delhi Super Group. These rocks have poor water yielding capacity as compared to the alluvium. The yield of open wells tapping hardrocks varies individually depending upon the extent of weathering. Higher discharge is observed when the well is located along the lineament. Moderate yield is also observed wherever the weathered mantle is overlain by considerable thickness of blown sand.

Exploratory drilling has been carried out in hard rock formations up to 143 mbgl depth. Wells tapping quartzites have generally good discharge compared to the other formations. Schist wherever traversed by quartz vein also yields fairly good discharge. Overall in hard rock especially in quartzite, the depth to water level ranges from 7.5 mbgl (Dariba in Neem ka Thana block) to 48.50 mbgl (Thet in Danta Ramgarh block). The average yield of this formation varies from 10 m3/day to 30 m3/day.

Exploratory drilling done in the district by GSI and CGWB under UNDP Project has revealed the extension of aquifer both in lateral and vertical directions. Three dimension aquifer disposition model has been prepared using Rock Works Software which is given in Figure 5.

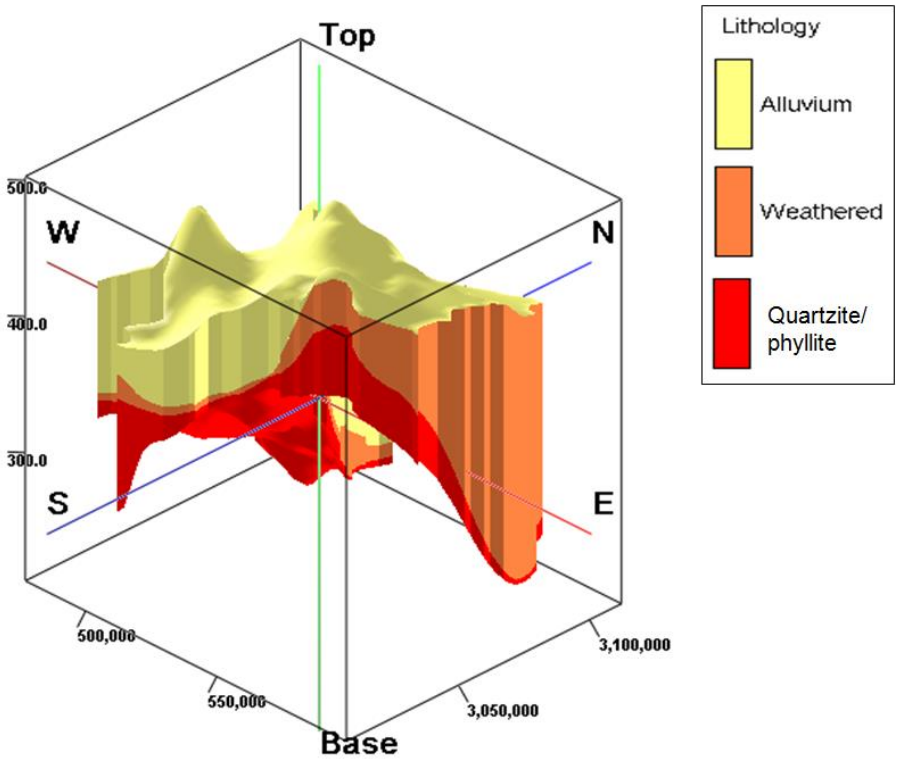

Figure 5: Aquifer Disposition, Sikar District

The 3-D Fence diagram has been prepared using the said software given in Figure 6.

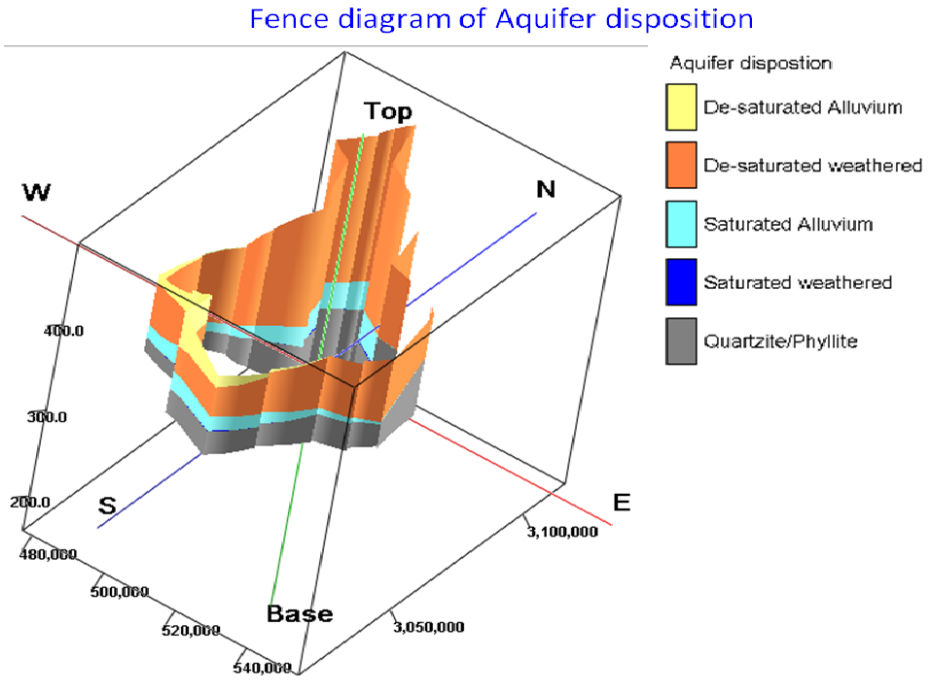

Figure 6: Fence Diagram of Aquifer Disposition, Sikar District

The aquifer saturation model of the district has been also prepared which is presented in Figure 7.

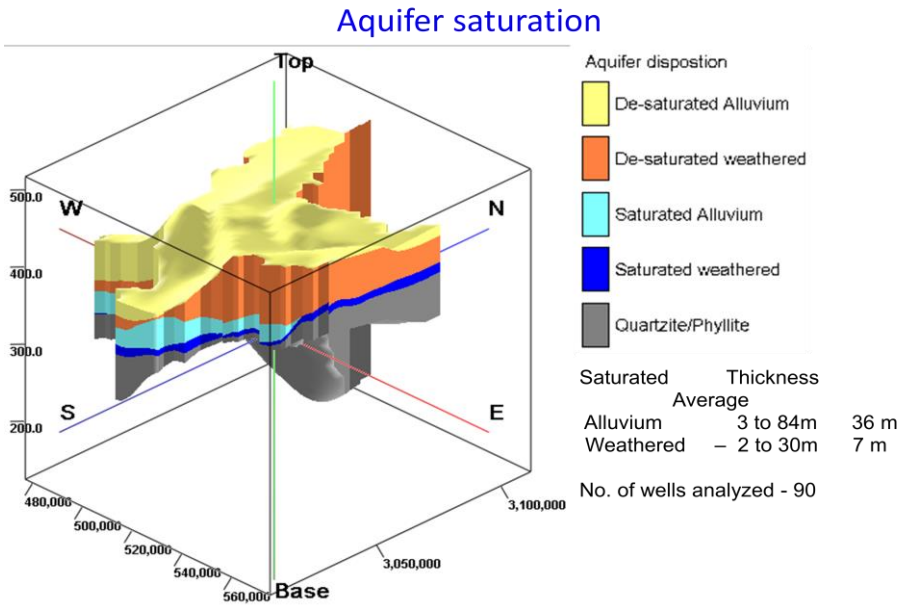

Figure 7: Aquifer Saturation Model, Sikar District

The hydrogeological sections showing aquifer disposition have been prepared and depicted in Figures 8A to 8F.

