केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

AQUIFER MAPPING AND MANAGEMENT PLAN

Fatehabad District, Haryana

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

FATEHABAD DISTRICT

HARYANA

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

2017

SR.NO.	ITEMS	STATISTICS
1.	GENERAL INFORMATION	
	a. Geographical Area (sq. km.)	2490
	b. Administrative Divisions:-	
	i. Number of Tehsils(3)	1.Fatehabad 2.Ratia 3.Tohana
	ii. Number of Blocks (5)	1. Fatehabad 2. Ratia 3. Tohana 4. BhattuKalan 5. Bhuna
	iii. Number of Villages	243
	iv. Population(As per 2011 Census)	942,011
	v. Average Annual Rainfall (mm)	252.98
2.	GEOMORPHOLOGY	
	a. Major Physiographic Units	Alluvial Plains
	b. Major Drainage	River Ghaggar
3.	LAND USE (Sq.Km.)	
	a. Forest Area	Less than 5 Sq.Km
	b. Net area sown	2250
	c. Cultivable area	2280
4.	MAJOR SOIL TYPES	Sandy loams to Loamysands
5.	AREA UNDER PRINCIPAL CROPS (Sq. Km.)	2499

CHAPTER-1

INTRODUCTION

1.0Background:-

Water is a natural resource unique to the planet Earth. It is essential to people and the largest available source of fresh water lies underground. Increased demand for water has stimulated development of underground water resources. Water is life to us and all living things. After discounting the volumes represented by oceans and polar ice, groundwater is the next most significant source.

The primary objective of the Aquifer Mapping 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 aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

1.1 Scope of the study:

Systematic mapping of an aquifer encompasses a host of activities such as collection and compilation of available information on aquifer systems, demarcation of their extents and their characterization, analysis of data gaps, generation of additional data for filling the identified data gaps and finally, preparation of aquifer maps at the desired scale. This attempts to evolve uniform protocols for these activities to facilitate their easy integration for the district as whole.

1.2 Approach and Methodology:

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behaviour of ground water levels and status of ground water development in various aquifer systems to facilitate planning of their sustainable management. The major activities involved in this process include compilation of existing data, identification of data gaps, and generation of data for filling data gaps and preparation of aquifer maps.

1.3HISTORICAL BACKGROUND OF STUDY AREA

Situated at National Highway number 10, between Hissar and Sirsa, the town of Fatehabad is of a great historical importance. The historians trace its origin to more than 2,000 years back. The town, according to them, came in existence during the time of Ashoka the Great. The area, they say, was inhabited by the "Bheels" during the ancient times and the town was known as UdiaNagri at that time. But the claim is contested by some other historians, who say that the town was known as lkdar during that period.Historians say that the town was surrounded by thick jungles in the ancient times. It was a good hunting place for the emperors of the northern India. According to the district gazetteer, after the death of Muhammad Bin Tughlaq and the coronation of Firoz Shah Tughlaq, the royal entourage of the emperor crossed through this place during its journey from Multan to Delhi. Attracted by the picturesque beauty of this place, the emperor made a halt here for hunting. The emperor was blessed with a son here. His forces also achieved victory over the army of VazirKhwajaeJahan on the same day. To celebrate the victory and the birth of his son, Firoz Shah Tughlaq named

the town Fatehabad and named his son Fateh Khan. The emperor constructed a big fort for the purpose of security of the town. The remnants of the fort can still be seen here.

1.2 Study Area

Fatehabad district of Haryana State has a total geographical area of 2520 sq.km. and is located between 30^{o} 28' 30" and 31^{o} 06' 15" N latitudes and 74^{o} 54' 40" and 75^{o} 24' 57" E longitudes. The district area falls in Survey of India degree sheet No's 53C, 53D, 53G and 53H.The district Fatehabad shares boundary with Sirsa in west and Jind in east. District is surrounded by district Hissar in south east to south east direction. River Ghaggar defines its boundary with Punjab state in northern part.Fatehabad, the district head quarter is located on Delhi- Sirsa National Highway. The district headquarter is well connected by a network of metalled roads and railways with all major cities of Haryana. The state highways and other metalled katcha roads connect the tehsils, block headquarters and villages of the district.The district has been sub-divided into five development blocks vizFatehabad,Tohana, Bhuna, BhattuKalan and Ratia.

1.3 Demography

The district has 4 towns and 243 villages with a total population of 942,011(495,360males and 446,651females) as per 2011 census. The density of population comes to 318 person/ sq km which is second lowest in the state. The decennial growth rate of population of the district for the decade 1991-2001 is 24.76 percent. The sex ratio of 902 has been reported during 2011 census as shown in figure (1.1). 80.94 %of the district population (762,423persons) lives in rural area while 19.06% (179,588persons) live in urban area as shown in figure (1.2)

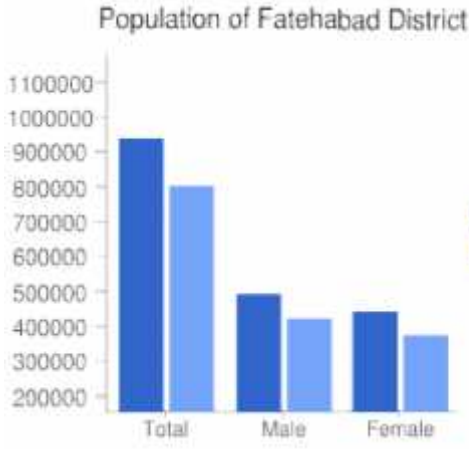


Figure 1.1 Sex Ratio

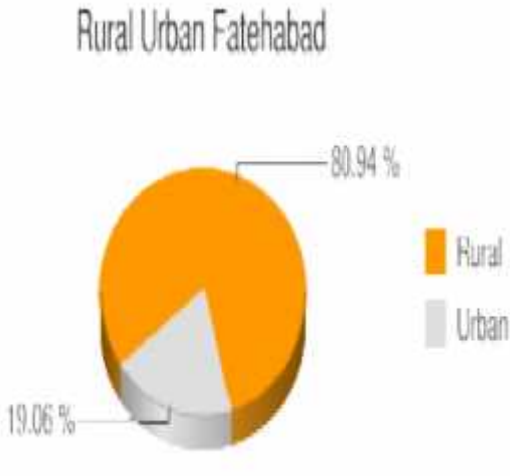


Figure1.2 Rural Vs Urban

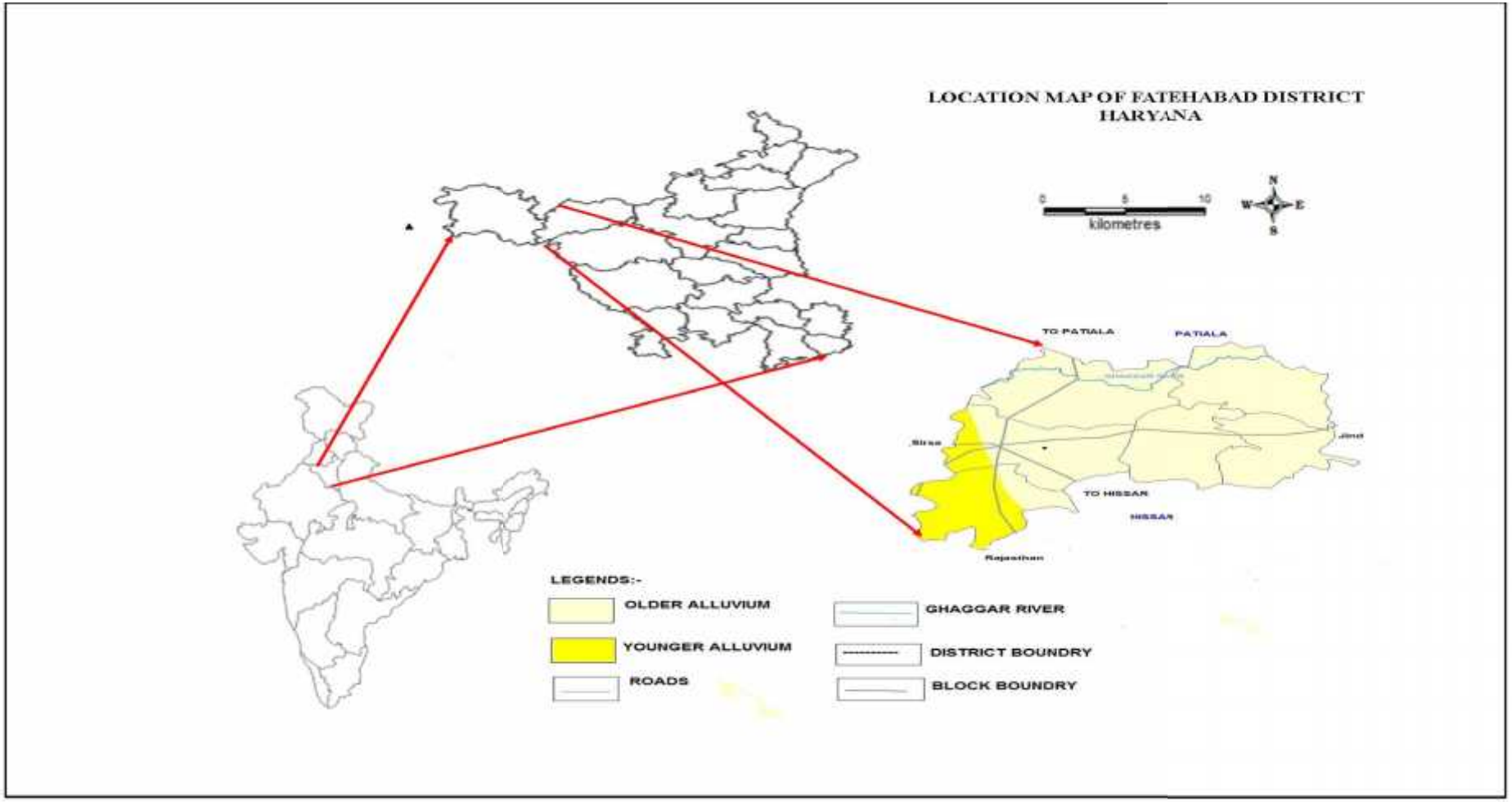


Figure 1.3 Location Map OfFatehabad District

2.0 CLIMATE

The type of soil is an important factor for the growth of plants and crops in any area. The soil system has various criteria to classify the soils of a region such as geology, humidity, rainfall pattern, soil texture, soil salinity etc. The climate of the district is characterized by its dryness and extremes of temperature and scanty rainfall. The year may be divided into four seasons. The cold season from November to March is followed by the summer season which lasts up to the end of June. The period from July to about the mid of September is the south-west monsoon season. The later half of September and October constitute the post monsoon or transitional period.

Rainfall.-Records of rainfall in the district are available for three stations for sufficiently long periods. The details of the rainfall at these stations are given in table 2.1. The average annual rainfall in the district is 395.6 mm. The rainfall increases generally from the west towards the east and varies from 339.1 mm at Fatehabad to 428.4 mm at Hisar. About 71 per cent of the annual normal rainfall is received during the short south-west monsoon period, July to September, July and August being the rainiest months. There is significant amount of rainfall in the month of June, mostly in the form of thundershowers and in the rest of the year, there is very little rainfall. The variation in the annual rainfall from year to year is very large. In the 50 years period (1901 to 1950), the highest annual rainfall, which was 235 per cent of the normal was recorded in 1977. The lowest annual rainfall amounting to only 33 per cent of the normal was recorded in 1938. In the same 50 year period the annual rainfall was less than 80 per cent of the normal in 16 years and two consecutive years of such low rainfall occurred twice. Considering the annual rainfall at the individual stations, such low rain fall in two consecutive years is quite common in the district. Such low rainfall has been recorded 4 times in Fatehabad block and twice in Tohana block for two or more consecutive years. Even 4 consecutive years of such low rainfall occurred once at all stations in the district except Tohana. It has been observed that the annual rainfall in the district was between 200 and 600 mm in 43 years out of 50.

Table 2.1: Rainfall recoreded in different blocks of Fatehabad District, Block Fatehabad:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	**2**	**0**	**0**	**14**	**25**	**50**	**60**	**85**	**N.A**	**N.A**	**N.A**	**N.A**
2007	**-**	**35**	**11**	**9**	**2**	**94.5**	**40**	**20**	**78**	**-**	**1.5**	**4**
2006	**-**	**-**	**26.5**	**-**	**37.6**	**81**	**110**	**25**	**71**	**3**	**3**	**2**
2005	**14**	**24.5**	**36**	**8**	**9**	**46**	**109**	**22**	**58**	**-**	**-**	**-**
2004	**13**	**4**	**-**	**10**	**35**	**57**	**2**	**85**	**1**	**-**	**-**	**2**
2003	**8**	**21**	**6**	**5**	**3**	**-**	**137**	**183**	**14**	**-**	**-**	**1**

Block Tohana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	10	-	-	25	33	156	55	92	N.A	N.A	N.A	N.A
2007	-	61	21	20	-	32	40	28	52	-	-	1
2006	-	-	47	-	31	18	48	35	118	-	4	5
2005	21	37	39	1	16	31	175	72	140	-	-	-
2004	15	-	-	14	45	86	5	128	18	7	-	-
2003	5	14	3	-	1	-	367	33	-	-	-	13

Block Ratia

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	3	-	-	6	24	51	27	98	N.A	N.A	N.A	N.A
2007	-	26	7	1	-	44	32	17	40	-	-	-
2006	-	-	21	-	26	30	57.5	10	39	2	-	5.5
2005	6	27	10	-	-	32	81	24	32.5	-	-	-
2004	16	3	-	-	34	57	8	61	7	3	-	-
2003	1	20	9	-	-	2	106	174	9	-	-	2

On an average there are 24 rainy days in a year. This number varies from 21 to 26 in the district. The heaviest rainfall in 24 hours recorded at any station in the district was 346.7 mm in August 16, 1926.

