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

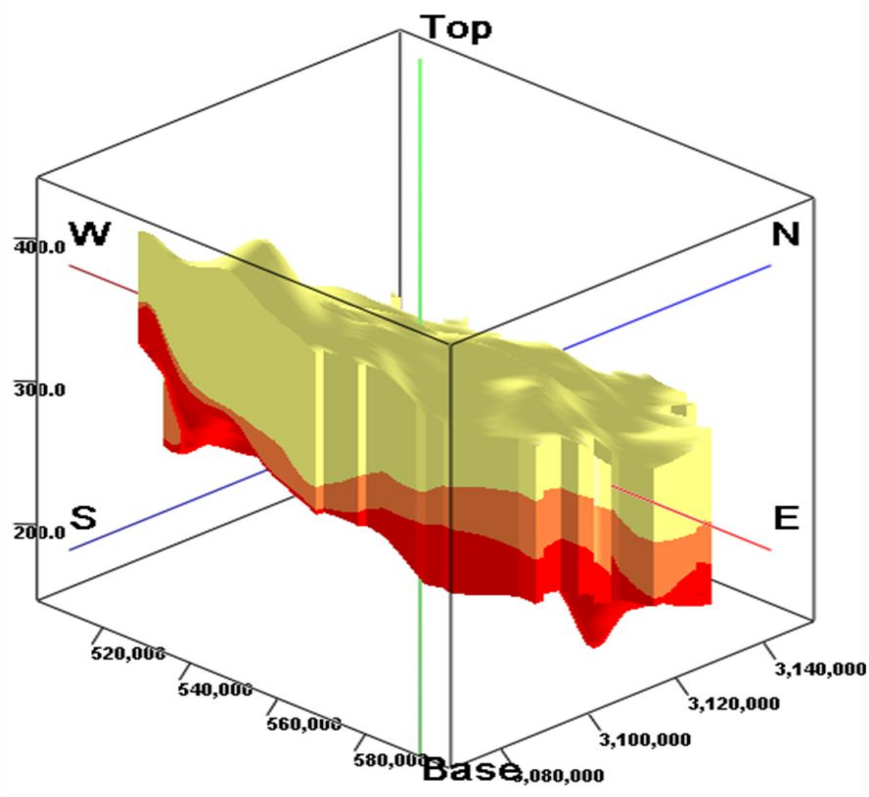
AQUIFER MAPPING AND GROUND WATER MANAGEMENT

Jhunjhunu District, Rajasthan

पश्चिमी क्षेत्र जयपुर

Western Region, Jaipur

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



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

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Contents

List of Tables

List of Figures

Part B

Report on National Aquifer Mapping Programme

(Based on Available Data)

District Jhunjhunun, Rajasthan

1. Introduction

1.1 Objectives

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 resource 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.

1.2 Scope of the study

Aquifer mapping can be understood as a scientific process wherein a combination of geological, Geophysical, hydrological and chemical fields and laboratory analyses are applied to characterized the quantity, quality, and sustainability of ground water in aquifers. Aquifer mapping is expected to improve our understanding of the geological framework of aquifer, their hydrologic characteristics, water level in aquifer and how they changes over time and space and the occurrence of natural and anthropogenic contaminants that affect the portability of groundwater. Results of these studies will contribute significantly to resource management tools such as long term aquifer monitoring network and conceptual and 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 achieve drinking water scarcity, improved irrigation facilities and sustainability of water resource in the state.

1.3 Approach & Methodology

As mentioned above, aquifer mapping is an attempt to integrate the geological, Geophysical, hydrological and chemical field and laboratory analyses are applied to characterize the quality, quantity and sustainability of groundwater in aquifer. Under the National aquifer Prograrmme, 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 system to facilitate planning of their suitable management. The major activities involved in this process include compilation of existing data, identification of data gaps, generation of data for feeling data gaps and preparation of different aquifer layers.

1.4 Area

Jhunjhunun district comprises of 5928 sq km geographical area having 535 sq km(9 %) is hilly area considered not suitable for recharge, 5393 sq km is mappable inclusive of 120 sq km saline area. Administratively the district comprises of 8 blocks and 872 villages. The administrative set up of the district is given in Table 1. The population of district is 2139658 based on Census, 2011 inclusive of 79.35% rural and 20.65% urban population. The density of population is 361persons per sq.km.

Table 1. Administrative set up of Jhunjhunun district

Sub-division	Tehsil	Block	Area (sq.km.)
Chirawa	Chirawa	Chirawa	493.04
		Surajgarh	779.09
Jhunjhunun	Jhunjhunun	Alsisar	827.15
		Jhunjhunu	751.90
Khetri	Buhana	Buhana	651.14
	Khetri	Khetri	819.44
Nawalgarh	Nawalgarh	Nawalgarh	696.80
Udaipurwati	Udaipurwati	Udaipurwati	867.28

1.5 Data availability

Exercises on Groundwater availability, data on monitoring (water level and chemical quality) and exploration had been carried out by CGWB and state Ground Water Department. 38 NHS are being monitored by CGWB, WR, Jaipur and 110Key observation wells have been monitored by State GWD Govt. of Rajasthan121 EW & OW have been constructed by CGWB while several exploratory wells have been constructed by State GWD, Rajastghan.

1.6 Data Adequacy

The data collected from State GWD and CGWB WR Jaipur have been compiled and analyzed. It has been observed that validation and georeferncing of the location coordinates, lithologs and hydrogeological data is needed and State GWD data is lacking in aquifer parameters. Geophysical data collected needs georeferncing 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.

1.7 Data Gap Analysis

Data collected from State GW agencies and CGWB has been brought to a standard format and integrated location maps has been prepared regarding groundwater monitoring, exploration, surface water and agriculture data. Based on these maps and hydrogeological conditions in Jhunjhunun District further need of generation has been felt in the gaps areas. The details of data gap for monitoring and exploration is given in appendix.

1.8 Drainage and Land use

Jhunjhunu district is covered under mainly Sekhawati basin and north western part falls under the outside the basin i.e. having inland drainage. The area is drained mainly by Kantli River. The area in the south eastern part is drained by Singhana River and a small area in the south western corner of district is drained by Budhi nala. The south and east of hill ranges in Khetri area is drained by Dohana River. All the rivers/nalas are ephemeral in nature and flows in response to heavy precipitation during monsoon. Being a desertic terrain particularly in north eastern and north western part of district has inland drainage. The land use statistics of the district are furnished below in Table 2.

Table 2: Land Use Statistics

Sl.No.	Particulars	Area (sq.km.)
1	Area not suitable for cultivation	355.92
2	Hills & hilly forest	396.14
3	Pasture land	401.74
4	Barren land	65.91
5	Others	79.00
6	Area suitable for cultivation but not cultivated	422.87
7	Area under cultivation	6463.23
	i. Area irrigated by wells	2267.38
	ii. Area irrigated by canals	0.17
	iii. Area irrigated by tanks/ponds	0.36
	iv. Area irrigated by other sources	Nil
	v. Un irrigated area	4195.32

1.9 Agriculture

Agricultural activity is spread over both kharif and rabi cultivation. Kharif cultivation is rainfed and rabi cultivation is mostly based on groundwater. The main kharif crops grown in the area are Bajra, Guar, Cow Pea (Chola), Moong, Moth whereas as principal rabi crops are Wheat, Gram, Mustard etc.

The total sown area is 6463.23 sq. km., out of which 2267.91 sq. km (forming 35.09%) is irrigated. Tehsil wise break up of area under various seasonal crops is given below in Table 3.

Table 3: Tehsil wise break up of area under various seasonal crops

Tehsil	Kharif		Rabi		Jayad Rabi	
	Area sown	Irrigated	Area sown	Irrigated	Area sown	Irrigated
Jhunjhunu	1239.48	5.55	304.58	303.41	11.57	11.57
Chirawa	1042.16	7.80	871.94	854.45	21.33	21.33
Khetri	346.85	6.53	220.19	192.09	5.04	5.04
Nawalgarh	517.75	18.11	208.30	207.36	15.10	15.10
Udaipurwati	488.22	11.61	279.97	275.56	11.31	11.31
Buhana	464.60	0.92	362.46	291.41	7.74	7.74

The area irrigated is mostly by groundwater forming 98.98% of total area irrigated. Source wise irrigation details are given below in Table 4.

Table 4: Source wise Irrigation Details

Tehsil	Wells/Tube wells		Ponds		Canals	Gross area irrigated	Net area irrigated	
	No.	Area irrigated	No.	Area irrigated		No.		Area irrigated
Jhunjhunu	4902	326.56	-	-	-	-	326.56	313.37
Chirawa	11653	898.64	-	-	-	-	898.64	876.57
Khetri	4146	182.55	2	0.36	-	0.17	183.08	164.45
Nawalgarh	6321	311.04	-	-	-	-	258.25	228.26
Udaipurwati	8117	258.25	-	-	-	-	311.04	293.48
Buhana	3495	290.34	-	-	-	-	290.34	282.98

1.10 Rainfall and Climate

The climate of the district can be classified as semi-arid. It is characterized by very hot summers and very cold winters with poor rainfall during south-west monsoon period. In May and June, the maximum temperature may sometimes goes up to 48oC. The potential evapo-transpiration rates are quite high, especially during May and June. The total annual potential evapo-transpiration is 1502.6mm.

The mean annual rainfall of the district based on 36 years data (1971-2006), works out to be 485.6mm. However normal annual rainfall (1901-71) of the district is 459.5mm. It can be inferred that the rainfall in the district has significantly increased in the recent years. The coefficient of variation is on higher side at 36.6% indicating that the rainfall is slightly unreliable. A perusal of the figure reveals that the district experienced very poor rainfall between the periods 1979 to 1991 with the exception of few years in between. Thereafter, the district was

fortunate to have very good spell of rainfall continuously for a period of 7 years from 1992 to 1998. The year 1996 was the best with annual rainfall exceeding mean annual rainfall by 85.4%. The district again experienced drought conditions from 1999 to 2002. The year 2002 was the worst with rainfall being 62.3% less than mean annual rainfall. The climatology data of district is shown in Figure 1.