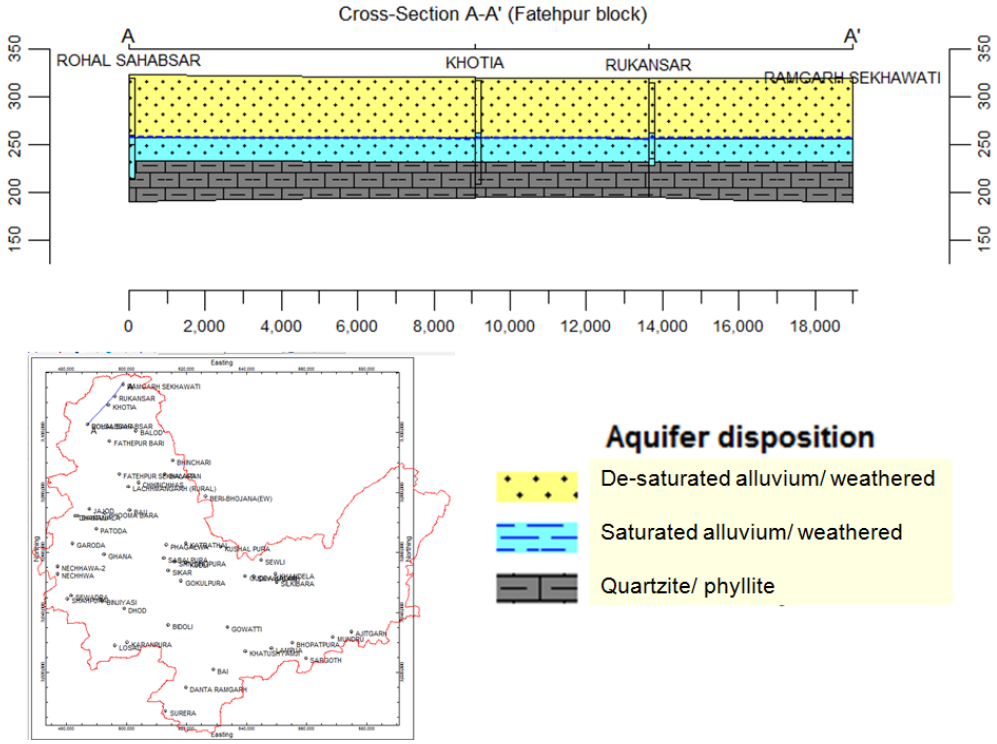

Figure 8A: Section A - A'

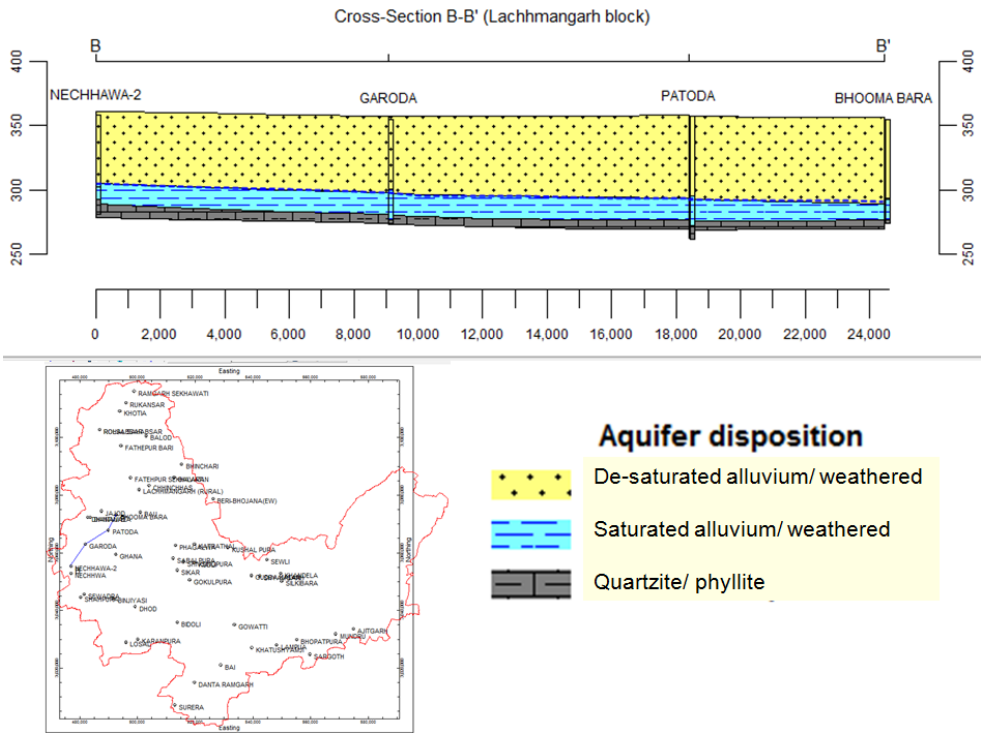

Figure 8B: Section B - B'

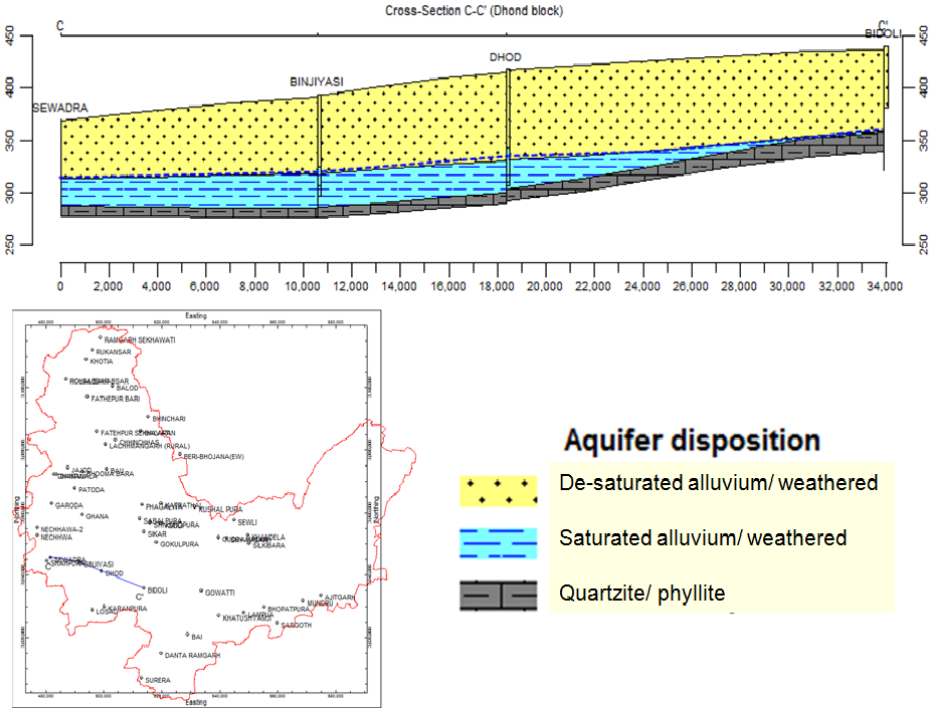

Figure 8C: Section C - C'