Temperature.-There is a meterological observatory at Fatehabad and rainfall data collection at Fatehabad, Ratia and Tohana. The records of this observatory may be taken as representative of the meterological conditions prevailing in the district in general. There is rapid increase of temperature after February. The mean daily temperature in May, which is the hottest month, is 41.60C. On individual days the maximum temperature during the summer season may rise up to about 47 or 48 degree C. The hot scorching winds, which blow in summer add to the discomfort. Afternoon thundershower, which occur on some days bring welcome relief, though only temporarily. During monsoons the nights are even warmer than those during the summer season. With the added moisture in the monsoon air, the nights are often uncomfortable. After the withdrawal of the monsoon in the latter half of September, the temperatures begin to decrease. The decrease in temperature is rapid after October and the drop in temperature after nightfall is particularly trying. January is generally the coldest month with the mean daily maximum at 21.7

degree C and the mean daily minimum at 5.5 degree C. In the cold season, the district is affected by cold waves in the wake of passing western disturbances and the minimum temperature drops down to about 3. 0 degree C occasionally.The highest maximum temperature recorded was 4.8.3 degree C on May 30, 1944. The lowest minimum temperature was 3.9 degree C on January 31, 1929.

Humidity.-Relative humidity in the morning is generally high during the monsoon season and during December to February, usually being about 70 per cent or more. Humidity is comparatively less during the rest of the year, the driest part of the year being the summer season with the relative humidity being about 30 per cent in the afternoons.

Cloudiness.-During the monsoon season, the skies are mostly moderately to heavily clouded. In the rest of the year, the skies are generally clear or lightly clouded. Cloudy skies prevail for brief spells of a day or two in association with passing western disturbances in the cold season.

Winds.-Winds are generally light in the district with some strengthening in force during the late summer and monsoon seasons. During the south-west monsoon seasons while winds from the south-west or west are more common, easterlies and south-easterlies also blow on some days. In the post monsoon and winter season while south-westerly or westerly winds are more common in the mornings, northerlies and north-westerlies are predominant in the afternoons. In the summer, winds are more common from' the west or south-west in the mornings. In the afternoons, they are mostly from directions between west and north-west.

Special weather phenomena.- Some of the depressions which originate in the Bay of Bengal in the south-west monsoon season, and which move across the central parts of the country reach the district during the last, stages of activity and cause widespread rain before dissipating. An occasional post monsoon storm or depression also affects the district.

Thunderstorms occur - Throughout the year but the highest incidence is during the monsoon season. Duststorm3 occur often during the hot season. Occasional fogs affect the district in the cold season.

PHYSIOGRAPHY, DRAINAGE & SOILS

2.1 PHYSIOGRAPHY

The district is part of the alluvial of Ghaggar-Yamuna plain and its southern and western portions mark a gradual transition to the 'Thar desert'. The topographic pattern of the district owes its existence to geomorphic processes having closer affinity with the climatic aridity, both of the recent and past geologic periods. Throughout the district most dominant feature of topography is the occurrence of aeolian sand of variable shape and thickness overlying the Pleistocene alluvium, which becomes fewer at the eastern border of the district. The mean attitude varies between 210 and 223 meters and generally slopes from north-east to south-west with a gentle gradient of 1 in 4000.

The district can be sub-divided into following topographic units

(i) Sub-Recent alluvial plain

(ii) Late Quaternary to Sub-Recent sand dune areas ;

(ii) Plain with sand dunes.

i) Sub-Recent Alluvial Plain.-The plain locally known as Nali occurs principally as floodplain sediments along the courses of the Ghagghar and nonexistent course of the Joiya. It is gently sloping, trending northeast to south-west in Tohana and Fatehabadtahsils. This part of the district experienced a demographic and agricultural revolution of significant magnitude during fifties. This geomorphic unit can be further sub-divided into three units; namely upland Plain, Younger flood Plain and Active flood plain.

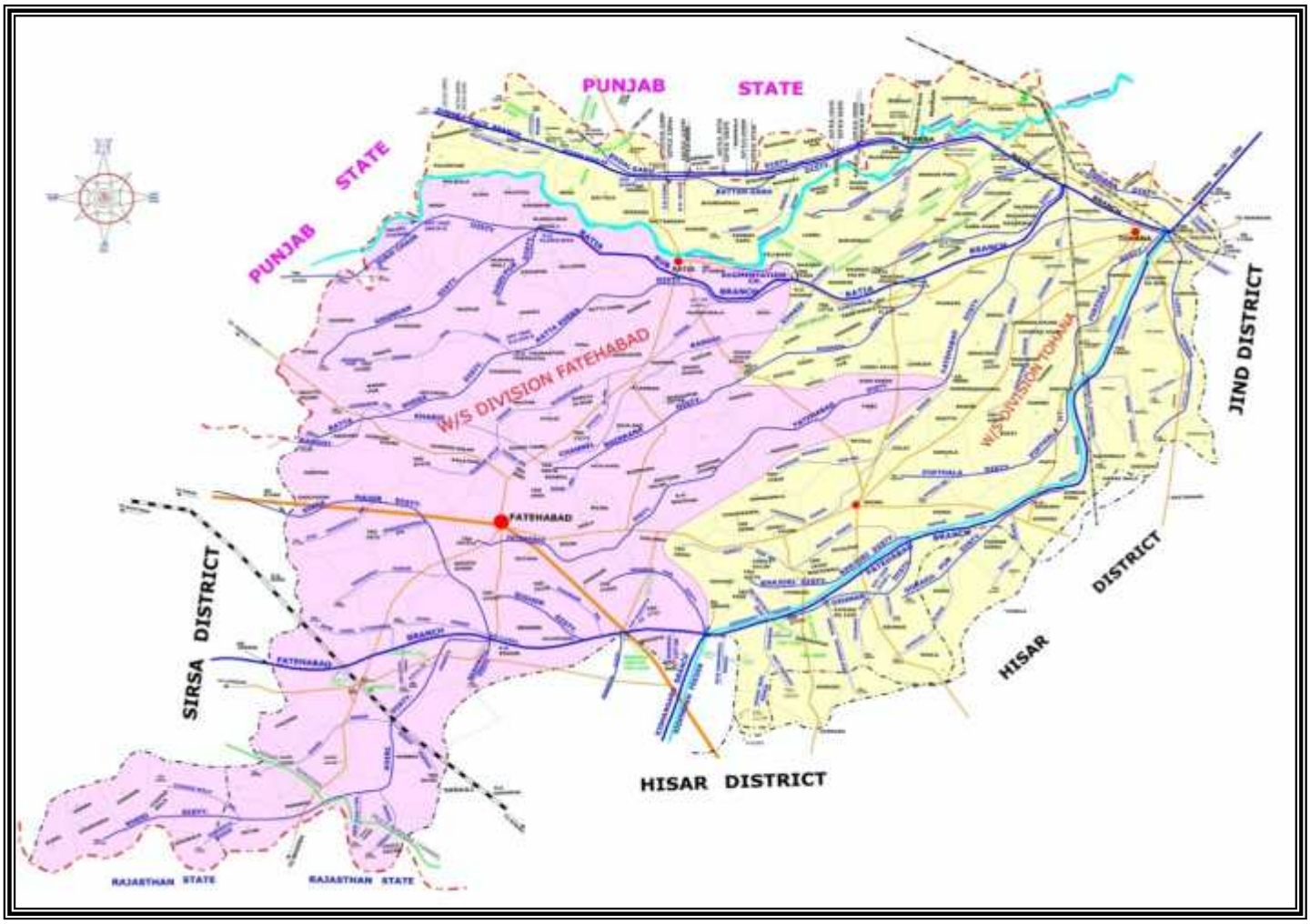
ii) Late Quaternary to Sub-Recent Sand Dune Areas. - The sand dune areas can be classified into conspicuous topographic units having different genetic types of sand dunes-active, semi-active and fossil or fixed. The active and moving sand dune generally occurs along the western fringe of the district where the mean annual rainfall varies between 200 to 250 mm. The vegetal cover is scant and it resembles the treeless undulating desert, locally known as Bagar. Exceptionally strong unidirectional south-west winds winnow loose sand grains from the surface and transport the material to long distances in the direction of the wind in this process. The landscape configuration undergoes dramatic changes and sand hills appear where yesterday was a cultivated field. Active sand dunes vary from uneven

sand cover, sand hummocks to small transverse dunes, some rising to about 2 metres above the surrounding surface. At places, extensive grazing and deterioration of scant Acacia vegetation on the slopes of stable sand dunes has reactivated the dune building activity. The active and reactivated dunes are Sub-Recent in age. There are features of great geomorphic significance, which are the fossil or fixed dunes, which generally lie along the south-west winds. They occur as broad features in long narrow chains but assume intersecting, forked, spiral and many other complex forms. They represent the eastward culmination of an intense and wider influence of marked climatic aridity during the late Quaternary. In comparison to the other deserts around the world, the fixed dunes of the area as also those of Thardesert are characterised by a finer composition of sand particles. The median grain size of the sand varies from 0. 13 to 0.16 mm in diameter. Almost all the fossil dunes carry a buried soil profile. The deeply weathered soil profile, dark brownish to red in colour, is decalcified and faintly acidic in nature which suggests two extremely dry phases separated by a humid climatic phase in the late Quaternary period when the dunes were formed. Fossil dunes show larger concentration in south and south-east of Fatehabad, Bhattu-Badopal-Seeswal triangle south of Fatehabad, and south and south-west of Tohana.. The dunes generally occur as transverse. broad-based ridges possessing highly variable morphology. The relative relief of individual features varies from under 3 meters to over 15 meters. Some fossil ridges can be traced continuously for 12 kms and more. In area lying south of Fatehabad ' fossil dunes generally occur in conjunction with active dunes of variable thickness and geometric form. Some ridges are up to 6 kilometres long and 15 metres high. A large number of dune and ridge crests are within 2 metres from the surrounding area but relief differences of 5-7 metres are also common. In the Tohana area, the sand forms occur in isolated small knobs, sand mounds and protuberances which do not show any definite pattern of alignment with the wind direction. A majority of dunes are up to 2 m high but some, such as south and west of Jamalpur, have a relief of the order of 6 m and above.

iii) Plain With Sand Dunes.- It is the most important area of the districtcovering the southern, part of Tohana tehsil. Sand dunes and sand hills found scattered h re and there in the plain give it a broadly undulating character. Patches of older alluvium are either exposed or occur at shallow depths beneath a veneer of sand in *tals*or topographic depressions enclosed by fixed dunes.

2.2 RIVER, DRAINAGE AND CANAL SYSTEMS

The River Ghaggar is an important seasonal river in the district, which drains the area towards southwest direction, and is a major drainage of the area runs parallel to the northern border of the district. It enters the district as deeply incised alluvial channel near Jakhal and makes an exit little to the west of BiraBadi covering the distance in a meandering course some 70 kilometres long. The river maintains a rough parallelism with most of the northern boundary, deviating from it by a margin of some 7 kilometres and at times delineating the northern limits of the district.TheGhaggar is a misfit stream since the scant volume of discharge stands in marked contrast to its large channel width. The river drains large volumes of flood flow during the rainy season mostly between July to September and is generally dry in summer.



Photograph 2.1 Canal and Drainage Network of Fatehabad District

.The river Ghaggar sometimes gets flooded in the lower reaches locally during monsoon and causes extensive damage to crops. However, recurrence interval of flooding is too low to be taken seriously. This water does not has much scope of surface water development due to already taken measures, also river Ghaggar has lots of silt and mud with this water which renders it unfit to be used as source water for artificial recharge .

The district is traversed by a good network of canal for irrigation purposes but area irrigated by canal is only 68000 hectare i.e. 19% of the total irrigated area. The main canals in the area which feed the various distributaries, minors, sub-minors & field channels (water courses) of Bhakra Main Line and FatehabadDistributory which partly irrigate southern part of the district and leaves Fatehabad to irrigate parts of Hisar district. Canals in the area are source of recharge to nearby area to enable tubewells to sustain in the area where water is saline. These canals have southwesterly to westerly course and irrigate Central and Southwestern parts of the district. Total length of the Bhakra Main Line and Fatehabad W/S can system is around 1037.22 km. these canals covers canal command area of approximately 554097 acre.