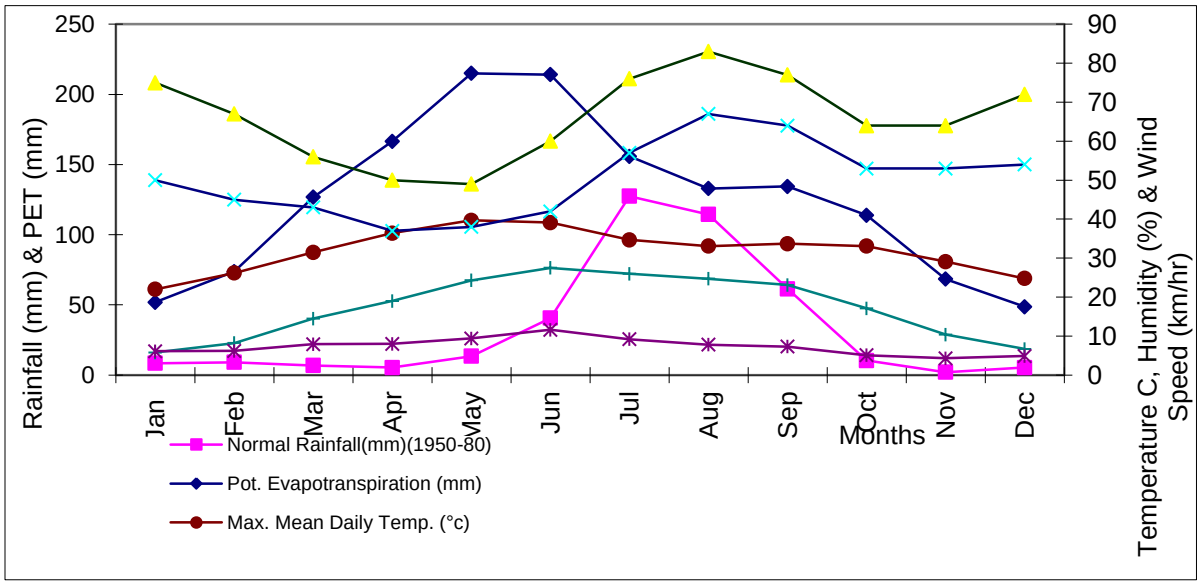


Figure 1: Climatology data of Jhunjhunun district

1.11 Geomorphology And Soil Types

The district encompasses of three distinct geomorphic units.

• The hilly area in south eastern part of district is characterized by hills of Aravalli range, running in north easterly direction. The highest peak, 1051 m high is in the south of Lohagar village bordering Sikar district. Hills are almost barren/ without vegetation except a few bushes of acacia and cactus.

• The undulating area with small isolated hills having steep slope lies in the south western part of district. The major portion of hills is found in Khetri and Udaipurwati tehsils. The general elevation above mean sea level rests between 300 and 450m Quaternary level forms are represented by sand and colluvial deposits of talus and scree at piedment slopes.

• The desertic plain generally lying at an altitude of about 300m above msl occupies the northern part of the district and is covered with sand dunes. The general slope of the area is from south to north. Sand dunes are drifting in nature.

The distribution of soil is given below.

i	Desert soil (Covers 2666 sq.km.area forming 44.97% of district)	Occurs extensively in the central part of the area covering parts of all the blocks except Surajgarh block. These are yellowish brown, sandy to sandy

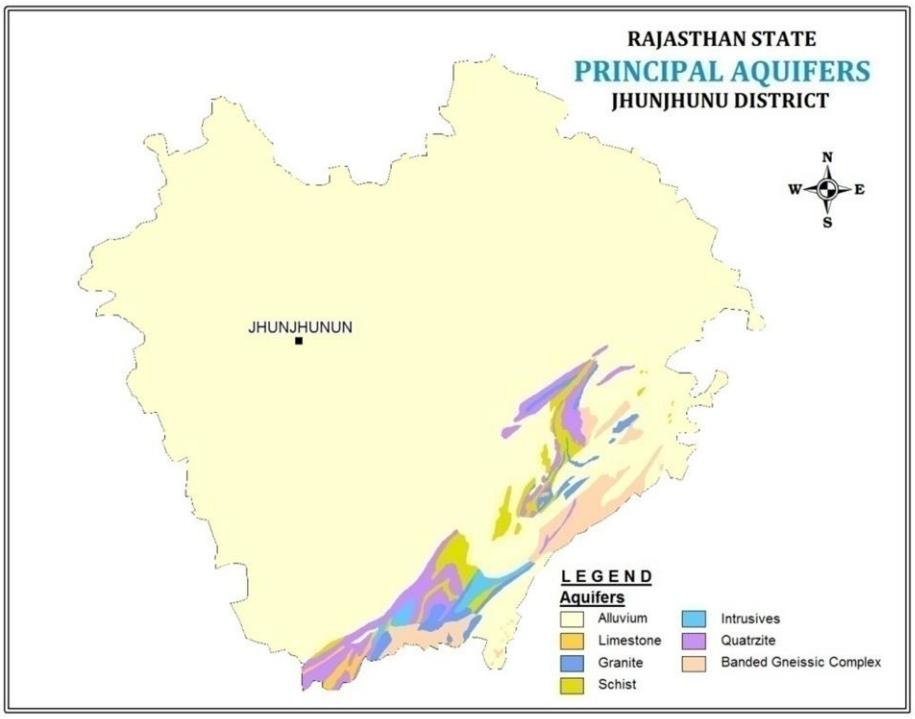
		loam, loose, structure less, well drained with high permeability. They are scanty of vegetation due to severe wind erosion and wind velocity high.
ii	Sand dunes (Covers 2149 sq.km.area forming 36.25% of district)	Present mostly in northern part of the district covering parts of Alsisar, Buhana, and Chirawa blocks. These are non-calcareous soils, sandy to loamy sand, loose, structureless and well drained.In favourable localities they cultivated.
iii	Red desertic soil (Covers 468 sq.km.area forming 7.90% of district)	Rests in parts of Jhunjhunu and Nawalgarh blocks. These are pale brown to reddish brown colour, structureless, loose and well drained having texture from sandy loam to sandy clay loam. Suitable for agriculture but suffers from adverse climatic conditions.
iv	Lithosols and regisols of hills (Covers 329 sq.km.area forming 5.55% of district)	Found on Delhi hills and hill slopes between Khetri and Gudagaurji and south of Udaipurwati in parts of Khetri and Udaipurwati and Nawalgarh blocks. They are shallow with gravels very near the surface, light textured, fairly drained, reddish brown to grayish brown in colour. Cultivation is restricted because of limited root zone.
v	Older alluvium (Covers 316 sq.km.area forming 5.33% of district)	Found in southern most parts of the area in parts of Khetri, Udaipurwati and Nawalgarh blocks. They are derived from alluvium and are non-calcareous, semi-consolidated to unconsolidated brown soils, loamy sand to sandy loam in texture. Well drained and occupy gently sloping terrains.

2. Groundwater Scenario

2.1 Hydrogeology

Quaternary alluvium is the principal water bearing formation (occupies 4639sq.km. forming 78.25 % of district) and hard rock's of Delhi Supergroup. Hard rock's aquifers include quartzite and post Delhi Intrusive (covers 754 sq.km. forming 12.71% of district) form ancillary aquifers in the district (Figure 2).

Alluvial aquifers composed of sand, silt, clay; kankar and gravel form the principal and potential aquifer system in the area. Thickness of alluvial sediments increases from south (having less than 60m) to north and north eastern parts of district (more than 100m). Groundwater occurs under unconfined to semi-confined conditions in the primary porosity i.e. pore spaces.



Area of aquifer (sq km)

Alluvium – 5273.69

Quartzite/Gneiss/ Schist – 754.08

Nature of Aquifer:

Single unconfined aquifer

Figure 2: Principal Aquifer map of Jhunjhunun District

Exploratory borehole data has revealed the presence of aquifer system down to the depth of 100 m in general and reaching maximum to 135 m in the Buhana block. Saturated thickness has been significantly reduced in parts of Jhunjhunun & Bhuana blocks and in areas around Singhana & Khetri, no more alluvial aquifers exist as water level declined and reached down into underlying hard rocks.

Quartzite, schist, phyllite, gneisses and limestone of Delhi Supergroup including granites, amphibolites and pegmatites of post Delhi intrusives form the ancillary aquifer and occupy the south eastern area of the district covering parts of Khetri and Buhana blocks. Groundwater occurs under unconfined condition in the weathered mantle (ranging in thickness from 10 to 15 m) and under unconfined to semi-confined conditions in deep seated secondary porosity i.e. fractures, joints, contacts etc. of hard formation.

Three dimension aquifer geometry and characterization model has been prepared using Rock Works Software which is given in Figure 3.