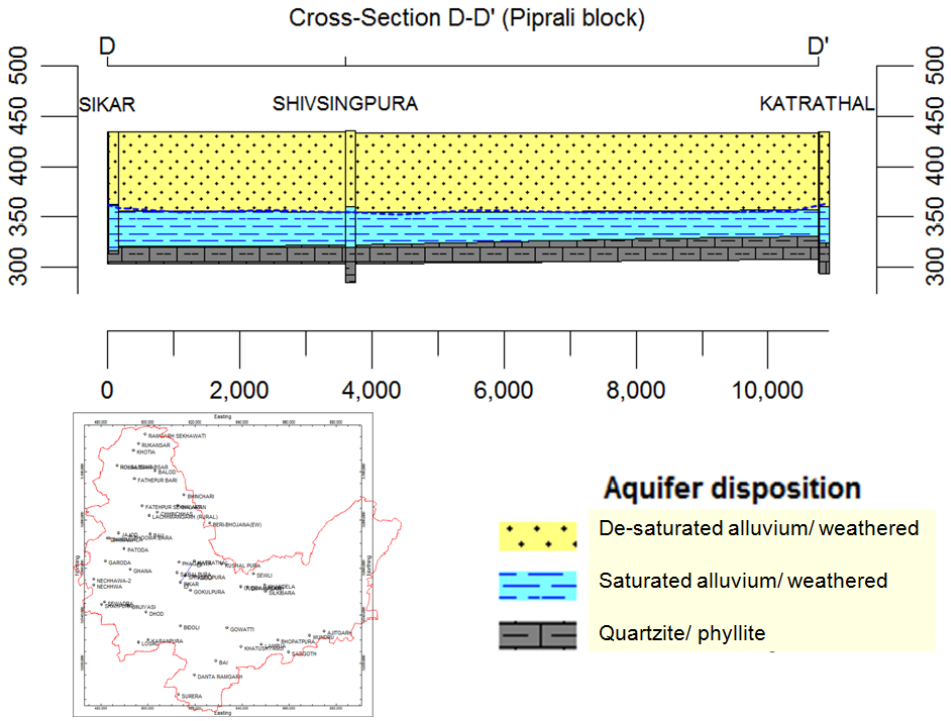

Figure 8D: Section D -D'

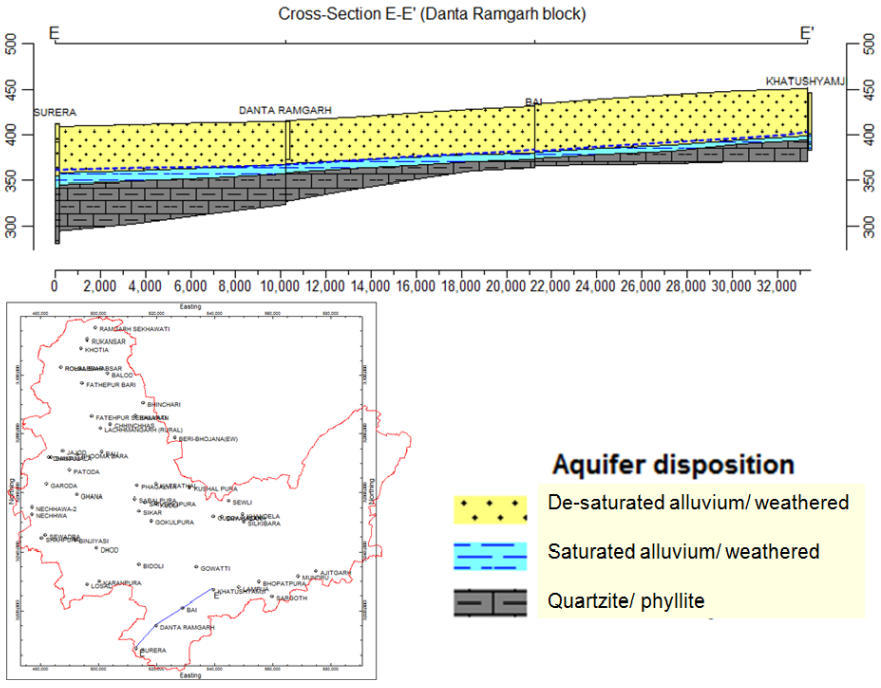

Figure 8E: Section E-E'

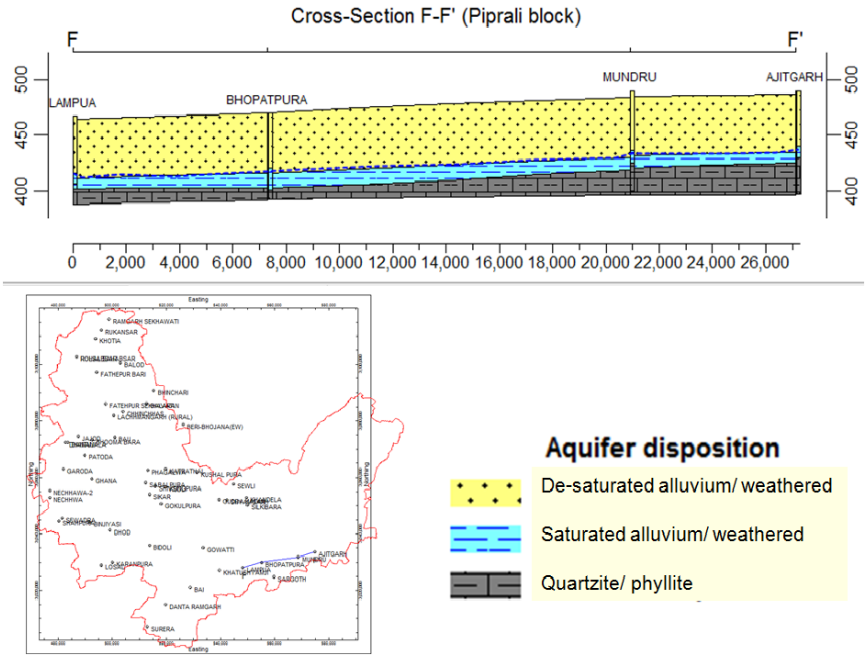

Figure 8F: Section F-F'

Depth to water level:

In order to study the behaviour of water level, National Hydrograph Stations of CGWB and key wells inventoried during the survey have been considered. It also includes the piezometers of Ground Water Department, Rajasthan State and CGWB. Based on the data of these net work stations and inventoried wells, a regional depth to water level map has been prepared. The depth to water level map of Sikar district according to pre monsoon 2015 data has been presented in Figure 9. It shows that 95% of area has water level more than 20 mbgl and maximum water level is 85 mbgl.

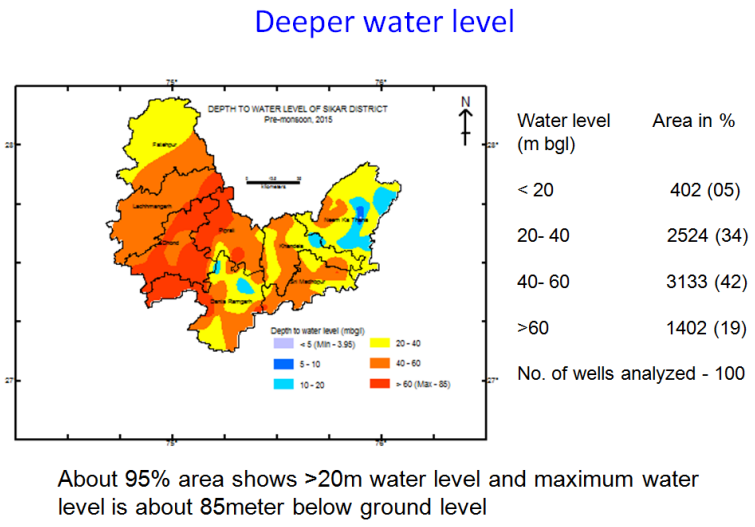

Figure 9: Depth to Water Level Map, May 2015

The depth to water level in general is less than 35m in eastern and central parts of the district falling in Neem Ka Thana, Khandela, Sri Madhopur and Danta Ramgarh blocks. In the western part of the district, it generally varies from 25 m to more than 45m. Depth to water level less than 10 m has been observed in central and eastern parts of the district, viz Khandela, Kanwat etc. The long term hydrograph of selected monitoring stations are depicted in Figure 10A & 10B.