Besides, the area is also drained by the artificial and natural drains, which are used to drain surface runoff. Main drains of the area are RangoiNala, Rangoi diversion, Gorakhpur drain, Gorakhpur Link drain, Unchu drain, Matkana drain, Peripheri drain, Joyanala which are kuchha drain. Some drains are lined drain like MahammadpurPucca drain, Badopal Link drain, Kirdhan Link drain, Bhattu Link drain.

Surface water being used is for the purpose of irrigation ad drinking in different part of district. Surface water is the lifeline of drinking water supply for the areas having serious problems of drinking water either due to salinity or Fluoride concentration.

2.3 Soil

The type of soil is an important factor for the growth of plants and crops in any area. The soil system has various criteria to classify the soils of a region such as geology, humidity, rainfall pattern, soil texture, soil salinity etc.

The district soil has been categorized broadly in two types of soils vizSierozem and Desert soils. The sierozem soils are found in major parts of the district and desert soils are comparatively found in smaller part of the district especially in northern part of the district.

a) Sierozem Soil

These soils are found in the areas where the normal annual rainfall varies from 300 to 500 mm. These soils vary from sandy loam to loamy sands in texture and are marginally fertile. Degree of salinity and alkali hazards is highly variable, though salinity is major hazard

b) Desert Soil

These soils are generally found in the areas where the annual rainfall is less than 300 mm. According to the classifications followed by Central Bureau of Soil Sciences, soils of the district are sandy to sandy loam in texture.

2.4 Status Of Drinking Water Supply

Drinking water supply to rural as well as urban area of the district is both tubewell and canal based and maintained by State Public Health Department and Sewerage Department along with Municipal Council of Fatehabad. In southern part of the district the ground water is shallow and marginally saline to highly saline. Therefore, the canal water constitutes the major source of water supply to the villages and towns especially in southern part of the district. Whereas most of water works in northern part of the district are tubewell based. At some places water works are using canal water in conjunction with tubewell water, wherever either water is not available or quality of water is fit for drinking purpose.Water supply in the district is maintained by public health department through four sub-divisions. Details of water works with each sub-division has been provided in the table below to indicate composition of canal and tubewell water.

3.1 Geology

Hard rock geology of the district is concealed under alluvial and aeolian deposits. The alluvial deposits of quaternary age are divisible as newer and older. The former usually occurs in the active floodplain of the Ghaggarriver, in the northern part of the district and comprises sand, silt clay and occasional gravel. Calcareous concretions in various proportions are found mixed with other constituents. The sediments are heterogeneous in character, and are deposited on a basement of metamorphic and igneous rocks of pre-Cambrian age. The bed rock topography over which the alluvial deposits rest, slopes towards north-east. The maximum thickness of alluvium as encountered in a borehole at Jhalnian (Fatehabadtahsit) is 365.51 metres below

ground level. The aeolian deposits comprising accumulations of sand blown from Thardesert of Rajasthan are mostly confined to south-western part of the district. These sand accumulations occupy vast stretches of land and occur in the shape of sandy flats, mounds and ridges at places attaining dunal shapes over the sandy flats. The geological information met in the district are Indo-Gangetic Alluvium consisting of Newer and older Alluvium with a thin blanket of aeolian deposit. The age of these formation range from upper-Pliestocene to Recent. Though the formation were laid down from Upper Pliestocene to Recent, they are conformable with each other. Exploratory work done in the area indicate that these Quarternary unconsolidated sediments are underlain by hardrok formation of Archaean age comprising of Granites, Schists and Gneisses.Stratigraphic sequence of the area with their occurance and water bearing characteristics have been given in table below.

Table 5: Stratigraphic Succession encountered in Fatehabad District

Group	System	Series	Stratigraphic unit	Description of Rock Type	Places of occurrence	Water bearing characteristics
	Recent		Newer Alluvium	Aeolian Deposits	Occurs in entire district except in some local patches. But are most thick and intense in western part of the district.	Ground Water occurs in the interspaces of Alluvium. Good aquifers but holds poor potential due to disposition.
Quaternary		Upper Pleistocene		Fluviatile Deposits	Confined only to the flood plains of Ghaggar River in the northern part of the area.	Very good aquifers. Holds large quantities of the ground Water and quality of ground water is fresh.
		Pleistocene	Older Alluvium	FluviatileDeposites	Occurs in entire district.	Ground Water occurs in the inter granular spaces of the Alluvial formation. Occasionally they

						are poor and rich water bearing formations depending upon lithological composition of the aquifer. Quality of water is fresh to saline.
Archean			Archeans	Consolidated formations consisting of Granite –mica schists and gneisses.	Only subsurface occurrences is known in the western part of the district.	Ground Water occurs in weathered zones, fracture zones, joints etc. However these formation have not been tapped to extract ground water from these formation.

Older Alluvium

The older alluvium is generally characterized by dark brown color, rich in concentrations and nodules of impure calcium carbonates known as kankars. The older alluvium normally forms slightly elevated terraces, generally above the flood level of present drainage, the river having cut through it to a lower level. The older alluvium consists normally of inter bedded lens and inter-fingering beds of clay sand, gravel, silt, silty sand, silty clays with kankar mixed in various proportions. The older alluvium is poorly sorted and fine grained. The most porous and permeable zones in these formation consist of coarse to fine grained sands, gravels. Sometimes kankar beds are known to yield moderate to large quantities of water, when suitable designed wells are constructed.

Newer Alluvium:

The unconsolidated Newer Alluvium occurring mainly along the flood plains of the River Ghaggar. These are light colored and poor in calcareous matter. It contains lenticular beds of sands, gravel and clays. Gravel and sand forms the main aquifer zones and are known to yield large quantities of water.

Aeolian Deposits:

Aeolian deposits loess and sand dunes are found in almost in the entire district but become less frequent in the northern part of the district. The loess are fine grained buff or grey coloredwind blown dust of sandy to clayey constitution. Wind blown formation are deposited irrespective of altitude of lowered surface and essentially a deposite of arid regions. At places sand are pilled up into dunes which are constantly being shifted by winds blowing from south west. These dunes are either longitudinal or crescentic type depending on the wind action.Sands and sand dunes of Aeolinedeposites may form very good aquifers but normally rest above the ground water table in the area.

SUB-SURFACE GEOLOGY:

In Fatehabad district, 17 exploratory boreholes (including two slim holes) were drilled and electrically logged. A fence diagram prepared by utilizing the lithologs and electrical logs of exploratory boreholes, indicating the disposition and inter-relationship of granular zones has been presented in fig….. The diagram as a whole indicates that the clay group of formations dominates over the sand group. However, comparatively the sand group percentage increases slightly in the central and northern parts of the district whereas clays exists predominantly in the southern part of the district. The granular zones are more of lenticular types in in the southern and north eastern part of the district are more persistant in the rest of the area. A striking feature of the formation in the area in that the clay beds are invariably much thicker than the permeable granular zones as a whole.Out of the exploratory boreholes drilled in the district bedrock was encountered in three boreholes located in the south western part of the district which indicates that bed rock is shallow in south western part and thickness of alluvium increases gradually towards northeast.The maximum thickness of alluvium so far recorded in the boreholes drilled in Fatehabad district is 365.70 m at Jhalnia (29°31’00” and 75°34’30”) None of the boreholes, except in the south western part drilled in the area down to 152.40 m to 365.70 m have encountered the bed rock.

GROUND WATER EXPLORATION:

The ground water exploration in Fatehabad district has been taken up in two phases. In the year 1969-1971, exploration was undertaken to delineate aquifer and to know the quality of ground water in deeper aquifer. In all thirteen exploratory tubewells have been constructed in Fatehbad district. During exploratory tubewells construction, four exploratory wells were constructed along river Ghaggar to know the aquifer potential. Out of 17 tubewells constructed, 5 were abandoned due to poor quality of water and lack of promising fresh water aquifer. In general 6-14 granular

zones mainly comprising of fine sand silt and kankar have been encountered. Fence diagram based on the exploratory wells constructed depicts the disposition of fresh water and granular formation. Discharge of the tubewells varies in the area between 220 to 4116 lpm with drawdown of 3.0 – 10.50 m. The wells constructed due to poor quality of water and inadequate discharge in the district are located in the southern part of the district. To assess the aquifer parameters, aquifer performance tests were conducted on 12 wells.

HYDROGEOLOGY

The major source of recharge to ground water in the area is inflow of ground water from northern parts, rainfall, seepage from canals, return seepage through irrigation and percolation from surface water bodies. The principal ground water recharge source of the district is through the rainfall however in southern part of the district river Ghaggar also contributes to the recharge. The other factors contributing to ground water recharge are inflow of ground water from north eastern parts, percolation from the surface water bodies like ponds, seepage from canals and return flow of irrigation water. The area along Ghaggar is underlain by recent flood plains, which is hydraulically connected with the river and is getting recharged from the river floods during the rain. The major part of the rainfall contributes to runoff and evaporation. The geological formations met within the district comprised of unconsolidated alluvial deposits of Quaternary age. The alluvial deposits comprises of sand, silt, clay and often associated with kankar. Fine to medium grained sand horizon form the potential aquifer in the area.

Aquifer System

The geometry and nature of aquifer provide the basic parameters for determining occurrence and movement of ground water and are significant for resource evaluation.The alluvial complex in the area constitutes a vast regional aquifer. Aquifer geometry is chiefly irregularly shaped tabular bodies of highly permeable sand interspersed with lenticular layer of semi pervious to impervious silty clay or clay layers.The area has both unconfined/ semi unconfind and confined/ leaky confined aquifers. The alluvium forms the principal ground water reservoir and the principal aquifer material comprises fine to medium sand and often mixed with kankar. This aquifer is either in the form of isolated lenses of sand embedded in clay beds or well connected granular zones that have a pinching and swelling disposition and are quite extensive in nature.The occurrence of clay beds is rather irregular and on a regional scale their extensions are limited. Thus while locally the presence of such beds can give rise to leaky confined or confined conditions.Granular zones which occur inter-bedded with clay in unconsolidated formations from the principal ground water reservoirs. Thickness of upper zone extending down to a maximum depth of 50 mbgl varies from place to place and water occurs under water table conditions. The ground water occurring under unconfined conditions are tapped by shallow tubewells but the deeper aquifers are tapped through medium to deep tubewells.The ground water from unconfined condition is abstracted through hand pumps and through shallow

tubewells maximum upto the depth of 50 meters. However medium depth tubewells for the purpose of irrigation and drinking area are being drilled upto the depth of 175 m. Aquifer upto the depth of 175 m is semi confined leaky aquifer. Water from aquifer below the depth of 200 m is saline to highly saline in the southern part of district. This aquifer is confined aquifer. However no information is available for quality of water for deeper aquifer.As we move towards the southern part of the district argillaceous sediments increases in percentage. Northern part of the district has specially more arenaceous sediments in comparison to southern part of the district due to presence of Ghaggar flood plains and presence of some paleo-channel passing through this area.

Aquifer Parameters

Ground water being a dynamic flow system the various fundamental parameters of the aquifers in the area were required to give it a mathematically treatment and quantify the same. Aquifer parameters viztransmissivity (T), storativity (S), hydraulic conductivity (K) and yield (discharge) of the test well have been determined on the basis of Aquifer Performance Test (APT) conducted on exploratory wells constructed in the district. To assess the aquifer parameters, aquifer performance tests were conducted on 12 wells. The transmissivity value in the area varies between 177 and 2900 m2/day . The storativityvalues varies from 2.3 x 10-3 to 5.4 x 10^{-2}.

Tubewell Design

The exploration has revealed that the occurrence of relatively impermeable fine-grained material is erratic and not regularly extensive. However within the depth of 175 m bgl the probability of their occurrence is very high in the entire area which give rise to a leaky confined aquifer conditions at depth. The aquifer system in the area can be taken as multilateral unit with possible interconnections. Results of the exploration show that tube wells within the depth range of 50- 175 m in can be designed to tap aquifer, leaving unconfined aquifer untapped. However at the time of construction of tubewell quality should be taken into account keeping requirement of water. Shallow tubewellupto depth of 50 m has been constructed in entire area depending upon quality of water in the area.Tubewells constructed in northern part of district in the are high yielding and are capable of providing good quality of water whereas tubewells in the southern part of the district are giving lesser yields and poor quality of water.

Irrigation

The main sources of irrigation in the district are canals and tubewells.Fatehabad has 393000 hectares as gross irrigated, and 200,000 hectare as net irrigated. Out of 200000 hectare, canals irrigate 68000 hectare, which is 3.50% of net irrigated area of Fatehabad and 96.50 % of net irrigated area is irrigated by tube wells. Tube-wells are more important in comparison to

Groundwater level Monitoring and Behavior

The hydro-geological scenario and ground water behavior has been assessed by the water level data of the ground water monitoring stations established during the pre-monsoon and post-monsoon period of the year 2016.Depth to water level data in the district varies from < 3.0 mbgl to >30.0 mbgl. South eastern and south western part of the district are having shallower water level, whereas in the central part and west central part of the district have deeper water levels. Areas close to Ghaggar also have relatively shallower water levels, in areas close to river water level even becomes shallower locally.