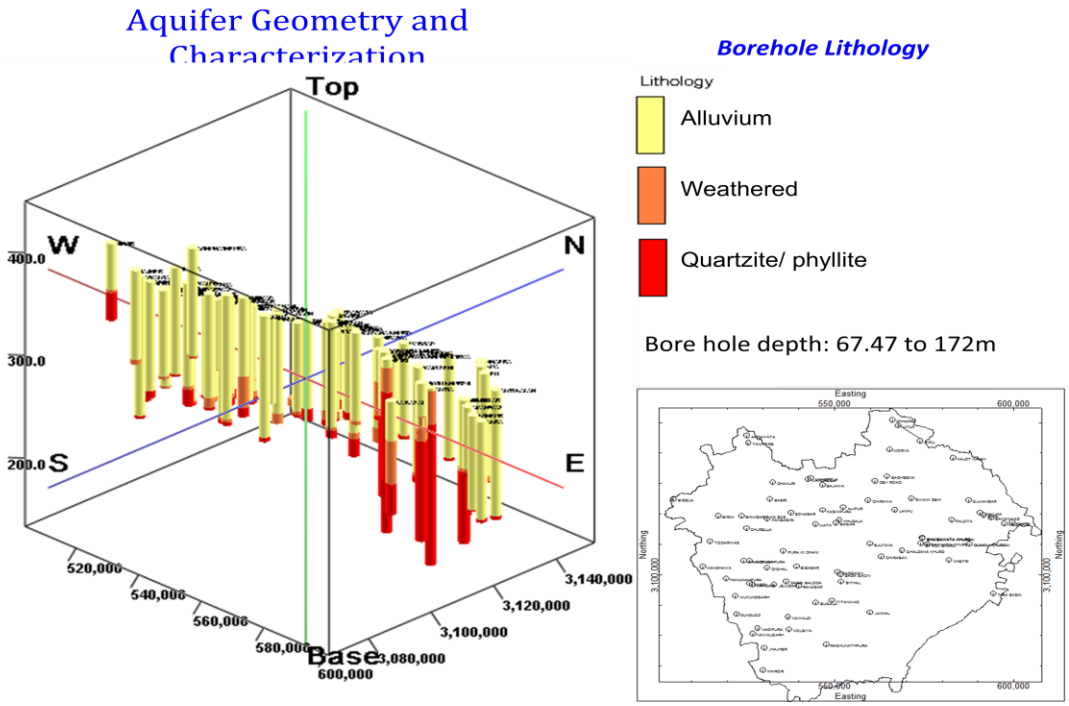


Figure 3: Aquifer Geometry and Characterization Model

Three dimension regional lithology model has been prepared using Rock Works Software which is given in Figure 4.

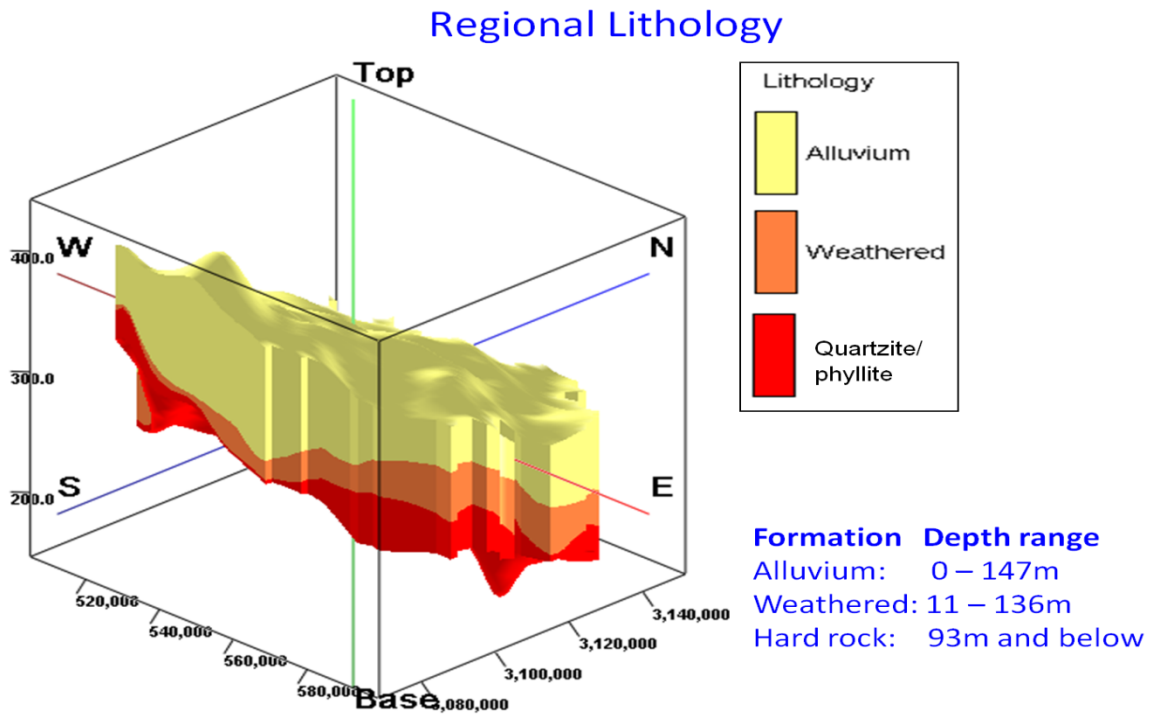


Figure 4: Regional Lithology Model

The fresh-saline interface based on VES conducted by CGWB is shown in Figure 5.

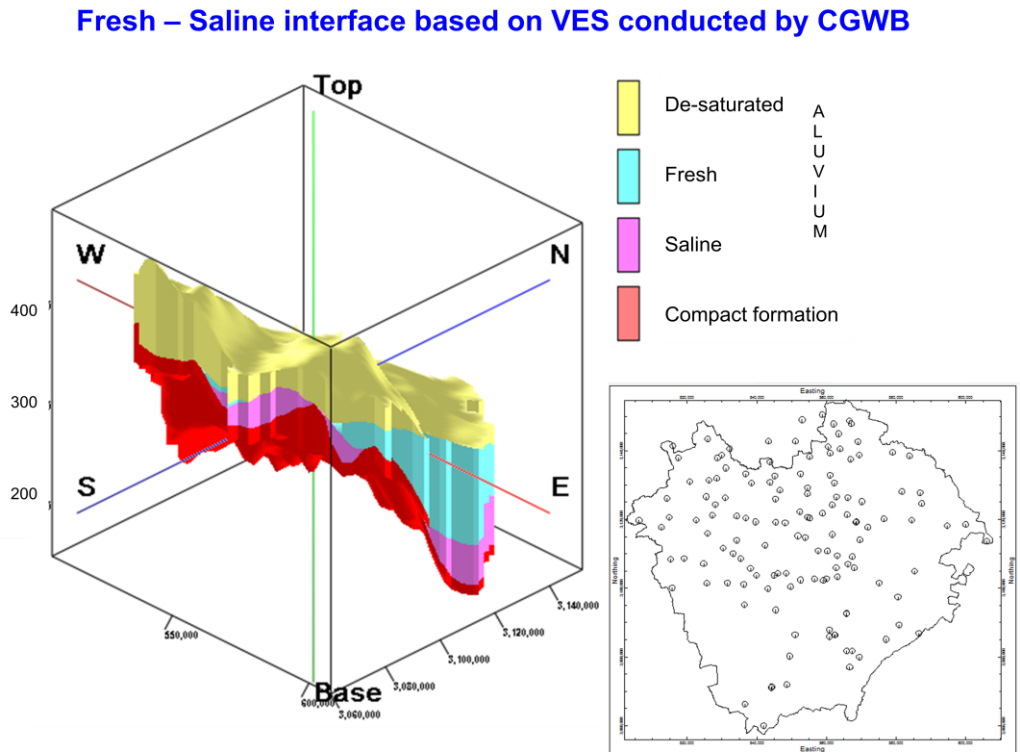


Figure 5: Fresh-Saline interface based on VES conducted by CGWB

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

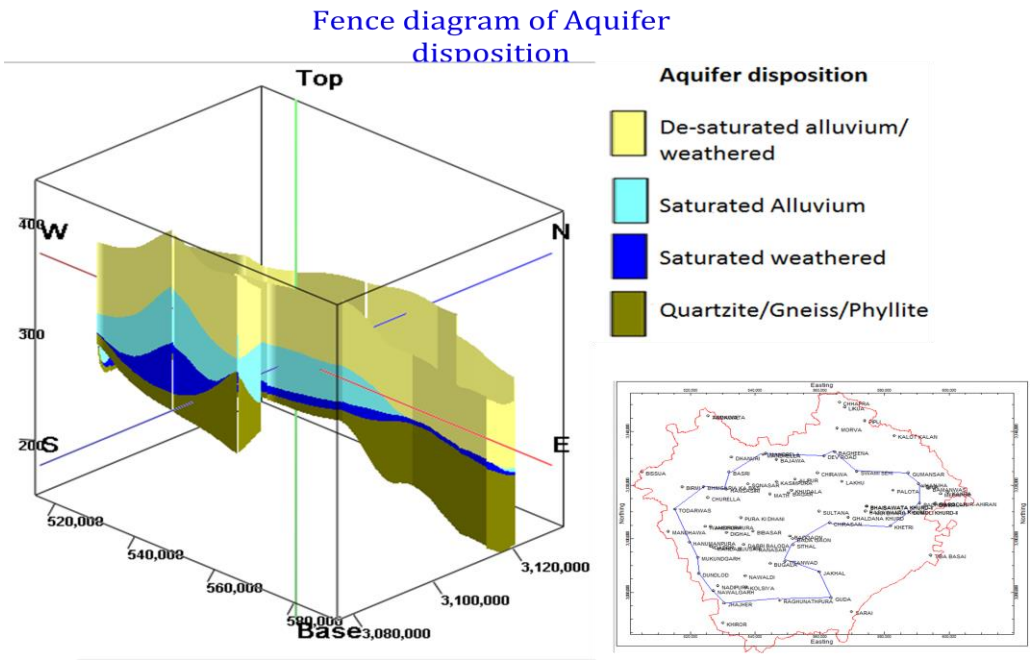


Figure 6: Fence Diagram of Aquifer Disposition

The hydrogeological sections showing aquifer disposition have been prepared and depicted in Figures 6A to 6G.