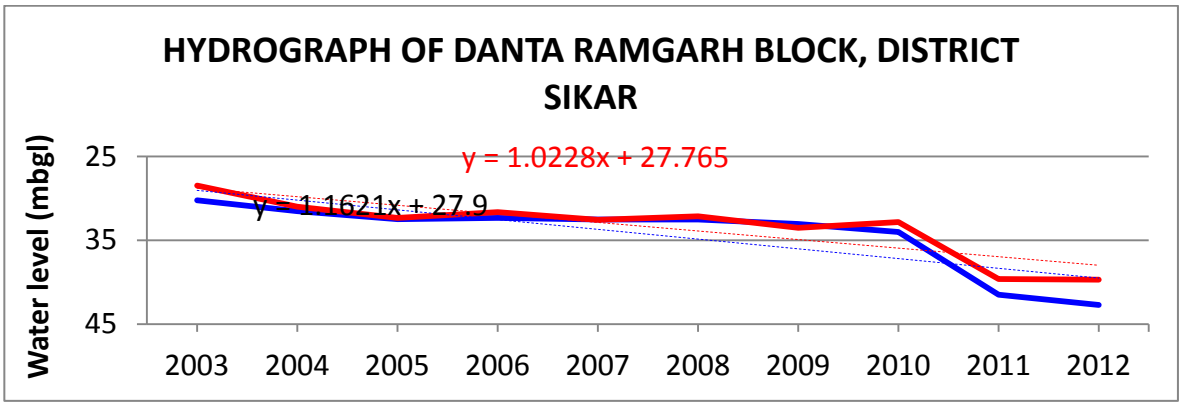

Figure 10A: Hydrograph of Danta Ramgarh Block, District Sikar

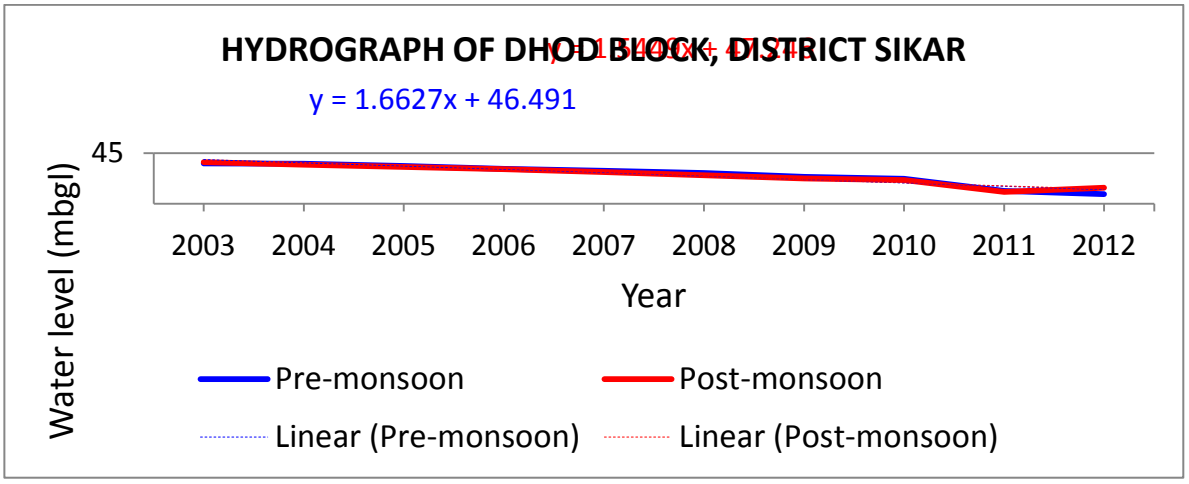

Figure 10B: Hydrograph of Dhod Block, District Sikar

The Block-wise details of depth to water level during Pre-monsoon and Post-monsoon periods and seasonal water level fluctuations are given in Table 3.

Table 3: Block wise depth to water level during Pre and Post monsoon periods and water level fluctuation during 2015

Block	Pre Monsoon		Post Monsoon		Water level fluctuation (Pre–Post)	
	Min	Max	Min	Max	Min	Max
Danta Ramgarh	14.10	72.64	13.55	71.55	-11.45	4.95

Block	Pre Monsoon		Post Monsoon		Water level fluctuation (Pre–Post)	
Dhod	37.88	77.20	38.10	78.25	-1.30	0.05
Fatehpur	30.15	51.60	29.99	50.90	0.04	1.15
Khandela	7.30	43.90	6.10	44.20	-4.05	9.11
Lachhmangarh	33.30	64.60	31.43	64.80	-0.83	1.87
Neem Ka Thana	1.80	53.75	0.80	46.99	-4.55	11.40
Piprali	13.05	74.73	7.95	75.25	-1.39	5.24
Sri Madhopur	27.72	58.95	27.80	58.20	-2.04	0.75
District	1.80	77.20	0.80	78.25	-11.45	11.40
(-) shows decline						

The study of fluctuation data indicates that rise in water level varies from 0.04m to 11.40 m. The decline in water level ranges from 0.83m to 11.45m. The decadal water level fluctuation map (2005-2014) of Sikar district is shown in Figure 11.The district shows declining trend of ground water during the period 2001-2015. Average trend of each block is given in Table 4.

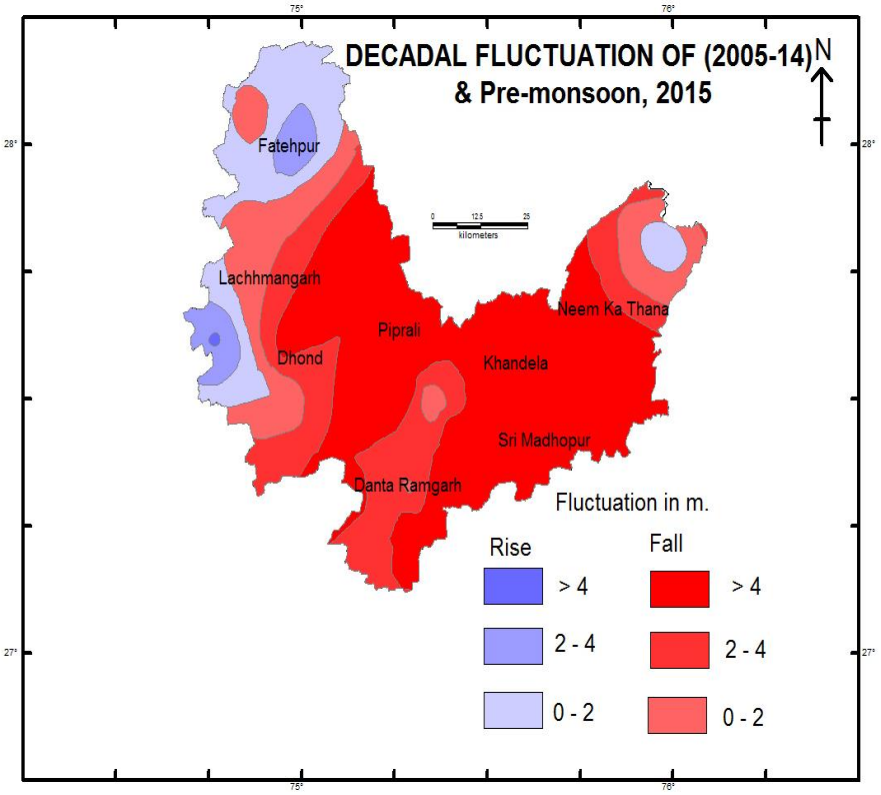

Figure 11: Decadal Water Level Fluctuation map, District Sikar

Table 4: Block wise average water level trend during 2001 – 2015

Block	Trend (m/yr)
Danta Ramgarh	0.70
Dhod	1.12
Fatehpur	0.15
Khandella	0.76
Lachhmangarh	0.37
Neem Ka Thana	0.48
Piprali	0.57
Sri Madhopur	1.04

Water Table Gradient:

The general direction of ground water flow is from south-west to north- east, however, in the north eastern part of the district viz. Neem ka Thana, Patan, it is towards north eastern direction. As far as, regional flow direction is concerned, the water table follows the slope of basement topography. In the alluvial tract, the gradient of water table is of the order of 1 to 1.5 m/km but in hard rock areas, it is steeper and is 3 to 5 m/km. Water table maps on plane and 3D of area have been prepared using Rock Works Software and portrayed in Figure 12.