3.2.3.1 Pre Monsoon and Post Monsoon

Pre monsoon survey,. The water level maps for pre-monsoon season are given in the figure

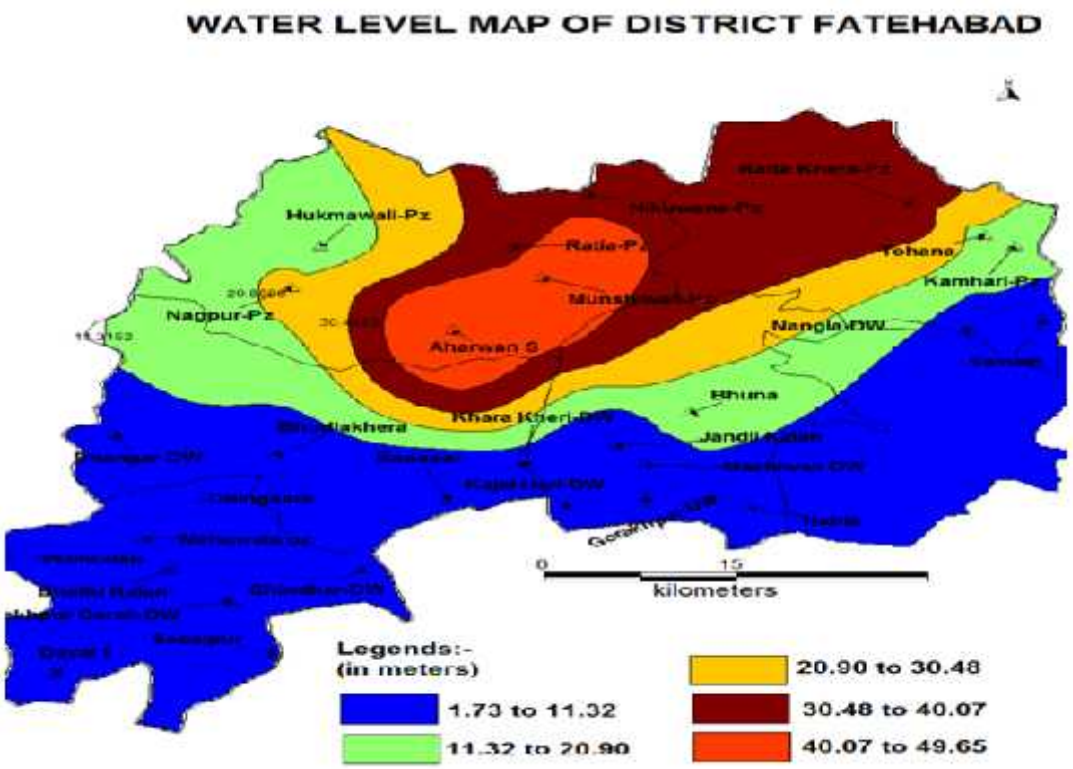


Figure: water level map May 2016

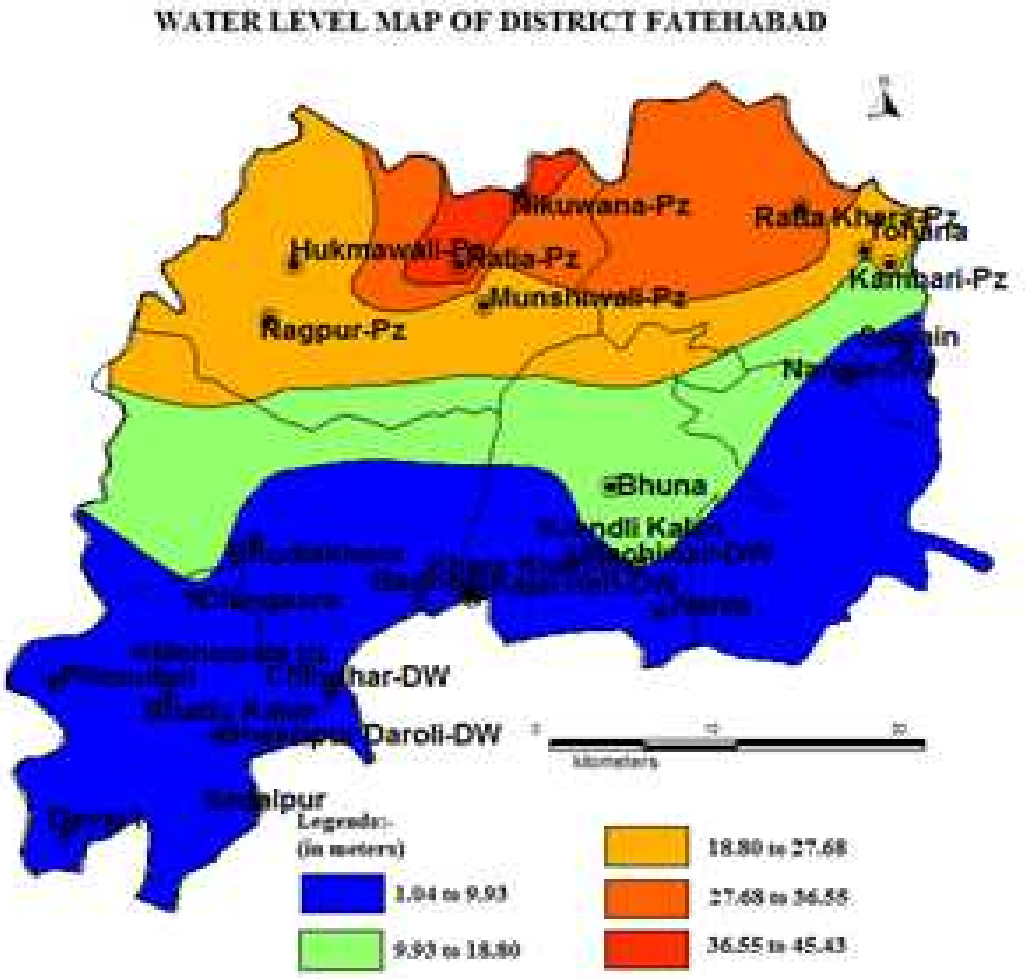


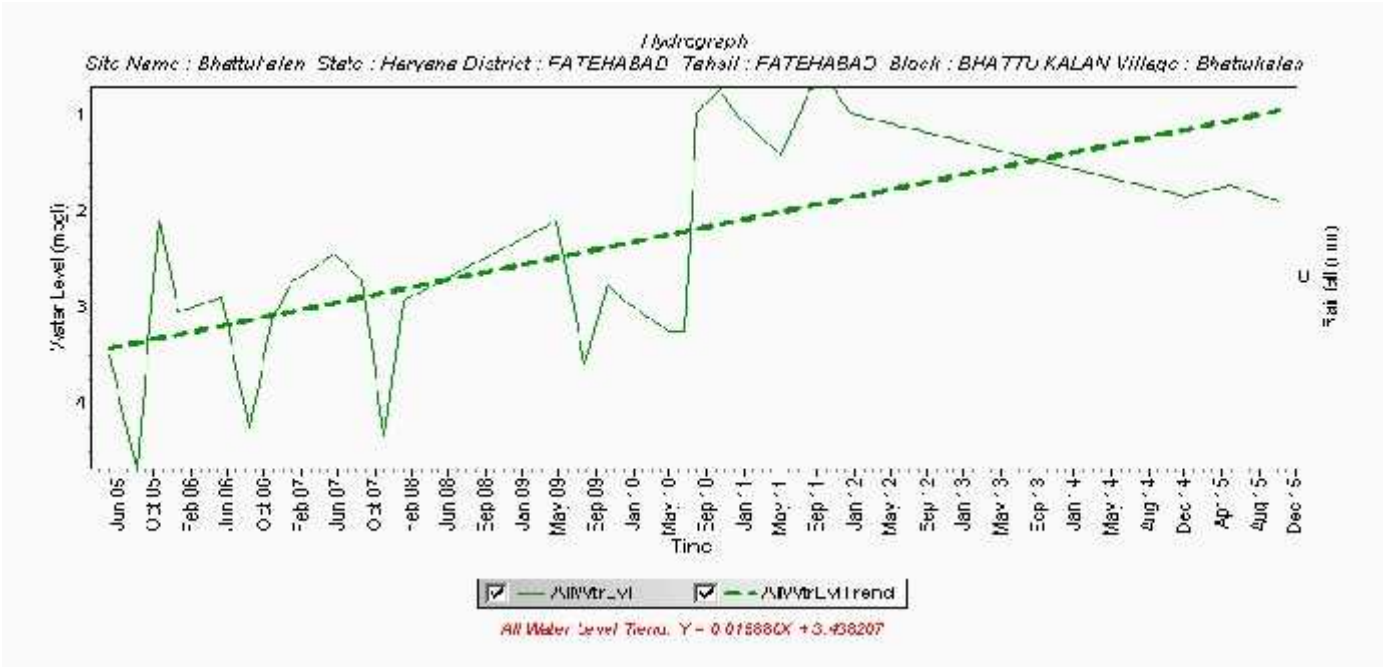
Figure: water level map Nov. 2016

Long Term Water Trend:

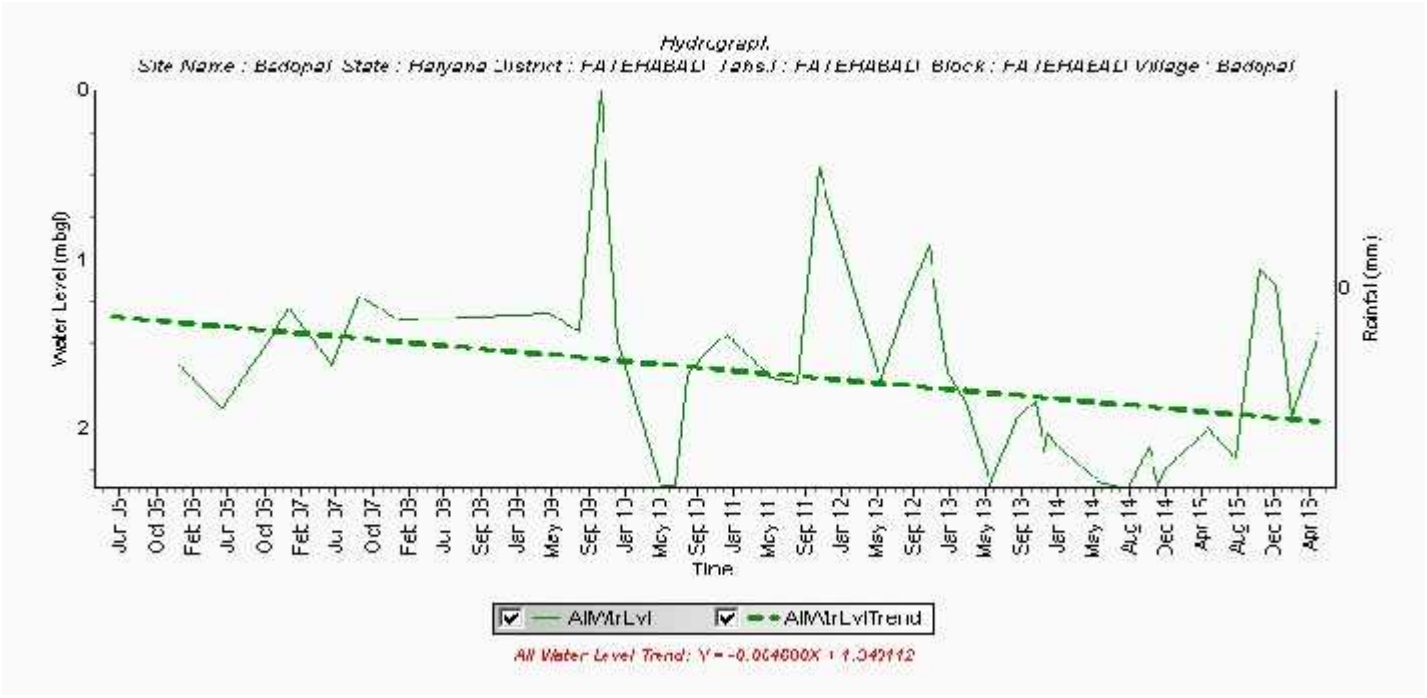
An attempt has been made to find out the changes ground water condition by comparing historic water level data of 2005 with the water levels of 2015. Present Water Level scenario when compared with water level of 2005, indicates the worsening ground water condition of the district. Most of the area of the district the trend of water is declining at a slow rate continuously and it indicates that the water level is declining from 0.4 m bgl to 8 m bgl in the district. Some hydrographs have a rising from 0.8 m bgl to 2.50 m bgl trends in the district due to the quality problems and less use of ground water.