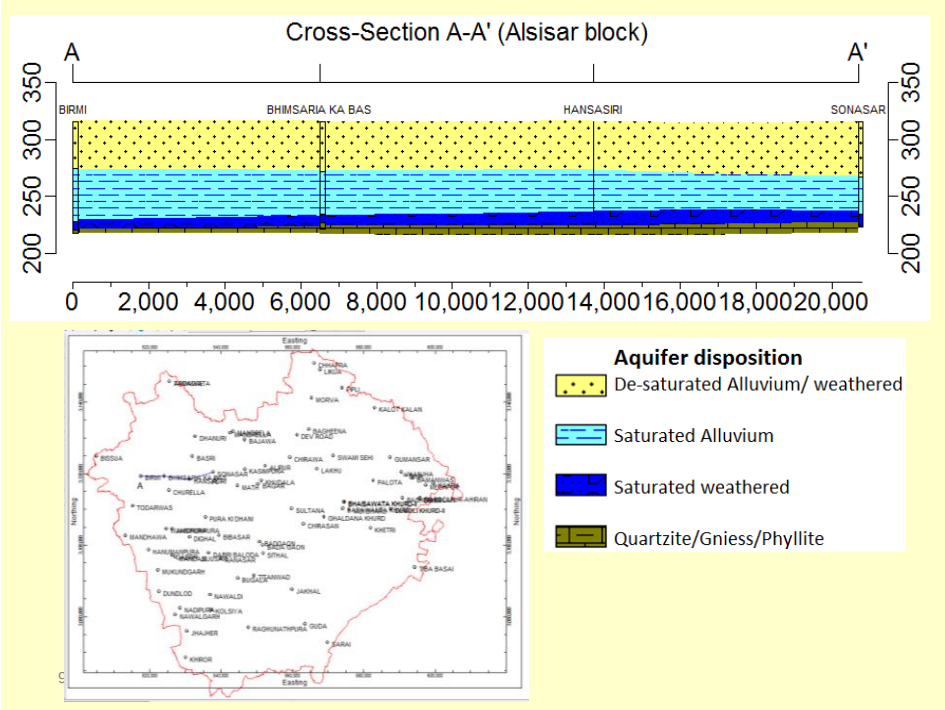


Figure 6A: Section A - A'

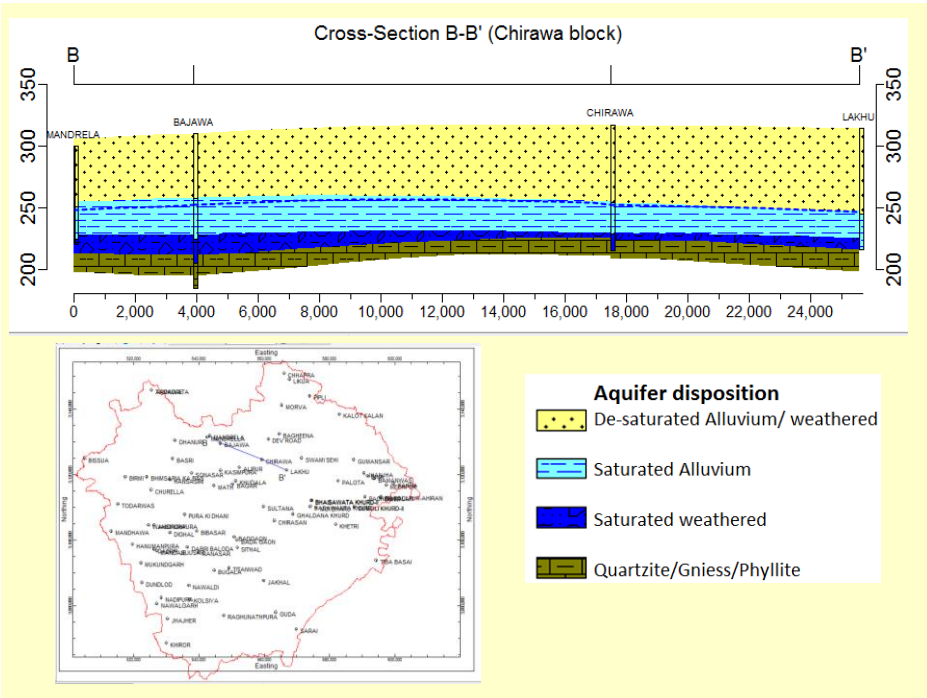


Figure 6B: Section B - B'

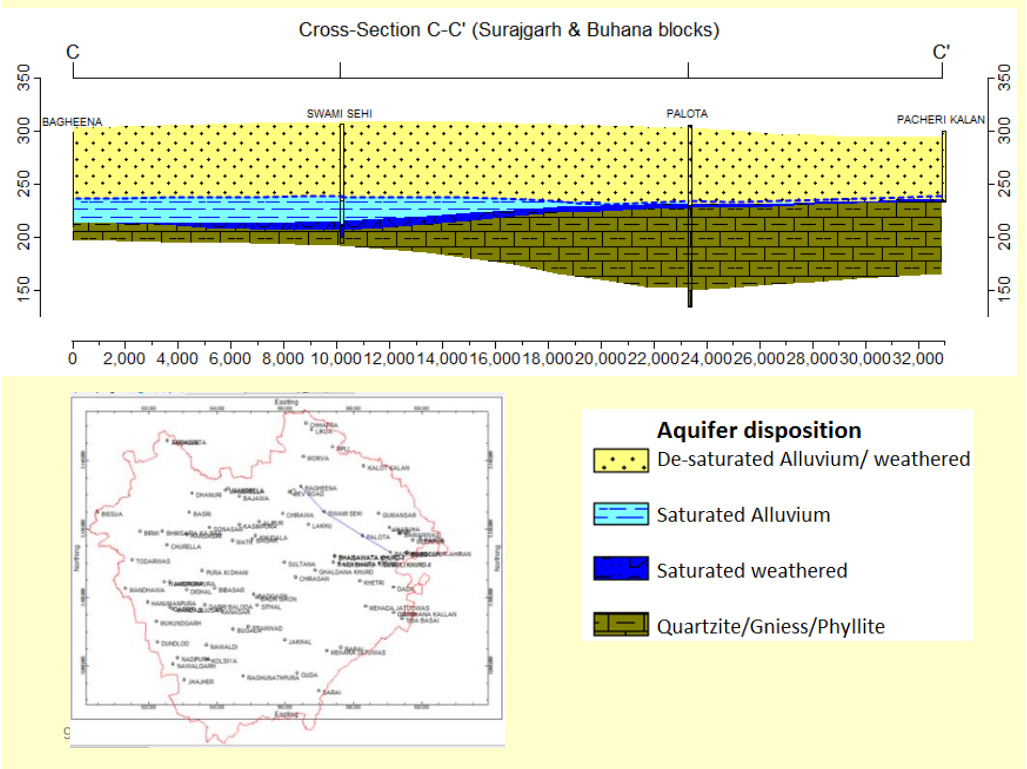


Figure 6C: Section C - C'

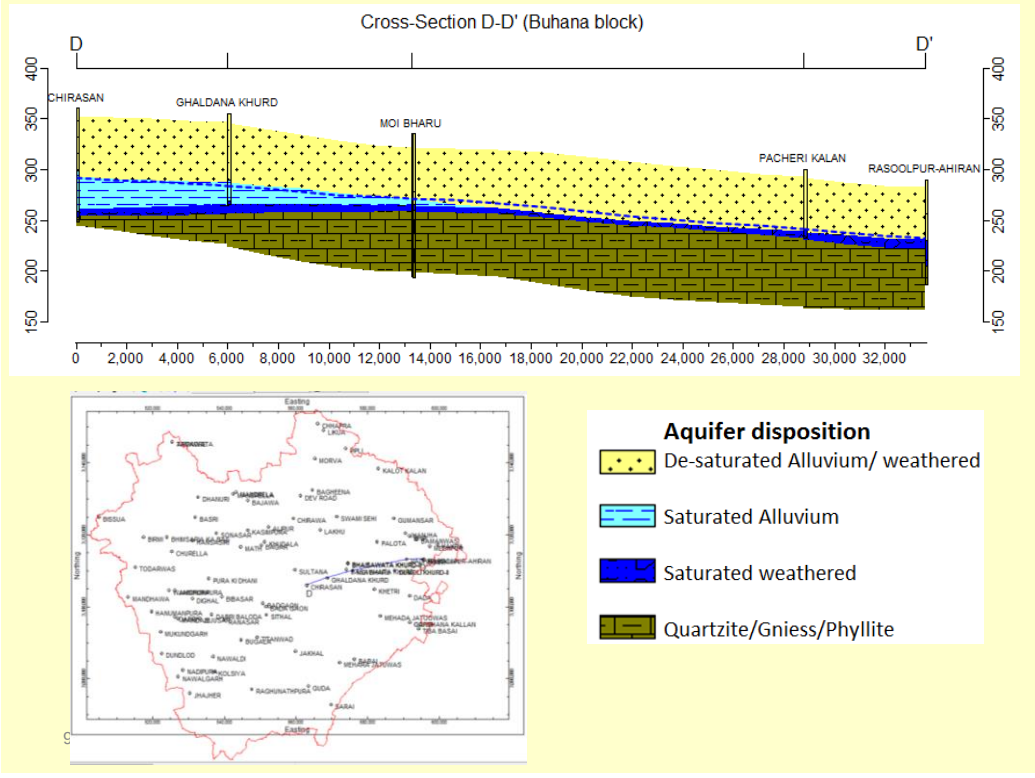


Figure 6D: Section D- D'

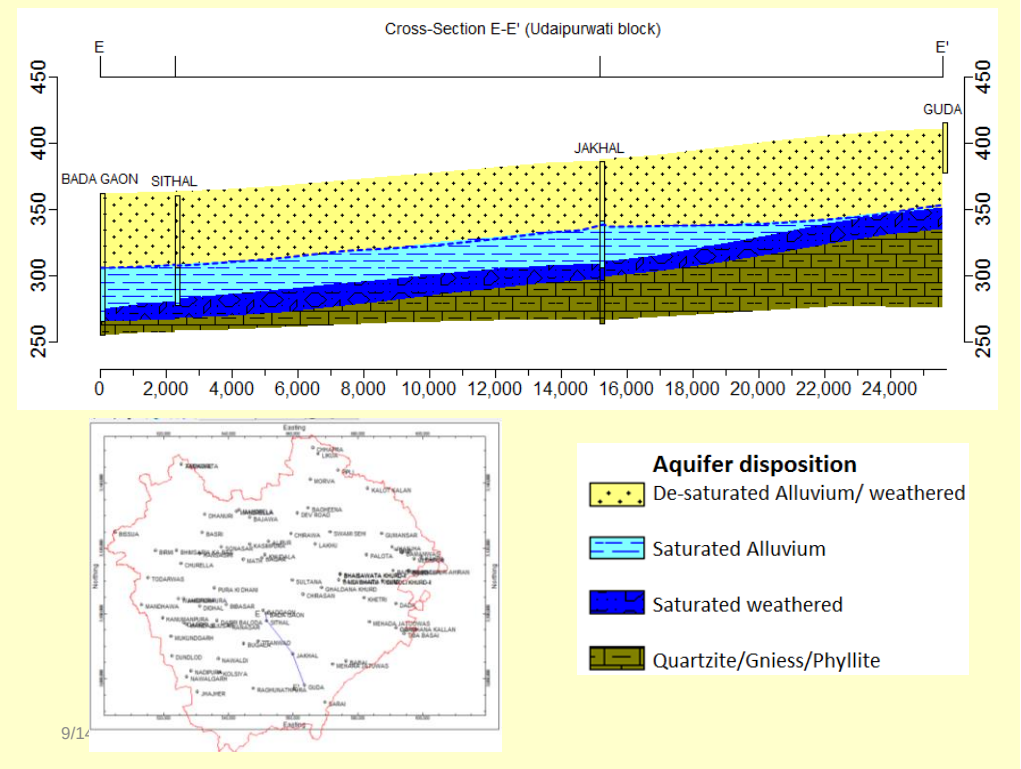


Figure 6E: Section E- E'