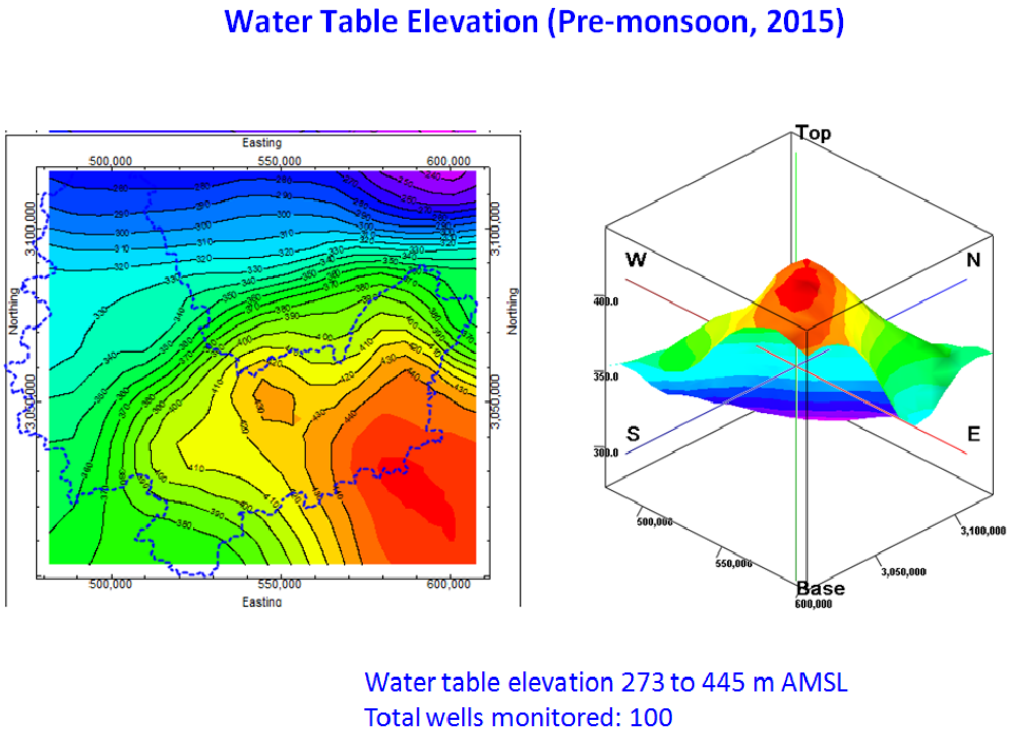

Figure 12: Water Table Map, Sikar District

3. Ground Water Quality

3.1 Quality of shallow groundwater

The study of quality data indicates that in general, the groundwater quality is suitable for domestic, irrigation and industrial purposes except at a few localized small patches. The minimum and maximum values and general range of various chemical constituents in ground water is furnished below in Table 5.

Table 5: Ranges of chemical constituents in shallow ground water, Sikar District

Chemical constituents	**Range**		**BIS 10500 Limits**	
	Minimum	**Maximum**	**Desirable**	**Permissible**
pH	7.02	9.00	6.5	8.5
EC (mmhos/cm at 250 C)	405	10860	500	2000
CO3 (ppm)	0	192	-	-
HCO3 (ppm)	171	1330	-	-
Cl (ppm)	14	1985	250	1000
Total Hardness (ppm)	50	2200	300	600
SO4 (ppm)	5	2325	200	400
NO3 (ppm)	1	1135	45	45
Ca (ppm)	16	436	75	200
Mg (ppm)	5	304	30	100
Na (ppm)	60	1074	-	-
K (ppm)	1	463	-	-
F (mg/l)	0.10	994	1.00	1.50

Electrical conductivity:

Electrical conductivity ranges from 405 to10860 mmhos/cm at 250C. However, in greater part of the District, it varies from 750 mmhos/cm 250C to 2500 mmhos/cm 250C. The electrical conductivity map prepared using pre-monsoon, 2011 data is depicted in Figure 13. The perusal of map indicates that in small areas around Fatehpur, Nechwa (in the western part of district), it is between 2000 and 3000 mmhos/cm 250C. More than 3000 mmhos/cm 250C is noticed around central part such as Samer, Kochhor, Gowati etc. Electrical conductivity more than 5000 mmhos/cm 250C has been found around Samer, Motlawas, Rewasa etc.

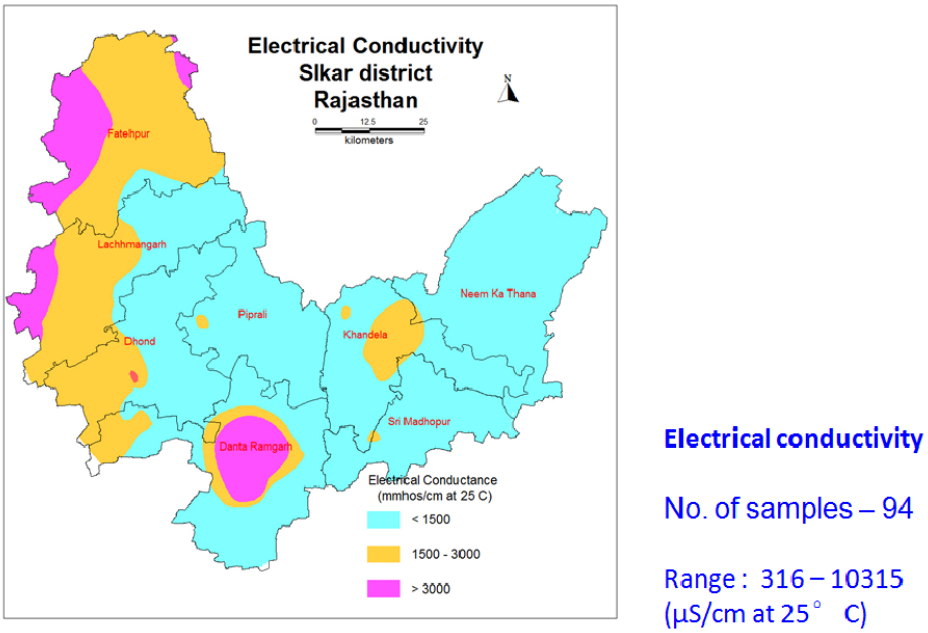

Figure 13: Map showing distribution of Electrical Conductivity, Sikar District

The fresh-saline interface based on VES conducted by CGWB is shown in Figure 14.