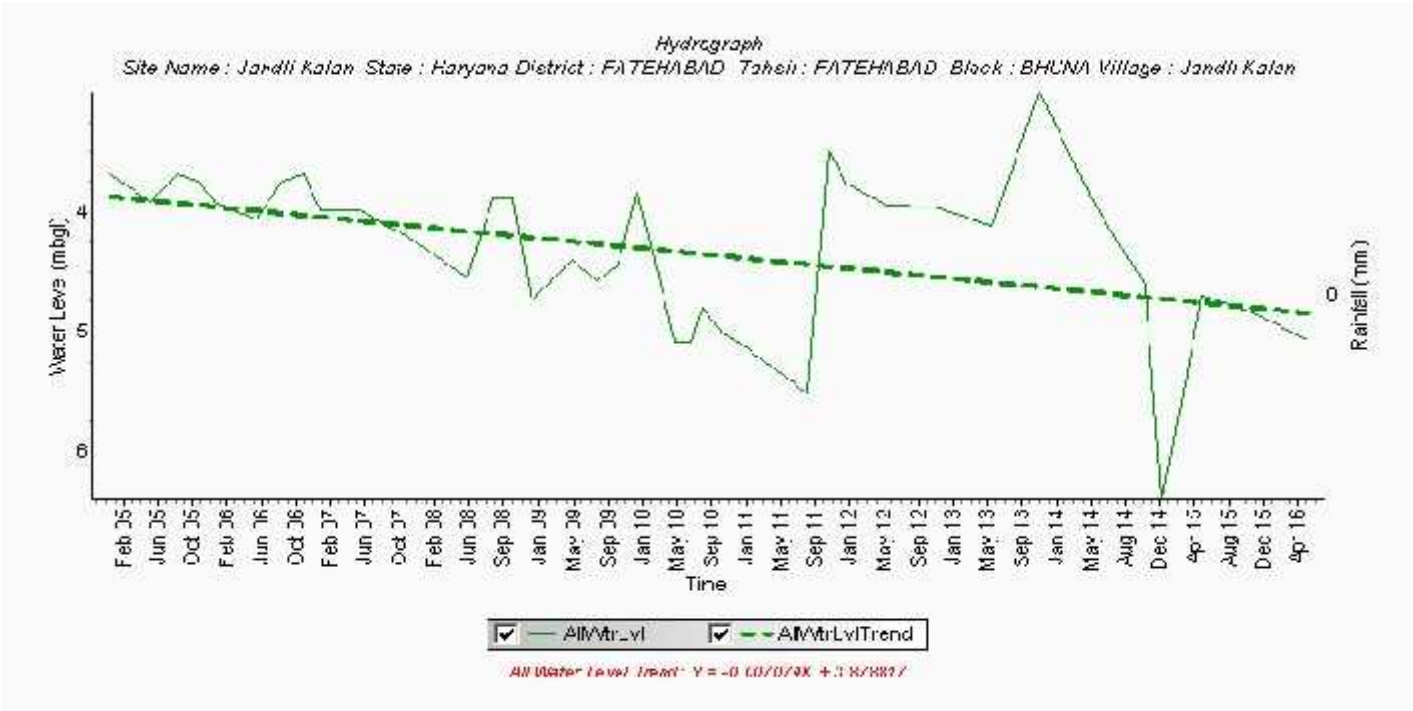
Some of the hydrographs of are shown here prepared by continues recording the data from 2005 to 2015.

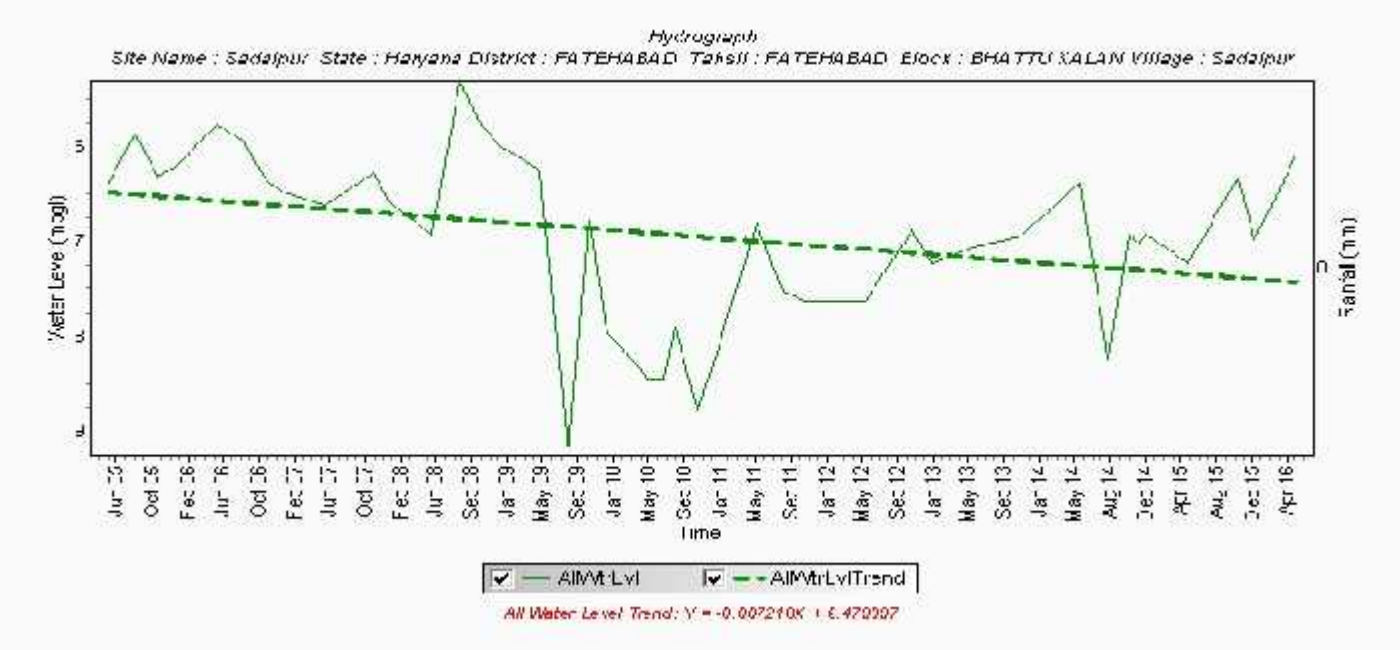
Long Term Water Trend of Bhattukalan, Fatehabad



Long Term Water Trend of Badopal, Fatehabad

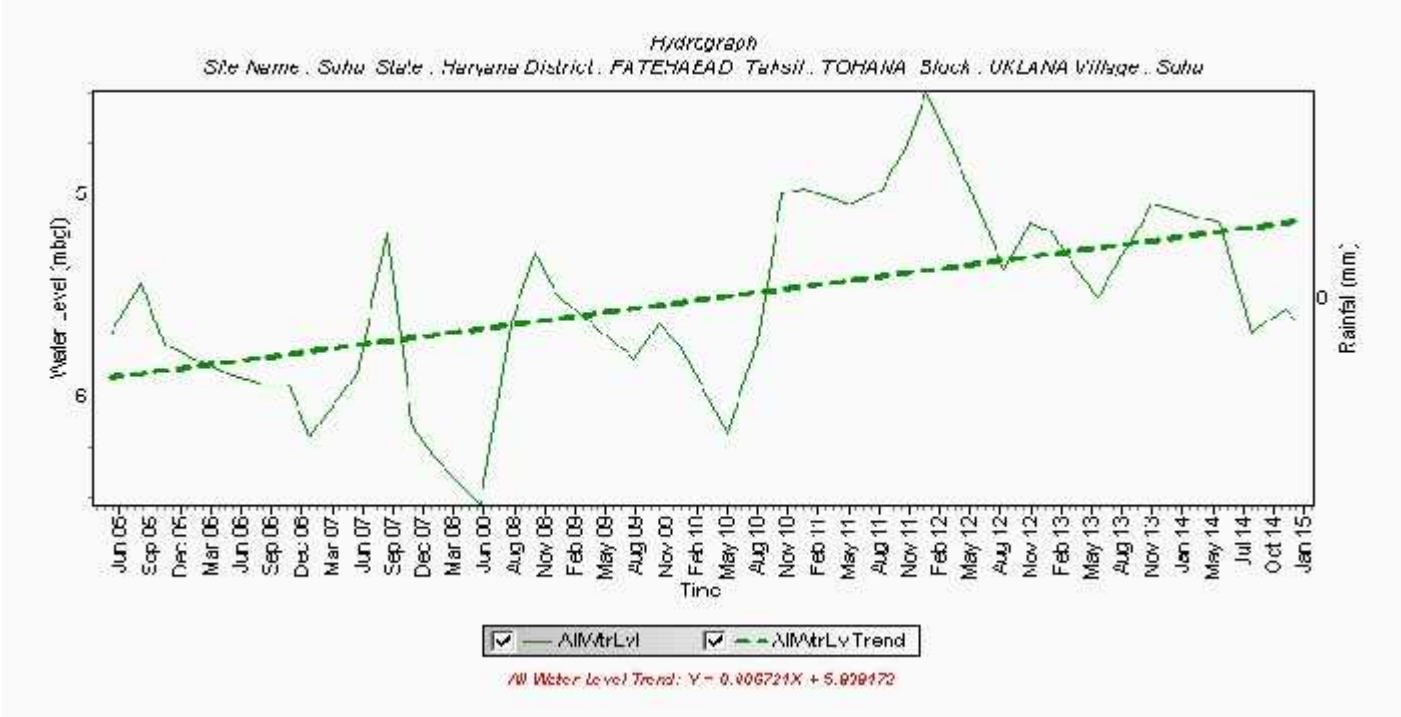




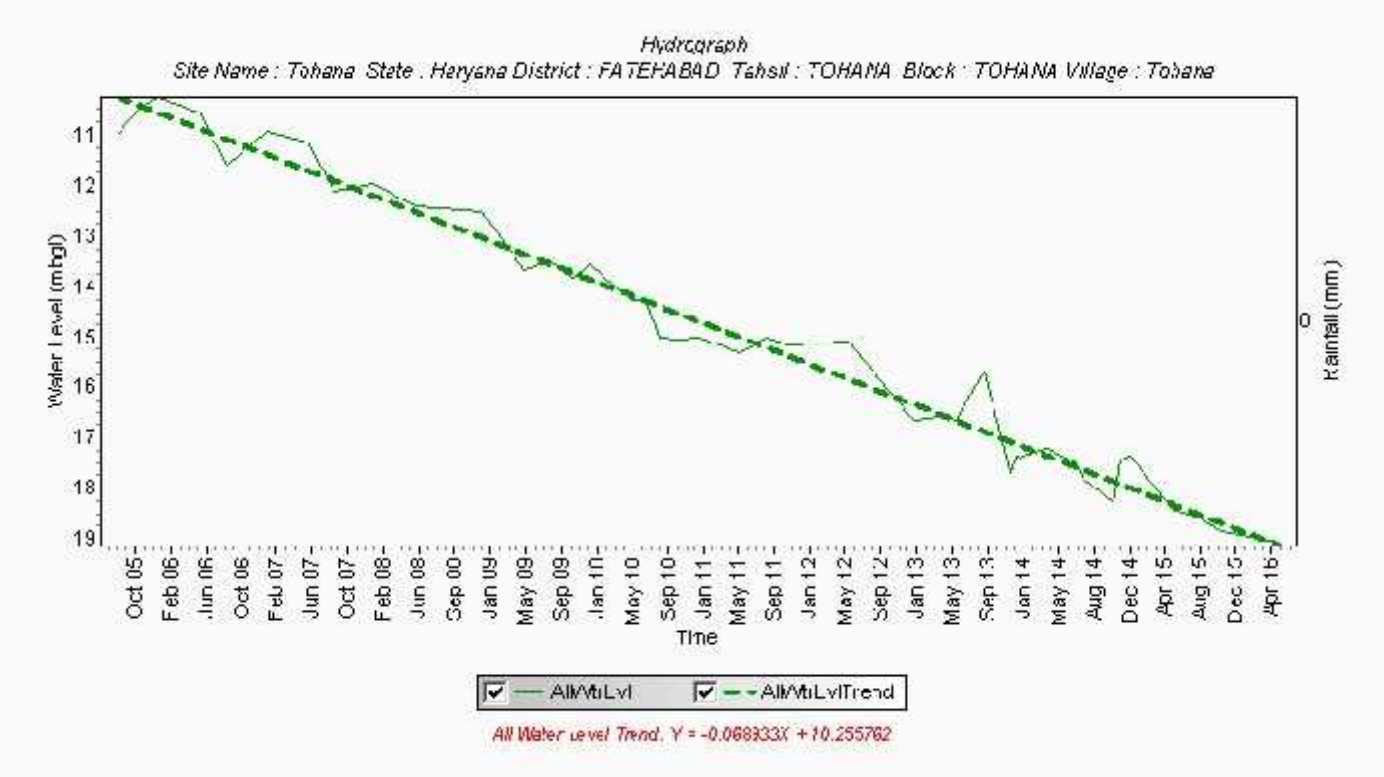


Long Term Water Trend of Sadalpur, Fatehabad

Long Term Water Trend of Sohu, Fatehabad



Long Term Water Trend of Tohana, Fatehabad



Ground water Quality Analysis

In general, predominantly there are three cluster type of water in the district, one Ca-Mg dominant Cl or SO_4 type other being Ca-Mg dominant CO_3 or HCO_3 dominant Mg-Ca type. This represents recharging type of water. This type of water occurs in area having high canal density or dense canal network.Other one is having permanent hardness but does not impart residual Sodium Carbonate hazards in irrigation use. Central, western, north central and southern periphery of district has this kind of water. This is Ca-Mg-Cl-SO_4 type water, either Ca-Mg dominant Cl or Cl dominant Ca-Mg type. Central part of district has been occupied by these two types of water.