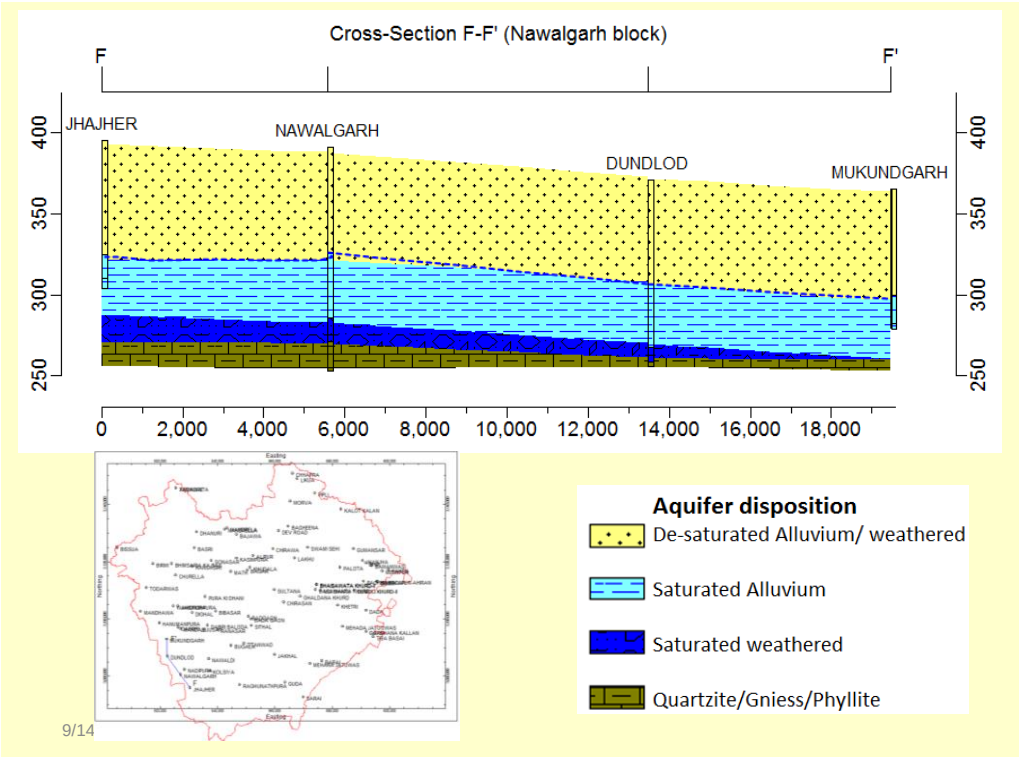


Figure 6F: Section F-F'

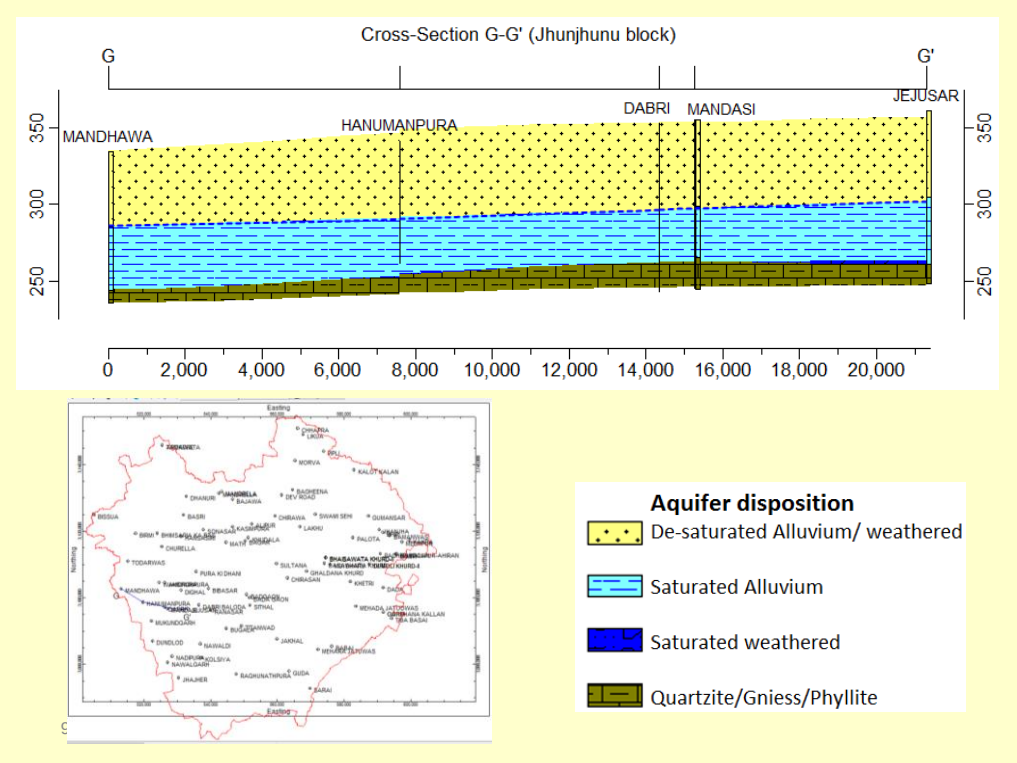


Figure 6G: Section G-G'

2.2 Depth to Water Level

The total number of monitoring stations in the district is 74 including 51 dug wells and 19 piezometers. Depth to water level varies from 16.45 to 73.29 m during pre-monsoon, 2015 (Figure 7) and 15.23m to 75.67m during post-monsoon, 2015. Deeper water level i.e. more than 40 m is constituted by 70.84% stations and rests in entire north eastern part of district covering entire Surajgarh, Buhana blocks, most part of Chirawa, Nawalgarh and Jhunjhunun blocks. Depth to water level between 20 to 40 m is constituted by 20.83% of stations covering most part of Alsisar, Udaipurwati and Khetri blocks. 8.33% of stations forms water level less than 20m which rests in isolated pockets falling in Khetri and Udaipurwati blocks. 85.70% of stations exhibit negative seasonal water level fluctuation (pre versus post-monsoon, 2015) has been noticed in major part of the district. Amplitude of negative fluctuation ranges from less than 0.08 m to 4m. Positive fluctuation (ranging from 0.57m to 1.53m) has been observed at local pockets falling in Khetri block.

The study of long term water level trend for the last ten years (pre-monsoon, 2001-2015) reveals that 89% of hydrograph stations exhibit declining trend ranging from 0.02 to 0.20 m/ year whereas only 11% of stations show marginal rising trend ranging from 0.008 m to 0.017m/ year indicated by only those stations falling in saline area having negligible ground water draft. Maximum declining trend has been noticed in eastern part of the district covering parts of Surajgarh, Bhuana and Khetri blocks (Figure 8). The representative hydrographs of selected stations have been depicted in Figures 9A & 9B, which are showing falling trend.

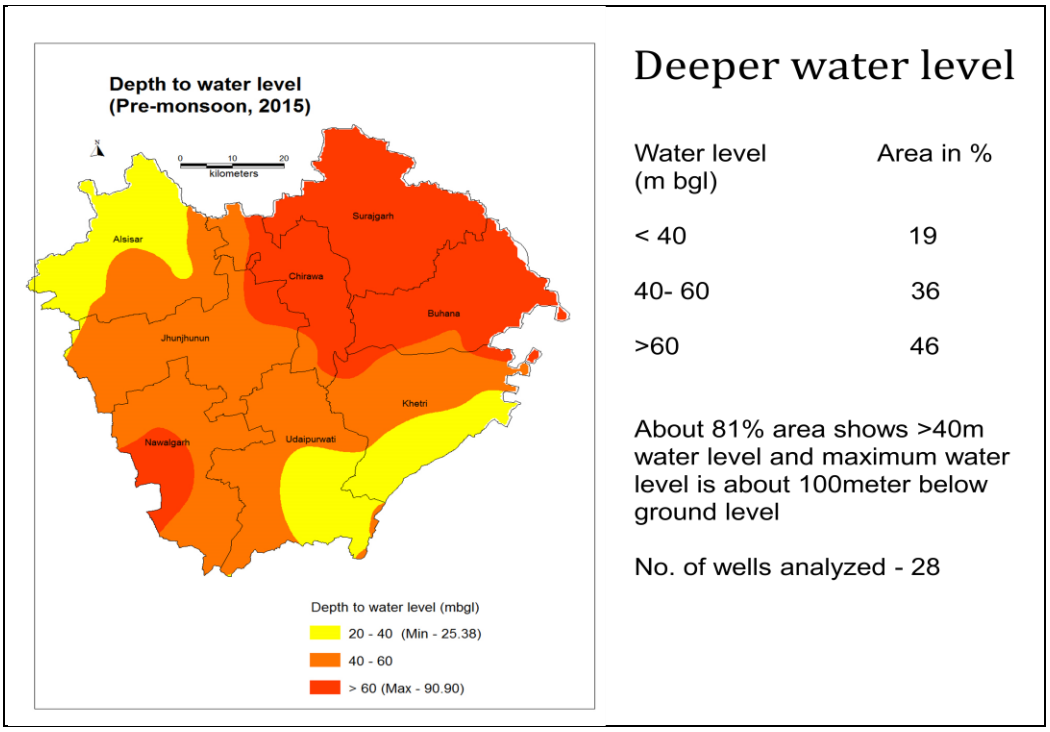


Figure 7: Pre monsoon depth to water level Map (May 2015)