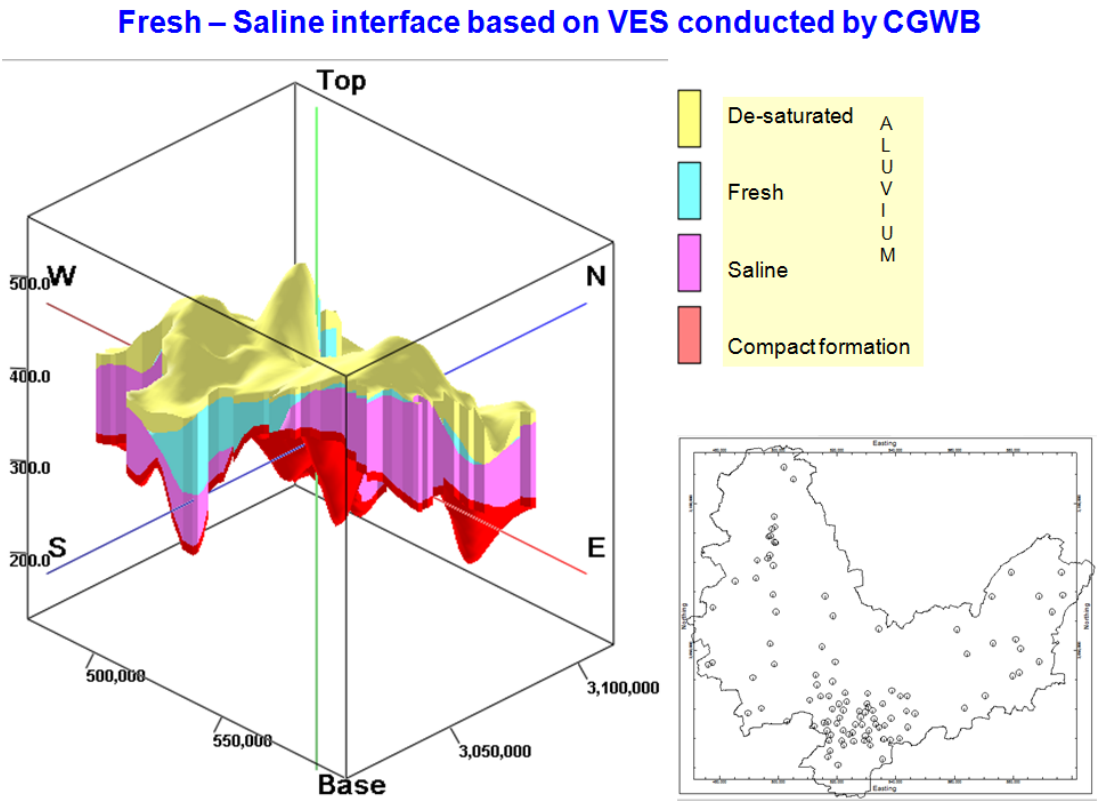

Figure 14: Fresh-Saline interface based on VES conducted by CGWB, Sikar District

Fluoride:

Fluoride concentration in ground water ranges from 0.10 mg/l to 7.25 mg/l. Higher fluoride concentration (14.28 mg/l) has been observed at Dukia village. In northern part around Khandela & Guhala concentration of fluoride varies from 2.67 to 7.08 mg/l. Fluoride in excess of maximum permissible limit has been observed in parts of Fatehpur, Lachhmangarh, Dhod, Danta Ramgarh and Khandela blocks (Figure 15).

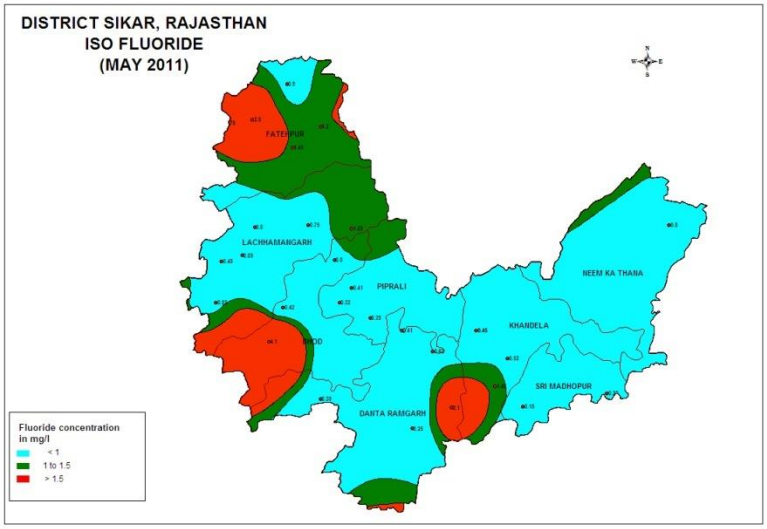

Figure 15: Map showing Fluoride distribution in Sikar district, Rajasthan

Nitrate:

Nitrate concentration in excess of maximum permissible limit of 45 mg/l has been observed from isolated pockets in all the blocks except Khandela and Sri Madhopur blocks (Figure 16).

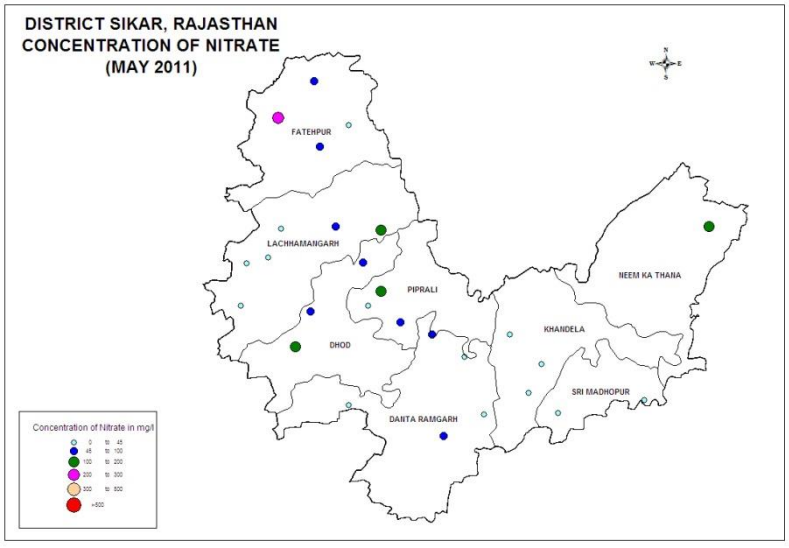

Figure 16: Map showing distribution of Nitrate in Sikar district, Rajasthan

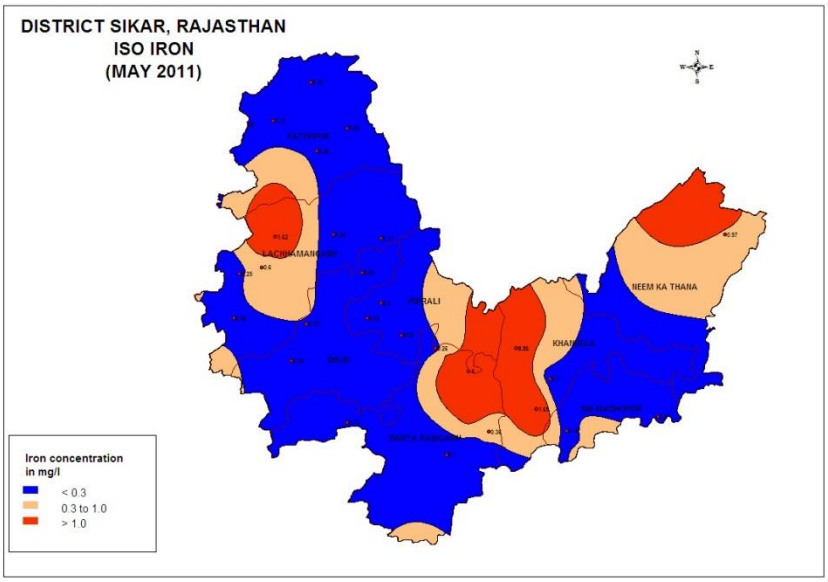

Figure 17: Map showing distribution of iron in Sikar district, Rajasthan

Iron:

Iron concentration in major part of the district is within the maximum permissible limit of 1 mg/l. Excess iron concentration has been observed in isolated pockets in almost all the blocks (Figure 17).