However in central part of the district at some places there is also third type of water which has salinity problem both in drinking and irrigation use. This type of water has its occurrence namely in Tohana and Bhuna blocks of the district. This is represented by either Na, K dominant Cl and SO_4 or Cl, SO_4 dominant Na type.

However existence of this type of water is limited to few patches of high salinity in term of spatial distribution in western and eastern part of district. This type of water is indicative of closed system of aquifers causing high salinity.

Fourth type of water, in which is Alkali metal exceeds alkaline earth and weak acid exceeds strong acids occur in northern most part of district bordered by river Sutlej. Such water imparts residual Sodium Carbonate hazards in irrigation use and would cause foaming problems in boiler, if used. This is represented by Na dominant HCO_3 or HCO_3 dominant Na type of water.Ground Water Quality.

The results of chemical analysis of water samples from both from shallow and deep aquifers indicate that all major cations (Ca, Mg, Na, K) and anions (CO3, HCO3, Cl, SO4) are within the permissible limits set by BIS, 1991, in majority of ground water samples. An exceptionally high concentration of Sulphate is found at village Badopal (2252 mg/L). The physical parameter such as electrical conductivity shows a wide variation between 800µS/cm in southern & northern area and 5610µS/cm in the central part of the district. Nitrate concentration (104 mg/L) above the prescribed permissible limit is recorded at village Badopal and high concentration of fluoride of 6.3 mg/L, 1.65 mg/L and 2.59 mg/L are reported at villages Loh-Khera, Sadalpur and Dhaula, respectively. 58.5% of the groundwater samples show sodium as the dominant cation whereas none of the anions is particularly dominant. Ground water generally depicts a mixed type of chemical character. Iron, an essential plant and animal nutrient, is found to be above permissible limits at Bhattu (1.44)

BhattuKalan (5.75) and Fatehabad (1.60) whereas in rest of district iron is found to be below the permissible limit. Arsenic is found above the prescribed limit at Samain (0.0570 mg/L) in Tohana Block

Besides an attempt has also been made to find correlation between different constituents of natural water of Fatehabad district.

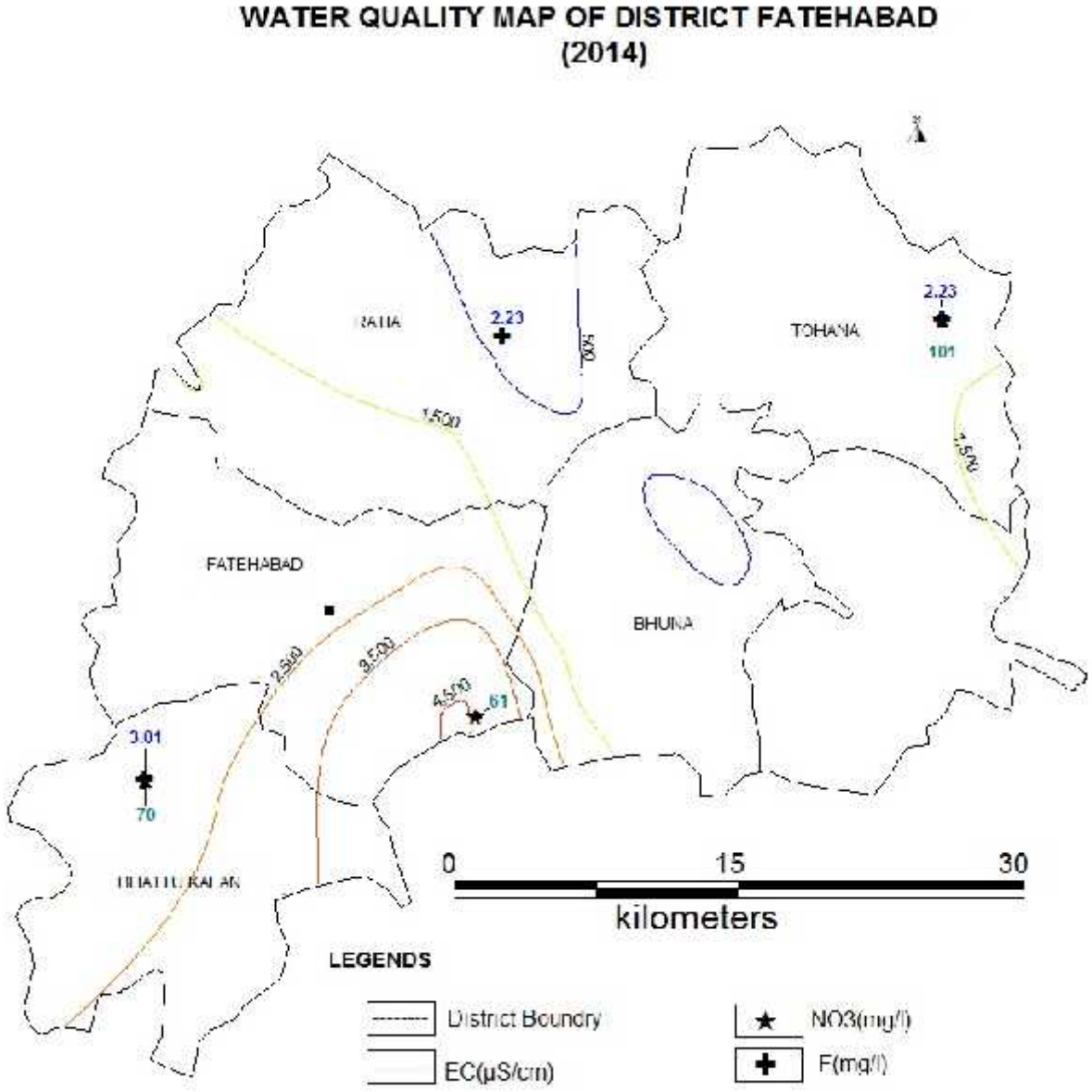


Figure 3.7 Water Quality Map Of District Fatehabad

Note:- Values shown in the map for NO_3& F are more than permissible limit

Exploratory drilling State - Data Availability:

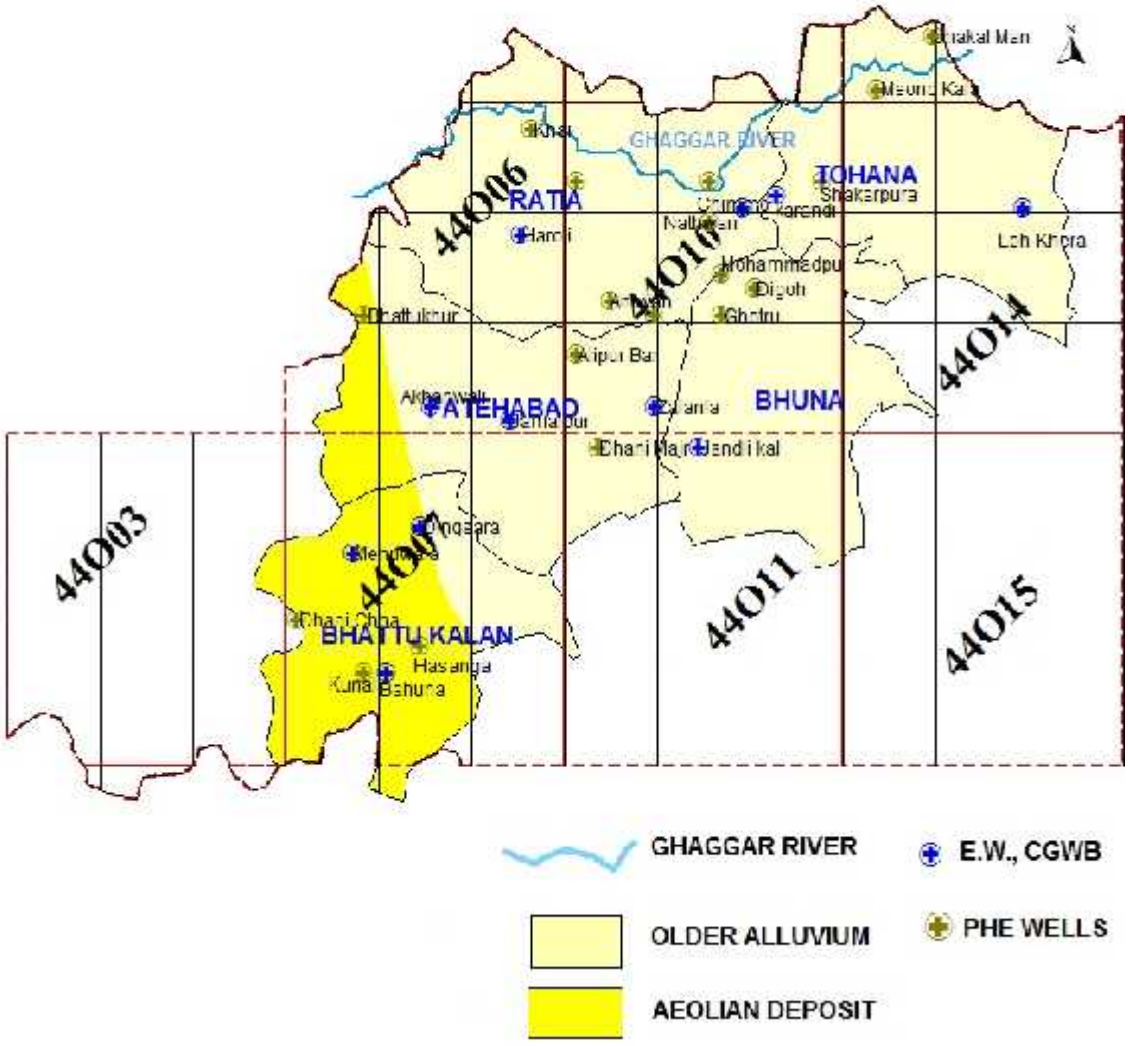
The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB and PHED have been collected and those supported electrical logs have been validated for aquifer map preparation. The details are given in below table.

TABLE OF TOTAL WELLS, FATEHABAD				
Agency	Well Depth (meters)			
	<100	100-200	200-300	>300
CGWB	0	5	7	0
PHED	7	20	0	0
Total	3	29	7	0

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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

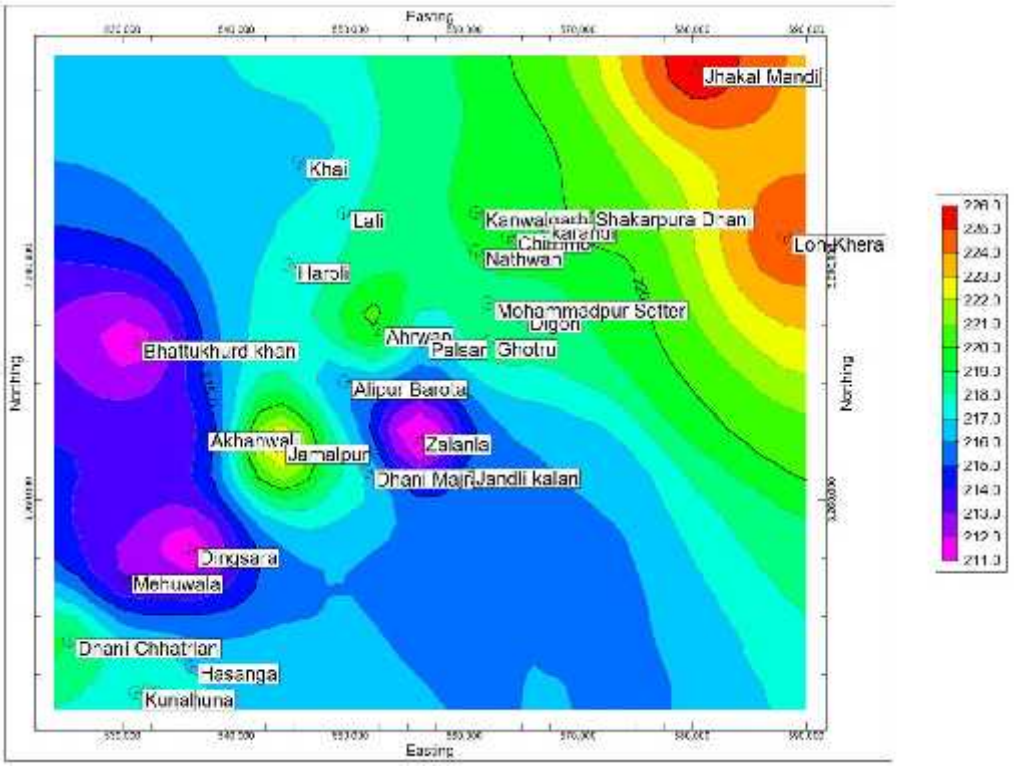
FINAL SELECTED WELLS, FATEHABAD				
Agency	Well Depth (Mt)			
	<100	100-200	200-300	>300
CGWB	0	4	7	0
PHED	3	15	0	0
Total	3	19	7	0



Fig

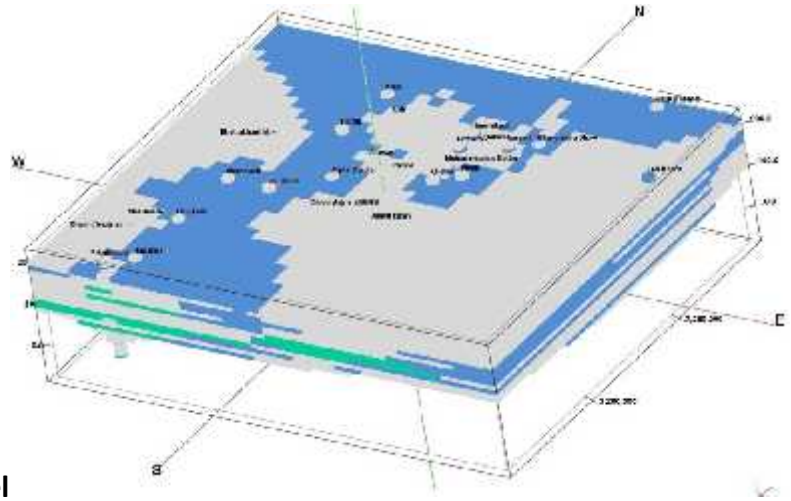
The optimized wells of CGWB, and PHED used to prepare theelevation or collar elevation map to identify the topographic variations on the ground surfaceso that it can give the synoptic picture of gradient variations in the water levels. Thetopographic elevation values have been plotted to prepare the elevation contour map and isin Fig.