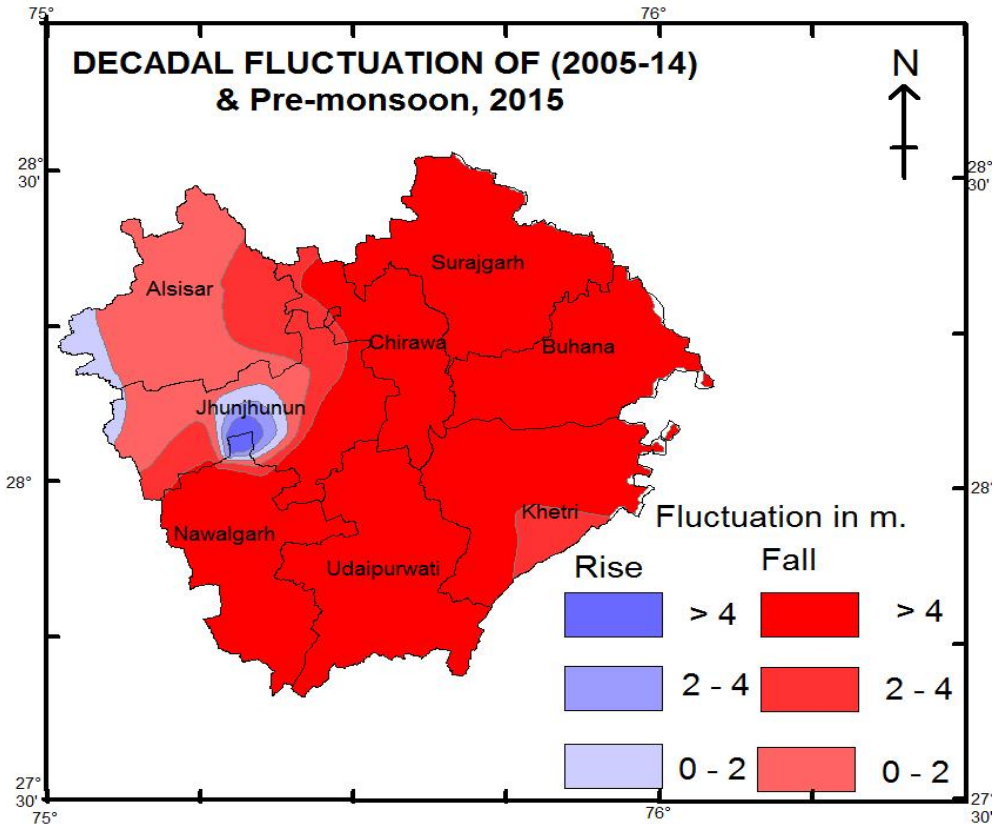


Figure 8: Decadal Fluctutaion Map

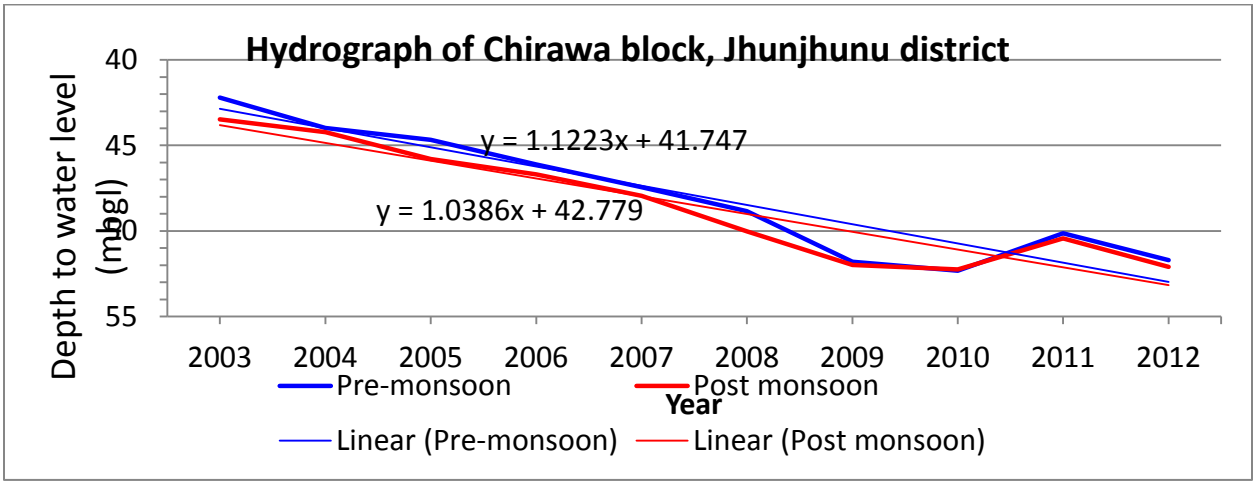


Figure 9A: Hydrograph of Chirawa Block, District Jhunjhunun

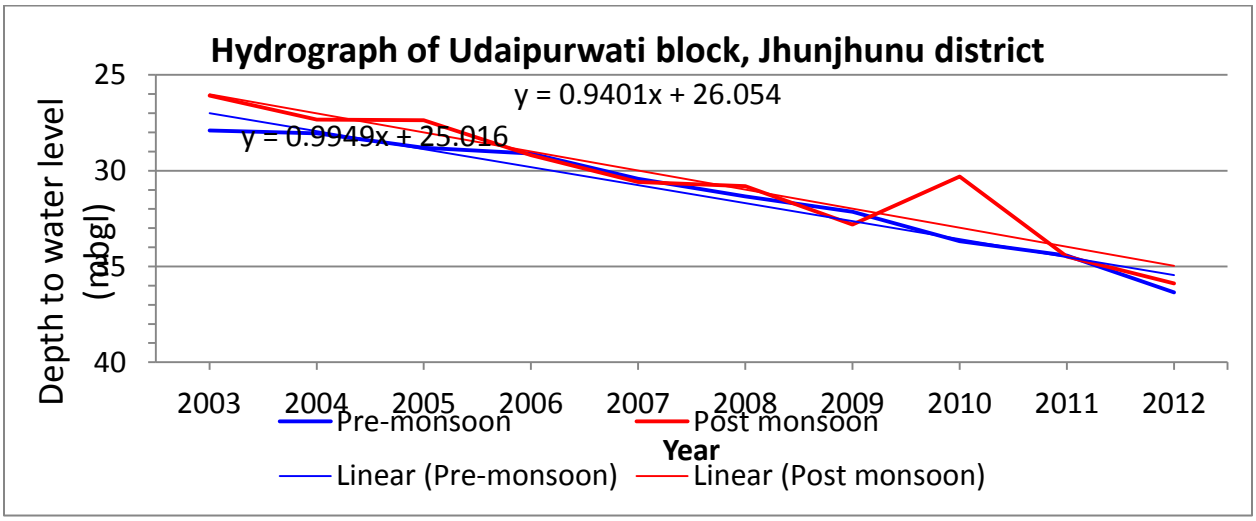


Figure 9B: Hydrograph of Udaipurwati Block, District Jhunjhunun

The study of water table contour map reveals that general direction of ground water flow is from the hills areas in south and south eastern to northern side except in the south eastern part (i.e. in the eastern part of Khetri) where it is from west to eastern side. In south eastern hilly areas of the district, movement of ground water is comparatively fast due to steep gradient while it is considerably slow in the remaining parts covered by alluvial formations having gentle gradient. The average hydraulic gradient of ground water table is southern part is 4m/km and is about 2 to 3 m/km in the northern part. The maximum elevation of water table has been observed in the south, south western part of area at village Rampura .i.e 449.9 mamsl (Nawalgarh block) while minimum elevation in the north eastern part of area at village peepli .i.e.225.60 m amsl (Surajgarh block).

The yield of open wells and dug cum bore wells tapping alluvial formation varies from 175 to 900 lpm having drawdown from 0.609 to 12.17 m depending upon the locations. The specific capacity of wells based on Slitcher's formula ranges from 0.0383 to 0.1131 m3/m/m. The optimum yield (Karanjack's method) of wells varies from 106 to 374 lpm. The permeability of wells tapping quartzite ranges from 0.016 to 0.045 m/hr and maximum water inflow capacity from 8.61 to 32.99 m3/ hr. The status of bore holes (as on 31/03/2015) drilled by CGWB is presented below in Table 5.

Table 5: status of bore holes (as on 31/03/2015) drilled by CGWB

Type of wells	Formation		Total
	Alluvium	Hard rock	
Exploratory well (EW)	98	12	110
Observation well (OW)	07	Nil	07
Slim hole (SH)	Nil	Nil	Nil
Piezometer (PZ)	32	Nil	32

Exploratory borehole data drilled in alluvial formation has indicated that depth of drilling ranges from 27.74 to 135.00 m having depth of wells from 30 to -115m. The discharge of wells varies from 160 to 2733 lpm having moderate drawdown. The transmissivity value of aquifer varies from 100 to 1915 m2/day and storativity from 5.48x10-5 to 1.05x10-2. In hard rock, the depth of bore wells lies between 106 and 172.50 m having discharge from less than 50 to 725 lpm with drawdown from 4.04 to 33.91m. The formations encountered are quartzite, shale, phyllite, schist, gneiss and limestone of Delhi Supergroup. The transmissivity of aquifer varies from 26.35 to 465.35 m2/ day. Water table maps on plane and 3D of area have been prepared using Rock Works Software and portrayed in Figure 10. The water table elevation varies from 207 to 360 m amsl.