3.2 Groundwater quality in deeper aquifers

Study of groundwater quality in deeper aquifers is based on water samples collected during survey from tube wells and exploratory wells drilled by Central Ground Water Board. Ground water quality in deeper aquifer is more or less similar to that of shallow aquifer, as the aquifers are interconnected and form single litho-unit. A perusal of chemical data indicates that electrical conductivity of ground water ranges from 595 mmhos/cm 250C (at Motlawas in Lachhmangarh block) to 2880 mmhos/cm 250C (at Ramgarh in Fatehpur block). The fluoride concentration varies from 0.73 mg/l to 9.94 mg/l and chloride concentration varies from 21 ppm to 362 ppm. Ground water in deeper aquifers in the district is by and large suitable for drinking purpose.

Depth wise salinity variation:

The depth wise salinity variation is indicated by the results of chemical data of water samples. Around areas such as Dukia, Samer, Motlawas, Dudwa, Bajyawas, Gowati etc., vertical salinity variation has been noticed. As a whole, some patches of salinity and fluoride hazards are emerging due to heavy exploitation of ground water.

Long term ground water quality variation:

Long term changes in ground water quality have been studied based on the chemical data of NHS. In general, there are no marked changes in the ground water quality. In the western part of the district i.e. in Fatehpur and Dhod blocks, some part of central area of Lachhmangarh block

and part of Piprali block are affected with salinity hazard. This may be the case of inland salinity caused due to inland drainage.

4. Groundwater Resources

Ground water resources have been reassessed jointly by Central Ground Water Board and State Ground Water Department as on 31.3.2013 based on Ground Water Estimation Committee (1997) is given in Table 6.

Table 6: Block wise details of annually replenishable ground water resources and withdrawal

Block	Total Annual Ground Water Recharge	Natural Discharge during non-monsoon season	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross G.W. Draft for Dom. & Ind. Use	Existing Gross Ground Water Draft for all uses	Stage of G.W. Development
Danta Ramgarh	50.8885	5.0888	45.7997	69.407	8.2474	77.6544	169.55
Dhod	45.0834	4.5083	40.5751	58.9594	6.7981	65.7575	162.06
Fatehpur	44.2333	4.4233	39.81	16.439	11.8211	28.2601	70.99
Khandela	32.0332	1.9262	30.107	25.3493	5.8834	31.2327	103.74
Lachhmangarh	50.0998	5.01	45.0898	50.9693	10.3849	61.3542	136.07
Neem Ka Thana	32.098	3.2098	28.8882	44.9575	8.6282	53.5857	185.49
Piprali	35.2697	3.527	31.7427	47.5641	11.703	59.2671	186.71

The changing scenario of ground water development over the years since 2004 has been depicted with the help of bar diagram in Figure 18.

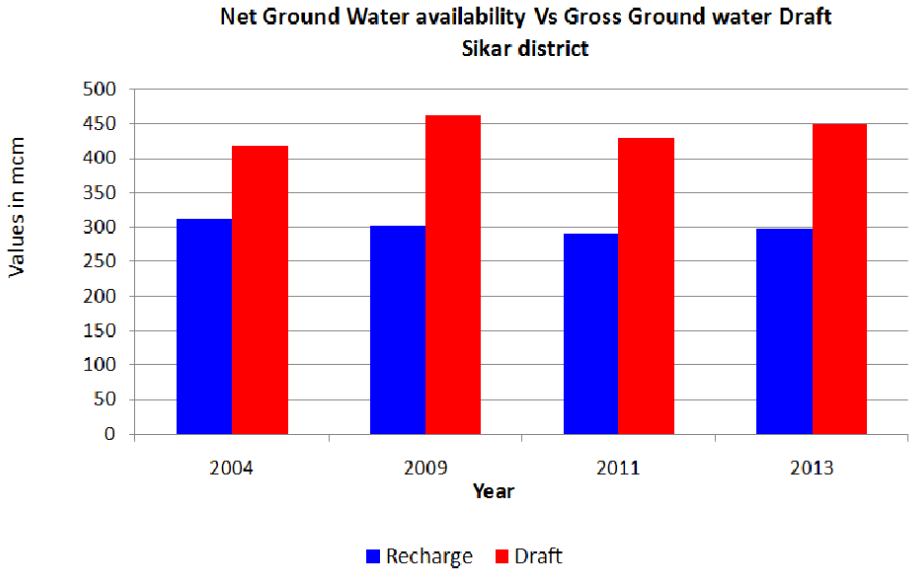

Figure 18: Ground Water Development Status, Sikar District

5. Groundwater Related Issues &Problems

Almost the entire district faces the problem of groundwater scarcity. However, there are some areas which are vulnerable to pollution and depleted water table.

Groundwater Quality hazards:

Chemical analysis results of water samples from phreatic aquifer indicate that nitrate, chloride, fluoride etc. occur beyond prescribed limit in isolated pockets in various parts of the district. Groundwater from deeper aquifer does not contain any such chemical constituents in excess concentration which may be harmful to local population. Electrical conductivity more than 5000 ms/cm at 250C is found in and around northern and western part of the district falling in Fatehpur and Lachhmangarh blocks. In and around the village Rewasa (in Piprali block), EC is more than 6000 ms/cm at 250C due to inland saline lake.

Chloride content in groundwater in excess of the prescribed limit occurs in Biramsar, Fatehpur, Shekhawas, Ramsisar, Udansar, Juliasar villages in the northern and western parts of the district falling in Fatehpur and Lachhmangarh blocks. High fluoride concentration in groundwater has been observed at Rookansar, Tejsar, Bikamsar, Dukia, Kochar and Bibipur villages in south central, northern and some pockets in western parts of the district. Overall, the northern and western parts of the district are affected with groundwater quality problem especially salinity hazard.

The district does not have any major industrial establishment and there are no large scale mining activities in the area. Hence, the chances of pollution are very limited. Till now, no report has been received either from State Govt. or from any other sources regarding large scale ground water pollution in the area. Central Ground Water Board is continuously monitoring the chemical quality in the area to keep vigil over the quality of ground water.

Water table depleted area:

As mentioned earlier, groundwater development in the district is more than 100%. Long term trends of hydrographs indicate that there has been some decline in western part, south central part and small area lying in eastern part of the district. Due to decline in water level, alluvium is no more yielding aquifer. Around 85% of monitored stations show decline in water level while only 15% stations indicate marginal rise in water level. In more than a decade, 6 to 8 m of decline in water level has been observed.

Areas Notified by CGWA:

Dhod & Sri Madhopur were Notified on 2nd December 2006 by the Central Ground Water Authority for ground water regulation and management making it mandatory to seek permission for any structure proposed to be drilled for groundwater abstraction. District Collector has been authorized to take necessary measures for implementation of regulatory measures.

6. Management Strategy

All the blocks except Fatehpur block are over exploited, thereby, leaving no/limited scope of further ground water development for various consumptions and area is devoid of sustained

surface water bodies. In order to manage the ground water resources and to control further decline in water levels, a management plan has been proposed. In order to manage the ground water resources and to control further decline in water levels, a management plan has been proposed. The management plan comprises two components- supply side management and demand side management. Since there is very little surplus surface water available in this district, very little intervention in the form of supply side management could be proposed.