Fig: Elevation contour map

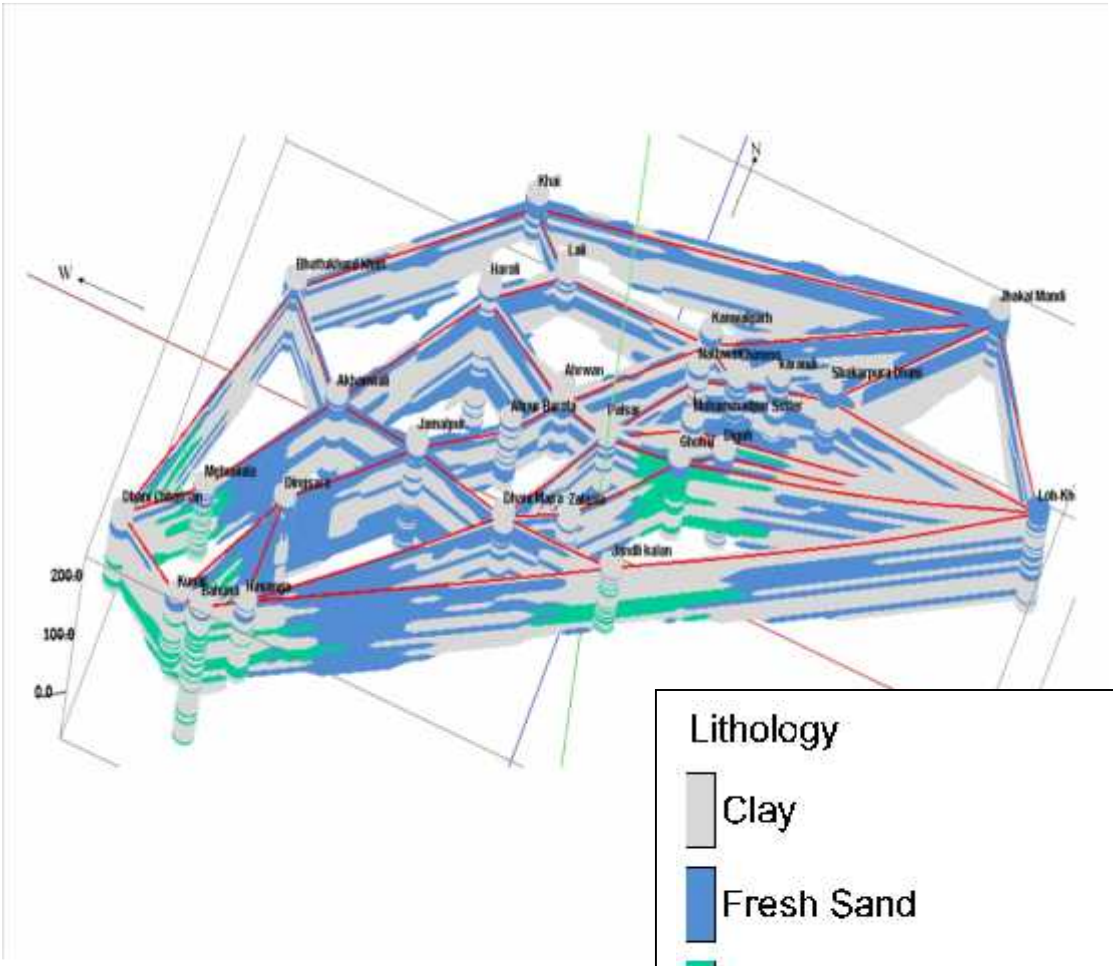


Sub Surface Aquifer Disposition

To understand the sub surface disposition in the study area, geological sections and fence diagram have been prepared by synthesizing the various sub-surface sections on the basis of study of the lithological logs and electrical logs of boreholes drilled by CGWB, PHED using the RockWorks15 software and a 3D lithological model has been prepared (Fig.14). The 2D lithology sectionsand 3D lithological fence diagramhas been prepared using lithology model and are shown in Fig. a, b & 16 respectively. The aquifers are composed of fine to medium sand with clay intercalations. The granular zones are extensive.



Dimension Lithological Model

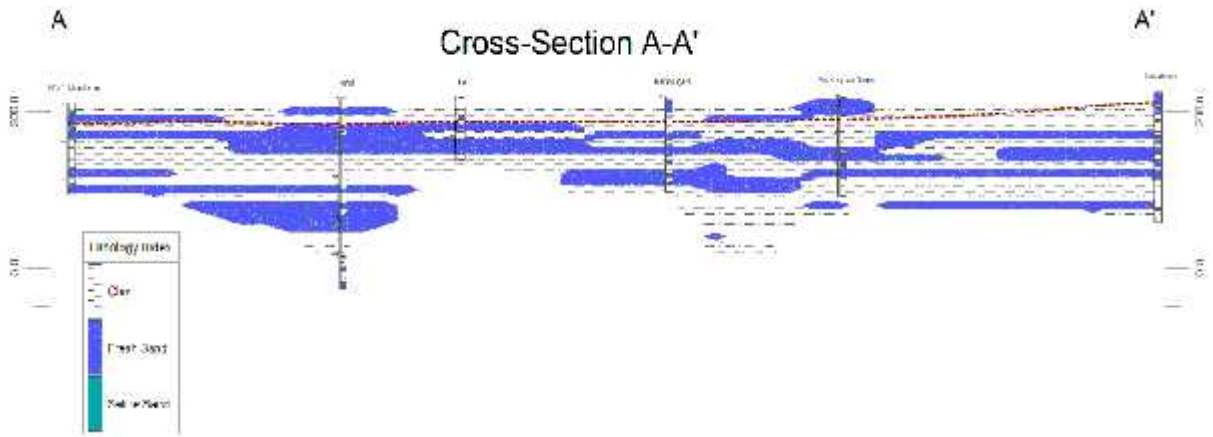


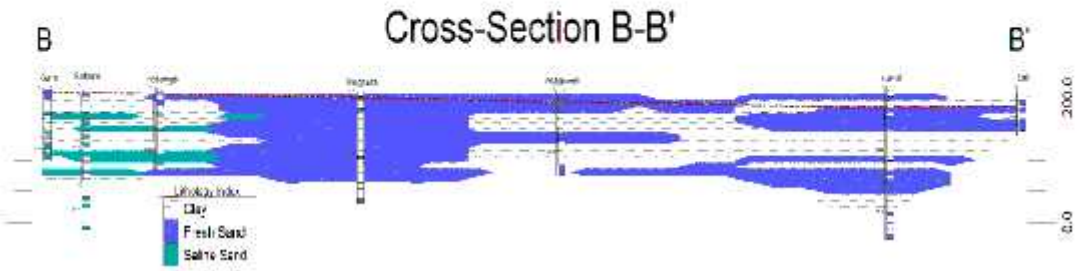
3-Dimension Lithological Fence

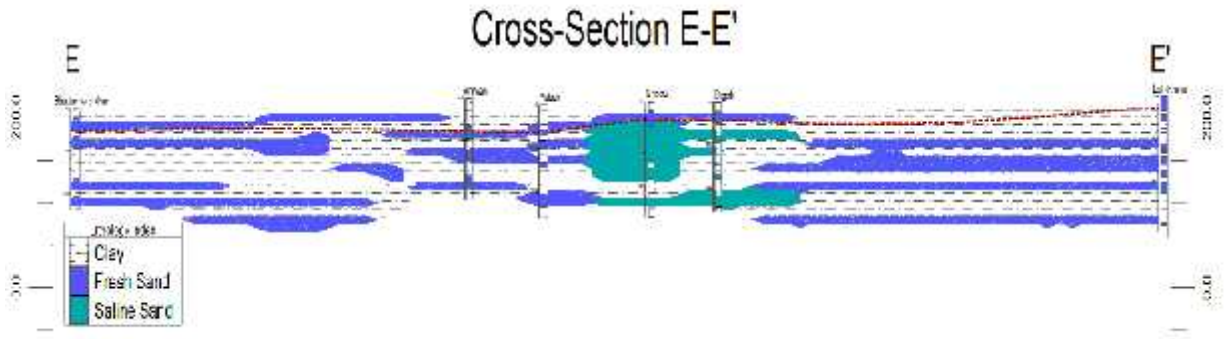
Aquifer Geometry:

Above fence diagram prepared by utilizing the litho logs and electrical logs of exploratory boreholes, indicating the disposition and inter-relationship of granular zones has been presented in fig….. The diagram as a whole indicates that the clay group of formations dominates over the sand group. However, comparatively the sand group percentage increases slightly in the central and northern parts of the district whereas clays exist predominantly in the southern part of the district. The granular zones are more of lenticular types in the southern and north eastern part of the district are more persistent in the rest of the area. Clay beds are invariably much thicker than the permeable granular zones as a whole.

2-Dimension Lithological Sections







GROUND WATER RESOURCES

Ground water resource estimation of the area have been carried out by taking Dynamic and In-storage resources of unconfined aquifer and confined aquiferspresent upto 300m depth. The assessment of dynamic ground water Resources of the studyarea have been carried out jointly by CGWB and Ground Water Cell, Department of Agriculture, Haryana on the basis of Ground Water Estimation Committee (1997)methodology.

The occurrence of potential aquifers (productive granular zones) upto 300 m depthhas been demarcated on basis of aquifer wise subsurface mapping. The total saturatedthickness of granular zones was derived from the exploratory borehole data of a particularblock. The granular zones occurring below the zone of water level fluctuation up to the firstconfining layer has been considered as static unconfined zone. The ground water resource ofthis zone has been calculated considering 12% specific yield of the formation. The specificyield value for the unconfined aquifer has been taken as 60% of 0.12 which comes as 0.072whereas for the confined aquifer, the storativity value has been considered. Since the specificyield 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 ofgranular zones, specific yield/storativity, and area of both fresh water and saline/brackishwater. It has been observed that in some of the blocks sufficient data on probable occurrenceof granular zones was not available. In those cases, the existing exploratory data of adjoiningblock/district has been either extrapolated or interpolated to derive such parametersrequired for estimation. This assessment of total groundwater resources has beencomputed based on the available data with CGWB &PHED, Haryana

Unconfined Aquifers

a. Dynamic Resources:

Block-wise ground water resource potential of the district has been assessed as per GEC-97 as on 31st March 2013. The primary source of recharge in the area is the rainfall.The ground water development in all the blocks has exceeded the availablerecharge, thus allthe blocks have been categorized as over exploited. Stage of groundwater development in the Fatehabad district has been assessed to be 184%. The details are explained in below Table

Table-: Dynamic Ground Water Resource & Development Potential (31.03.2013) in mcm