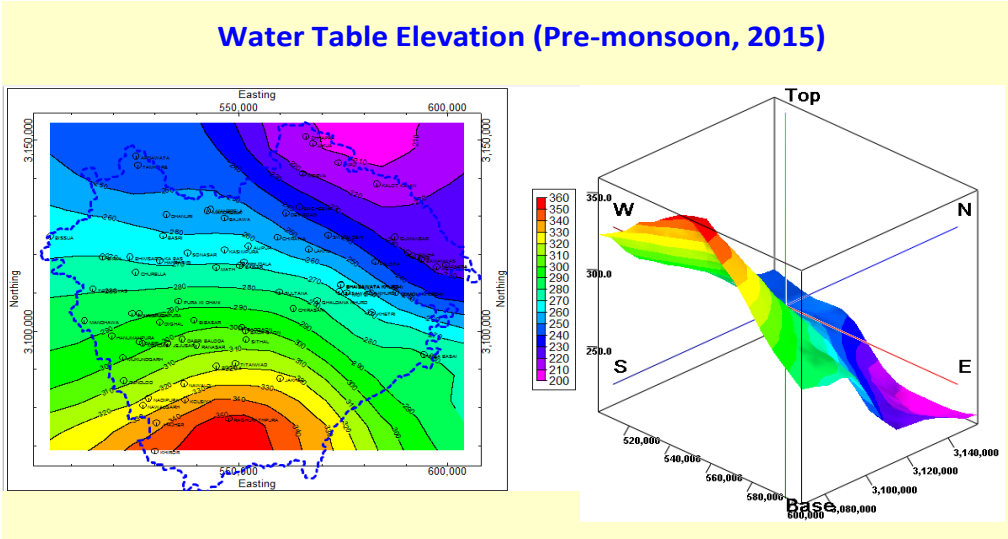


Figure 10: Water Table Map, District Jhunjhunun

3. Groundwater Quality

The groundwater is alkaline type having pH value more than 7 and is potable in major part of the district except in northern part Alsisar block, northern most portion of Chirawa block, area lying south of Buhana and isolated pockets lying east of Surajgarh, south east of Chirawa and in south eastern border (located at midst) of Khetri block. The EC ranges from 450 ms/cm at 250 C (minimum at Parasrampura in Nawalgarh block) to 10600 ms/cm at 250C (maximum at Jawaharpura in Alsisar block), however in general it rests between 450 and 3000 ms/cm at 250 C which is constituted by 78 % of stations. The electrical conductivity between 3000 and 6000 ms/cm at 250 C is represented by 17 % of stations while more than 6000 EC is by only 5% of stations (Figure 11).

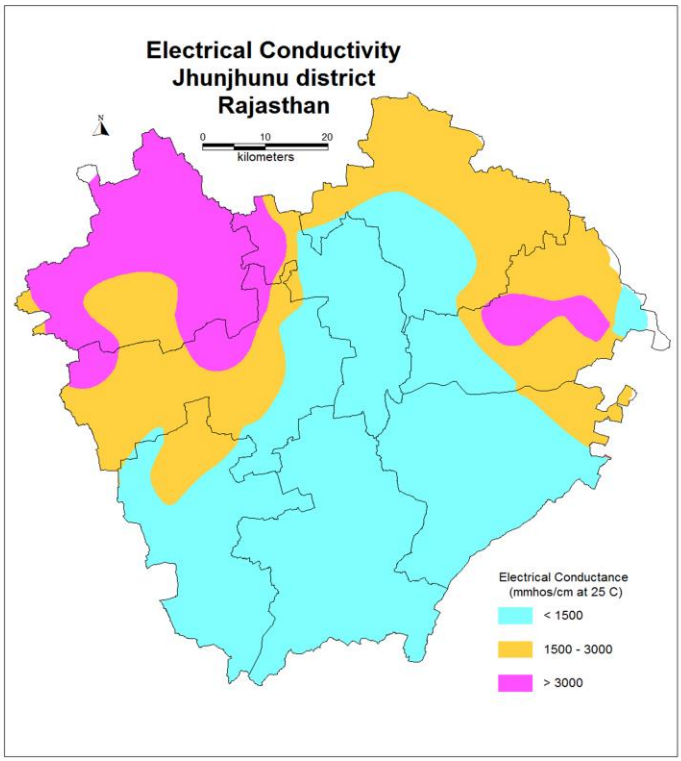


Figure 11: EC map of Jhunjhunun district

Nitrate concentration ranges from nil to a maximum value of 770 mg/l. Nitrate concentration within permissible limit i.e. 100mg/l is constituted by 69.14% of stations whereas 30.86% of stations represent more than 100 mg/l of nitrate concentration in the district. Nitrate concentration more than permissible limit has been found in the entire Alsisar block, Northern part of Jhunjhunun block, south of Mandawa, north east of Surajgarh, around Buhana, area lying south west of Buhana and isolated pockets falling in Buhana, Udaipurwati blocks (Figure 11).

Fluoride content ranges from 0.12 to a maximum of 15.3 mg/l (on Anasagar road, Jhunjhunun town) but in general lies between less than 0.5 and 3 mg/l. 57.87% of stations represent fluoride concentration within desirable limit of 1.0mg/l, 21% stations fall between 1.0 and 1.5mg/l, 11.23% stations between 1.5 and 3.00mg/l and 8.99% stations constitutes fluoride concentration

beyond 3.00mg/l. The Jhunjhunun urban faces very high fluoride hazard having fluoride concentration reaching maximum to 15.3mg/l which is substantiated by the fact that 66.67% of stations constitute fluoride concentration above permissible limit of 1.5 mg/l. Apart from this, most part of the Alsisar block and north western corner of Chirawa block have fluoride content more than 1.5mg/l. Isolated pockets having fluoride content more than permissible limit have been noticed in Surajgarh, Buhana, Udaipurwati blocks. Most of the stations have iron concentration with permissible limit of 1.0mg/l.

The sodium absorption ratio ranges from 0.60 to 28.85. Irrigation suitability of ground water has been determined based on the USSL diagram which indicates that ground water belongs mostly to C3-S1, C3-S2, and C3-S3 class connoting moderate suitability of ground water for irrigation. The high sodium absorption ratio (SAR) poses problem for irrigation water but sandy, highly porous and permeability nature of soil permit the use of ground water for irrigation. Ground water in Jhunjhunun urban area belongs to C3S3 and C3S4 class indicating the ground water's low suitability for irrigation purposes.

The Jhunjhunun urban faces very high fluoride hazards having fluoride concentration reaching maximum to 15.3 mg/ l which is substantiated by the fact that 66.67% of stations constitutes fluoride concentration above permissible limit of 1.5 mg/l. Apart from this, most part of the Alsisar block and western corner of Chirawa block have fluoride content more than 1.5 mg/l.

Nitrate Hazards:

Nitrate concentration more than permissible limit i.e. 100 ppm is constituted by 30.86% of stations in the district area. Nitrate concentration more than permissible limit has been found in the entire Alsisar block, Northern part of Jhunjhunun block , south of Mandawa, North east of Surajgarh, around Bhuana, area lying south west of Bhuana and isolated pockets falling in Bhuana. Udaipurwati blocks.

High sodium absorption ratio Hazards:

Irrigation suitability of groundwater is moderate as it belongs to mostly to C3-S1, C3-S2, C3-S3 class. The high sodium absorption ratio (SAR) poses problem for irrigation water but sandy, highly porous, and permeability nature of soil permit the use of groundwater for irrigation. Groundwater in Jhunjhunun urban area belongs to C3S3 and C3S4 class indicating the groundwater's low suitability for irrigation purposes.

4. Ground Water Resources

The dynamic groundwater resources as per groundwater estimation as on 31.03.2013 is furnished below in Table 6. The entire area falls under non-command and over-exploited category due to excessive withdrawal of groundwater being the only available source of irrigation. The condition in Alsisar block is better which is attributed by negligible groundwater draft being area underlain by saline water.

Table 6: Ground Water Resources, Jhunjhunun District

Block	Ground Water Availability (MCM)	Irrigation Draft (MCM)	Domestic/ Industrial Draft (MCM)	Gross Draft (MCM)	Stage (%)
Alsisar	26.7296	17.7706	9.1498	26.9204	100.71
Buhana	26.6425	40.3020	9.9937	50.2957	188.78
Chirawa	5.6765	5.2762	3.1069	8.3831	147.68
Jhunjhunun	32.3191	45.5782	13.1006	58.6788	181.56
Khetri	5.0267	9.1164	1.0592	10.1756	202.43
Nawalgarh	17.8170	44.3556	10.4390	54.7946	307.54
Surajgarh	22.8437	53.4720	11.4982	64.9702	284.41
Udaipurwati	29.8514	56.5182	15.5900	72.1082	241.56
Total	250.7626	462.6845	104.0513	566.7358	226.00

5. Major Groundwater Related Issues

Jhunjhunun district has the following major groundwater related issues:

- Over exploitation
- Decline in groundwater level
- Deep water levels
- Groundwater quality - Salinity
- Major groundwater related issues
- Deeper water level and decline in groundwater level due to over exploitation
- Low and erratic rainfall Normal (1901-2012) annual rainfall – 536.38 mm
- Increase in draft from 399 MCM to 463 MCM due to increase in irrigated area from 1271 to 2363sq km in 2013 as compared to 2004.
- Increase in domestic demands due to increase in population and change in life style.
- Considerable increase in the area of water intensive crops like wheat (33% of irrigated area) and oil seeds (32% of irrigated area.)
- More crop water requirement due to sandy soil and arid climate
- Ground Water salinity
- Inherent salinity due to inadequate flushing, inland drainage and silty formation

6. Management Strategy

All the blocks 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 Jhunjhunun district 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 Jhunjhunun 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