6.1 Supply Side Management

The supply side management of ground water resources can be done through the artificial recharge of surplus runoff available within river sub basins and micro watersheds. Also it is necessary to understand the unsaturated aquifer volume available for recharge. The unsaturated volume of aquifer for the Sikardistrict is computed based on following; the area feasible for recharge, unsaturated depth below 5 m bgl and the specific yield of the aquifer.

6.1.1 Artificial recharge to ground water through interventions of various structures

The following parameters are inevitable for planning of artificial recharge to ground water.

- Availability of sufficient storage space to accommodate recharged water
- Availability of surplus water to recharge
- Feasibility of sub-surface geological formations

In case of Sikar district, sufficient sub-surface storage space is available to accommodate the recharged water. Details of feasible recharge structures to recharge the surplus water in respective block is given in Table 7.

Table 7: Block-wise details of feasible recharge structures, Sikar District

Block	Zone AREA (sq. km.)	surplus available in the Zone (in Mm3)	No. of RS 0.03 MCM/RS	No of RS possible in block (as per water bodies)	Remaining Surplus water for Recharge and Conservation	No. of PT (Rounded off to nearest integer)	No. of PT possible in block	Surplus for Farm pond	No of Farm Pond
Fatehpur		0	0	0	0	0	0	0	0
Lachhmangarh		0	0	0	0	0	0	0	0
Dhond		0	0	0	0	0	0	0	0
Piprali	60.47	0.0273	1	1	0	0	0	0	0
Khandela	661.34	1.1346	38	38	0	0	0	0	0
Srimadhopur	526.62	0.2554	8	8	0	0	0	0	0
Danta Ramgarh	784.92	0.3414	11	11	0	0	0	0	0
Neem Ka Thana	949.65	4.9377	164	98	1.98	10	10	0	0
Total	2983.00	6.6964	222	156	1.98	10	10	0	0

Out of total computed 222 no. of feasible recharge structures, only 156 are possible as per the availability of water bodies. Remaining surplus water for recharge of 1.98mcm after intervention of 156 recharge structures, may be recharged through 10 no. of possible percolation tanks. Summary of recharge structures and percolation tanks and their cost component is as below:

Information	**Figure**
Surplus available	6.69 MCM
Number of recharge shafts (in existing village ponds)	156
No. of percolation tanks	10
Net ground water recharge	4.68 MCM
Total cost of proposed interventions	Rs 13 crore

6.2 Demand Side Management

Though not much augmentation can be done through supply side management due to less availability of surplus water, applying the techniques of demand side management can save large amount of water. Demand side management has been proposed through two interventions – changing the more water intensive wheat crop to gram (chick pea) and use of sprinkler irrigation in the areas where rabi crop is being irrigated through ground water.

6.2.1 Change in cropping pattern

In view of the alarming decline of water level, drastic reduction in saturated thickness of aquifer and resulting of depletion of aquifer, there is need to bring paradigm change/shift in cropping pattern in the area. It is proposed to grow low water requirement crop like gram in the instead of wheat. Growing of gram will save the water to the tune of about 100 mcm per annum @ 0.1m (Table 8).

6.2.2 Adoption of modern practice of sprinkler irrigation/improved irrigation practices

Data indicate that flooding method of irrigation is still in practice in many parts of the district which causes wastage of ample quantity of water. In view of this, it is proposed to bring about 50% of total irrigated area under sprinkler irrigation which may save water to the tune of about 224.09mcm/annum @0.08m (Table 8). Total cost of sprinkler sets has been computed as Rs. 738 crore @50,000/hectar

- Sprinkler
    - Area already under irrigation by sprinkler – 1476 sq km (50%)
    - Additional irrigated area to be brought under irrigation by sprinkler - 1476 sq km (remaining 50%)
    - Net Water saving - 118 MCM (20% of crop water requirement)
    - Total cost for sprinklers – Rs 738 crore @Rs 50,000 per hectare
- **Land levelling**

- Land levelling in 295 sq km (10% irrigated area)
- Net water saving - 6 MCM (2% of crop water requirement)
- Total Cost – Rs 30 Crore @Rs 10,000 per hectare
- **Change in cropping pattern**
- From wheat to gram in 1000 sq km irrigated area
- Net water saving - 100 MCM

- **Total water saving : 224 MCM**
- **Total Cost / Outlay: Rs. 768 Crores**

Table 8: Block-wise water saving through change in cropping pattern and irrigation practice

Block	Irrigated Area (ha)	Total cost sprinkler (Rs in cr)	Total cost of land levelling (Rs in cr)	Water Saving by sprinkler in mcm @0.08 m	Water Saving by land levelling in mcm @0.02 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saving (mcm)
Fatehpur	6870	17.18	0.69	2.75	0.14	2.84	5.72
Lachhmangarh	25893	64.73	2.59	10.36	0.52	8.36	19.24
Dhond	60573	151.43	6.06	24.23	1.21	18.31	43.75
Piprali	51003	127.51	5.10	20.40	1.02	16.20	37.62
Khandela	38809	97.02	3.88	15.52	0.78	13.76	30.06
Sri Madhopur	29277	73.19	2.93	11.71	0.59	10.38	22.68
Danta Ramgarh	61422	153.56	6.14	24.57	1.23	22.99	48.79
Neem Ka Thana	21406	53.51	2.14	8.56	0.43	7.24	16.23
Total	295253	738.13	29.53	118.10	5.91	100.08	224.09

Considerable saving of ground water can be achieved if the proposed supply side and demand side management plans are implemented. With the implementation of supply side management, additional 4.68 MCM/year can be recharged. It can be seen that not much augmentation in ground water resources can be achieved through artificial recharge due to constraints of availability of surplus/non-committed surface water. However, considerable improvement in ground water situation can be achieved with implementation of demand side management plans.

With the proposed use of sprinkler irrigation in the areas where rabi crop is being irrigated through ground water it is expected that 118 MCM/year can be saved due to reduction in pumping and with changing the wheat crop to gram (chick pea) and additional 100 MCM/year can be saved due to reduction of pumping. With implementation of these two interventions, a total of 224 MCM/year can be saved. This may lead to a total reduction in ground water draft from 428.95 MCM/year to 204.86 MCM/Year and with this, the stage of ground water development may come down from 151.22 to 70.48%. Block wise details of ground water recharged and saved along with expected improvement in stage of ground water development is given in Table 8.

Table 8: Summary of expected benefit of management strategies, Sikar district

Block	Net G.W. Availability (mcm)	Additional Recharge from RWH & conservation (mcm)	Total Net G.W. Availability after intervention (mcm)	Existing G.W Draft for all purpose (mcm)	Saving of Ground water through projects (mcm)	Net GW draft after interventions (mcm)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. (in %)
Fatehpur	43.65	0.00	43.65	30.62	5.72	24.90	70.14	57.03
Lachhmangarh	42.7	0.00	42.70	43.13	19.24	23.89	101.01	55.95
Dhond	37.63	0.00	37.63	60.82	43.75	17.07	161.64	45.37
Piprali	29.2	0.02	29.22	59.72	37.62	22.10	204.52	75.64
Khandela	29.73	0.79	30.52	47.47	30.06	17.41	159.68	57.04
Sri Madhopur	33.02	0.18	33.20	65.53	22.68	42.85	198.45	129.08
Danta Ramgarh	45.8	0.24	46.04	81.74	48.79	32.95	178.48	71.57
Neem Ka Thana	29.38	3.46	32.84	39.92	16.23	23.69	135.85	72.14
Total	291.11	4.69	295.80	428.95	224.09	204.86	151.22	70.48