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
Chirawa	176.83	0.4359	15	15	0	0	0	0	0
Surajgarh	0	0	0	0	0	0	0	0	0
Udaipurwati	582.69	1.4364	48	48	0	0	0	0	0
Nawalgarh	0	0	0	0	0	0	0	0	0
Khetri	725.73	3.9635	132	58	2.22	11	6	1	20
Buhana	262.75	1.8766	63	1	1.86	9	9	0	0
Jhunjhunun	22.74	0.0561	2	2	0	0	0	0	0
Alsisar	0	0	0	0	0	0	0	0	0
Total	1770.74	7.7685	260	124	4.08	20	15	1.00	20

Out of total computed 260 no. of feasible recharge structures, only 124 are possible as per the availability of water bodies. Remaining surplus water for recharge of 4.08 mcm after intervention of 124 recharge structures, may be recharged through 15 no. of possible percolation tanks and 20 no. of farm ponds. Summary of recharge structures and percolation tanks and their cost component is as below:

- **Rain water harvesting and artificial recharge**
    - Surplus available - 8 MCM
    - Number of recharge shafts

    (in existing village ponds): 124 (Nos)
    - Percolation tanks 15 (Nos)
    - Net ground water recharge 4.70 MCM
- **Conservation measures**
    - Farm ponds : 20 (Nos)
    - Net ground water saving: 0.70 MCM
    - Total Cost of proposed interventions: Rs 15.41 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 73.71 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 94.53 mcm/annum @0.08m (Table 8). Total cost of sprinkler sets has been computed as Rs. 591 crore @50,000/hectar

- **Sprinkler**
    - Area already under irrigation by sprinkler – 2363 sq km (50%)
    - Additional irrigated area to be brought under irrigation by sprinkler - 2363 sq km (remaining 50%)
    - Net Water saving - 94.52 MCM (20% of crop water requirement)
    - Total cost for sprinklers – Rs 591 crore @Rs 50,000 per hectare
- **Land levelling**

- Land levelling in 118 sq km (8% irrigated area)
- Net water saving - 2.36 MCM (5% of crop water requirement)
- Total Cost – Rs 12 Crore @Rs 10,000 per hectare

- **Change in cropping pattern**
  - From wheat to gram in 737 sq km irrigated area
  - Net water saving - 74 MCM
- **Total water saving : 171 MCM**
- **Total Cost / Outlay: Rs. 591 Crores**

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

Block	Irrigated Area (ha)	Total cost (Rs in cr)	Water Saving by land levelling in mcm @0.02 m	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)
Chirawa	34978	87.45	1748.91	13.99	0.35	12.05	26.39
Surajgarh	54710	136.77	2735.48	21.88	0.55	18.85	41.28
Udaipurwati	34612	86.53	1730.58	13.84	0.35	10.47	24.67
Nawalgarh	33679	84.20	1683.93	13.47	0.34	9.29	23.10
Khetri	16843	42.11	842.14	6.74	0.17	5.77	12.67
Buhana	28410	71.02	1420.50	11.36	0.28	8.77	20.42
Jhunjhunu	15220	38.05	760.99	6.09	0.15	3.91	10.15
Alsisar	17867	44.67	893.33	7.15	0.18	4.59	11.92
Total	236317	590.79	11815.85	94.53	2.36	73.71	170.60

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 4.70 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 94.53 MCM/year can be saved due to reduction in pumping and with changing the wheat crop to gram (chick pea) and additional 73.71 MCM/year can be saved due to reduction of pumping. With implementation of these two interventions, a total of 171 MCM/year can be saved. This may lead to a total reduction in ground water draft from 541.75 MCM/year to 371.15 MCM/Year and with this, the stage of ground water development may come down from 224.51 to 148.51%. Block wise details of ground water

recharged and saved along with expected improvement in stage of ground water development is given in Table 9.

Table 9: Summary of expected benefit of management strategies

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
Net G.W. Availability (mcm)	26.7296	32.3191	22.8437	29.8514	28.5980	34.6588	32.8995	42.8625
(B)Additional Recharge from RWH & conservation (mcm)	0.31	0.00	1.01	0.00	2.77	1.31	0.04	0.00
Total Net G.W. Availability after intervention (mcm) i.e after recharge	27.03	32.32	23.85	29.85	31.37	35.97	32.94	42.86
Existing G.W Draft for all purpose (mcm)	26.9204	58.6788	64.9702	72.1082	52.6131	101.8505	82.1472	107.4474
Saving of Groundwater through projects (mcm) sprinklers	13.99	21.88	13.84	13.47	6.74	11.36	6.09	7.15
Saving of Groundwater through projects (change in cropping pattern) (in mcm)	12.05	18.85	10.47	9.29	5.77	8.77	3.91	4.59

Saving of Groundwater through projects ((land leveling of the area already under irrigation (in mcm))	0.350	0.547	0.346	0.337	0.168	0.284	0.152	0.179
Net GW draft after interventions (mcm)	0.53	41.28	24.67	23.10	12.67	20.42	10.15	11.92
Present stage of G.W. development (%)	100.71	181.56	284.41	241.56	183.97	293.87	249.69	250.68
Projected stage of G.W. Dev. (in %)	1.95	127.73	103.42	77.37	40.40	56.77	30.82	27.80

Part B

Block wise Aquifer Maps and Management Plans

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
Geographical Area (km2)	837.15	653.30	493.04	751.90	831.44	699.80	779.09	882.28
Rainfall (1971-2014)	NA	NA	455.96	405.90	579.29	NA	NA	550.4
Groundwater Resource Availability and Extraction as per 2013	26.7296	32.3191	22.8437	29.8514	28.5980	34.6588	32.8995	42.8625
Irrigation Draft	17.77	45.58	53.47	56.52	44.30	87.21	67.47	90.36
Existing Water Demand	26.9204	58.6788	64.9702	72.1082	52.6131	101.8505	82.1472	107.4474
Future water demad for domestic & industries	9.7035	10.6266	11.3107	15.9359	7.3993	12.0604	11.3719	14.4899
Water Level Behaviour, DTW (m)	35.29	75.17	53.49	43.27	31.81	46.16	64.95	37.62
Trend (m/yr)	0.09	0.51	1.25	0.62	0.31	0.64	0.84	0.9
Aquifer Disposition								
Geology	Alluvium	Alu/Qtz	Alluvium	Alluvium	Alu/Qtz	Alu/Qtz	Alluvium	Alu/Qtz
Depth of Occurrence	60	95	93	100	75	85	105	85

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
Type of Aquifer	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
Thickness of Aquifer (Utilisable)	5	5	9	9	8	5.5	10	8
Hydraulic Characters (Transmissivity)	23	20	29	30	18	15	31	15
Groundwater Resource Extraction, Contamination and Other Issues								
Aquifer wise resource Availability and Extraction	40.9065	44.3863	19.6643	51.5717	44.2114	32.2458	55.527	32.1485
stage of development in %	114.49	113.07	149.59	172.6	134.43	117.01	208.53	133.76
whether significant decline pre monsoon/ post monsoon	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Categorisation	OE	OE	OE	OE	OE	OE	OE	OE
Chemical Quality of Groundwater in General	Fresh/saline	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh
Other issues								
Groundwater Resource Enhancements								

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
Aquifer wise Space Available for Recharge and Proposed Interventions	2405.058	2405.058	2563.808	3490.883	838.865	2664.576	4826.463	2347.954
Other Interventions Proposed, if any								
surplus available in the Zone (in Mm3)	0.0000	1.8766	0.4359	0.0561	3.9635	0.0000	0.0000	1.4364
No. of RS possible @ 0.03 MCM/RS as per surplus available in the zone		63	15	2	132	0	0	48
Nos. of RS possible in block (as per water bodies)		1	15	2	132	0	0	48
Demand side Interventions								
(A) Promoting Advanced Irrigation Practices								
i)Irrigated Area (ha) proposed for irrigation through sprinkler	17489	27355	17306	16839	8421	14205	7610	8933
B)Change in Cropping pattern								
i)Irrigated Area under wheat cultivation (ha)	34978	54710	34612	33679	16843	28410	15220	17867

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
ii)Irrigated Area (ha) under wheat proposed for Gram cultivation @50% of the present wheat area	17489	27355	17306	16839	8421	14205	7610	8933
Alternate water Sources	No source	No source	No source	No source	No source	No source	No source	No source
Regulation and Control	Not yet notified	Not yet notified	Not yet notified	Not yet notified	Not yet notified	Not yet notified	Not yet notified	Not yet notified
Other Interventions , if any (irrigated area proposed for land leveling)								
surplus available in the Zone (in Mm3)	0.0000	1.8766	0.4359	0.0561	3.9635	0.0000	0.0000	1.4364
Surplus available in zone as per the water level (in Mm3)	0.0000	1.8766	0.4359	0.0561	3.9635	0.0000	0.0000	1.4364
No. of RS 0.03 MCM/RS	0	63	15	2	132	0	0	48
No of RS possible in block (as per water bodies)	0	1	15	2	132	0	0	48
Net G.W. Availability (mcm)	26.7296	32.3191	22.8437	29.8514	28.5980	34.6588	32.8995	42.8625

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
(B)Additional Recharge from RWH & conservation (mcm)	0.31	0.00	1.01	0.00	2.77	1.31	0.04	0.00
Total Net G.W. Availability after intervention (mcm) i.e after recharge	27.03	32.32	23.85	29.85	31.37	35.97	32.94	42.86
Existing G.W Draft for all purpose (mcm)	26.9204	58.6788	64.9702	72.1082	52.6131	101.8505	82.1472	107.4474
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Saving of Groundwater through projects ((land leveling of the area already under irrigation (in mcm))	0.350	0.547	0.346	0.337	0.168	0.284	0.152	0.179
Net GW draft after interventions (mcm)	0.53	41.28	24.67	23.10	12.67	20.42	10.15	11.92
Present stage of G.W. development (%)	100.71	181.56	284.41	241.56	183.97	293.87	249.69	250.68

Name of the Block	Alsisar	Buhana	Chirawa	Jhunjhunun	Khetri	Nawalgarh	Surajgarh	Udaipurwati
Projected stage of G.W. Dev. (in %)	1.95	127.73	103.42	77.37	40.40	56.77	30.82	27.80