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 (11+12)*	*Provision for domestic, and industrial requirement supply to 2025*	*Net Ground Water Availability for future irrigation development (10-11-14)*	*Stage of Ground Water Development {(13/10) * 100} (%)*	*Category*
BhattuKalan	**5832**	6067	0	6067	33	-269	104	Over Exploited
Bhuna	**7301**	6562	21	6583	37	702	90	critical
Fatehabad	**9051**	20244	98	20342	98	-11291	225	Over Exploited
Ratia	**16731**	37198	121	37319	121	-20588	223	Over Exploited
Tohana	**15661**	30053	125	30178	125	-14517	193	Over Exploited
Jakhal	**8653**	15634	0	15634	0	-6981	181	Over Exploited
TOTAL	**63229**	**115758**	**365**	**116123**	**414**	**-52943**	**184**	

b. In-storage Ground Water Resources

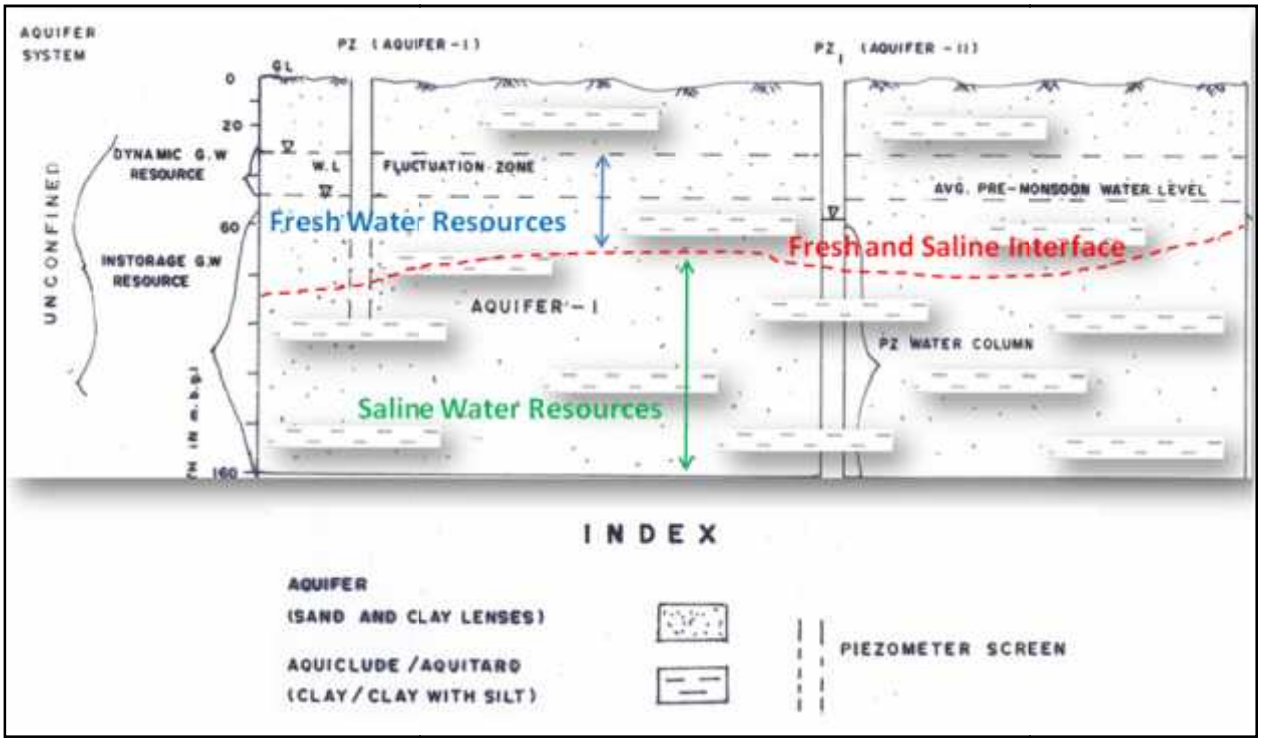
As per revised guidelines recommended by the Central Level Expert Group on groundwater resources assessment, the resources are separately considered as dynamic andin-storage unconfined. In case of alluvial area, the in-storage resources of unconfined aquiferhave been computed based on specific yield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

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

Aquifer) layer of unconfined aquifer aquifer

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

Fig-16: Conceptual figure to understand the fresh and saline water resources in the aquifer up to 300 m for Resource Estimation in Unconfined and Confined Aquifer System



(The clay lances are more dominant in the aquifer and sometimes huge thickness of clay deposits are also observed in the litholog

Table-9: BLOCK WISE IN-STORAGE GROUND WATER RESOURCES OF FRESH WATER IN AQUIFER UPTO AVERAGE DEPTH OF 30 M (i.e SURFACE TO 30 M)

Name of Assessment Unit	Areal extent (ha)			Average Pre-monsoon Water Level (m bgl)	Depth to bottom of Aquifer Zones (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Total thickness of the Granular Zones up to the depth of 30 m (m)	Thickness of the unsaturated granular Zones up to Pre-monsoon WL (m)	Thickness of the saturated granular Zones up to 30 m of aquifer below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Fresh Ground Water Resources up to 30 m(ham)	In-Storage Saline Ground Water Resources up to 30 m(ham)	Total In-Storage Ground Water Resources up to 30 m(ham)	Volume of unsaturated zone
	Total Geographical Area	Assessment Area												
		Fresh Water	Brackish/Saline Water											
1	2		4	5	6	7	8	9	10	11	12	13	14	15	16
FATEHABAD															
Fatehabad	53321	53321		1883	23.6	30	6.4	22	12	10	0.072	38391	1355.76	39747	76782.24
Ratia	61014	60962		52	24.37	30	5.63	13	8	5	0.072	21946	18.72	21965	58573.44
Tohana	31344	31060		284	19.29	30	10.71	23	13	10	0.072	22363	204.48	22568	48896.64
Jakhal	16942	16942		0	26.33	30	3.67	21	13	8	0.072	9759	0.00	9759	26429.52
BhattuKalan	43511	39576		3935	6.75	30	23.25	12	9	3	0.072	8548	849.96	9398	46991.88
Bhuna	42978	42978	41178	1800	13.08	30	16.92	10	2	8	0.072	23719	1036.80	24755	10314.72
Dist. Total(ham)	**228406**	**228406**	**228406**	**7954**								**124726**	**3466**	128192	267988.44
Dist. Total(MCM)												1247	35	1282	2679.8844
Dist. Total(BCM)												1.25	0.03	1.28	2.6798844

Table-10: BLOCK WISE IN-STORAGE GROUND WATER RESOURCES OF SALINE WATER IN AQUIFER UPTO DEPTH OF 300 M (i.e 30 M to 300 M)

Name of Assessment Unit	Areal extent (ha)				Average Pre-monsoon Water Level (m bgl)	Depth to bottom of Aquifer Zones (Available Depth) (m bgl)	Total Thickness of formation below 30 m of depth (m) (9-8)	Total thickness of the Granular Zones up to the depth of 30 m (m)	Average Specific Yield	In-Storage Fresh Ground Water Resources from 30 m to available depth(ham)	In-Storage Saline Ground Water Resources from 30 m to available depth(ham)	Total In-Storage Ground Water Resources up to 30 m(ham)
	Total Geographical Area	Assessment Area										
		Total	Fresh Water	Brackish/ Saline Water								
1	2	3	4	5	6	7	8	9	10	11	12	13
Fatehabad												
Fatehabad	53321	53321	53321	1883	23.6	255	225	44	0.072	168921	5965.34	174886
Ratia	61014	61014	60962	52	24.37	300	270	91	0.072	399423	340.70	399764
Tohana	31344	31344	31060	284	19.29	167	137	50	0.072	111816	1022.40	112838
Jakhal	16942	16942	16942	0	26.33	114	84	31	0.072	37815	0.00	37815
BhattuKalan	43511	43511	0	43511	6.75	230	200	54	0.072	0	169170.768	169171
Bhuna	42978	42978	0	42978	13.08	107	77	25	0.072	0	77360.40	77360
Dist. Total(ham)	**228406**	**228406**	**228406**							**717974**	**253859.62**	**971834**
Dist. Total(MCM)										**7180**	**2538.60**	**9718**
Dist. Total(BCM)										**7.18**	**2.54**	**10**

Table-11: BLOCK WISETOTAL AVAILABILITY OF TOTAL FRESH AND SALINE GROUNDWATER RESOURCES IN DISTRICT FATEHABAD UPTO MAX. 300 M DEPTH AND DRILLED DATA AVAILABLE IN THE BLOCK

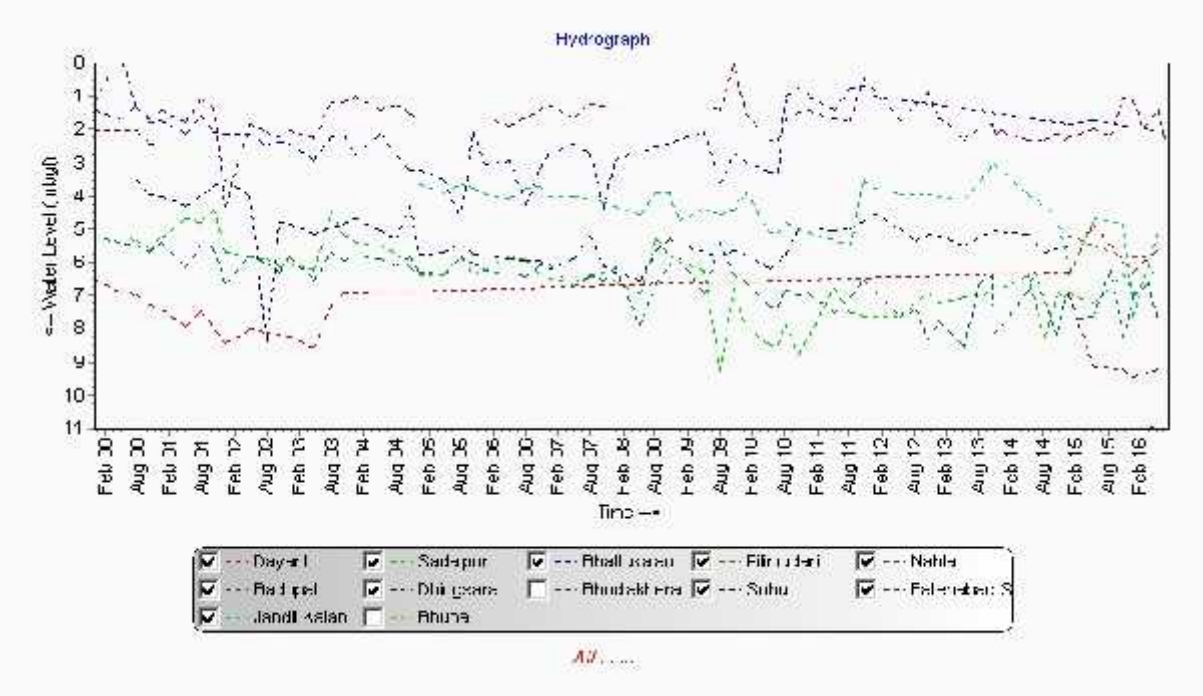
Sl.No	BLOCK	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*Available Depth(m)*	*Total In-storage Fresh Groundwater Resources upto Available Depth*	*Total In-storage Saline Groundwater Resources upto Available Depth*	Total Availabilty of Groundwater Resources [(5)+(6)+(7)]	
						ham	mcm
1	*2*	*3*		*4*	*5*	*8*	*9*
1	Fatehabad	**9051**	255	207312	7321	223684	2237
2	Ratia	**16731**	300	421369	359	438460	4385
3	Tohana	**15661**	167	134179	1227	151067	1511
4	Jakhal	**8653**	114	47573	0	56226	562
5	BhattuKalan	**5832**	230	8548	170021	184401	1844
6	Bhuna	**7301**	107	23719	78397	109417	1094
Dist.Total (ham)		***63229***		***842701***	***257325***	1163255	11633
Dist.Total (mcm)		**632**		**8427**	**2573**	**11633**	
Dist. Total(BCM)		0.63		8.43	2.57	11.63	

GROUND WATER ISSUES

5.1 Ground Water Depletion

The study area is famous for its paddy and non-paddy cultivation. The quality of ground water in the area is fresh to saline owing to which at some places canal water and at other ground water for irrigation and drinking purposes are being utilised but overall ground water is constantly being pumped for the irrigation due to its easy access through tube wells at shallow depths and they are the main source of irrigation. This will lead to its deepening of ground water levels speciallyin northernblocks of FatehabadDistrict as the recharge of the groundwater through rainfall and other sources are less than the overall extraction. The hydrographs also shows the mixed nature of ground water level trend over the years in the district (Fig.23)and is categorized as over-exploited.This declining water table trend, if not checked, would assume an alarming situation in the near future affecting agricultural production and thus economy. Ground Water Recharge and Conservation may be carried out in these areas to overcome the depletion.

Fig.23: Long term ground water table variation



5.3 Ground Water Irrigation Scenario

As per the data available from minor irrigation census 2006-07, the detailed number of shallow, deep, tube wells, lined, unlined water distribution system, land holdings of wells are given in Table-10,11 &12 .

Table-10: Distribution of Tube wells According to Well Owner's land holding Size

Type of Tube well (TW)	***Marginal (0-1 ha)***	***Small (1-2 ha)***	***Semi-Medium (2-4 ha)***	***Medium (4-10ha)***	***Big (>10ha)***	***Owned by other than individual farmers***	***Total***
Shallow TW	1559	4265	13092	13165	3259	42	**35382**
Deep TW	7	14	106	201	104	0	**432**
Total	**1566**	**4279**	**13198**	**13366**	**3363**	**42**	**35814**

Table-11: Distribution of Tube wells According to Depth

Depth of Tubewells in metres								**Total depth Range 0-150m**
Depth range	0-20 m	20-40 m	40-60 m	60-70 m	70-90m	90-150m	>150 m	
Tubewells	75	8930	2882	23495	279	153	0	**35814**
Tubewells (%)	0.21	24.93	8.05	65.60	0.78	0.43	0.00	

Table-12: System of Ground water distribution device

	Open Water Channels			
Lined/pucca	*Unlined/kutcha*	*Underground Pipe*	*Others*	*Total*
125	32685	2992	12	**35814**

6.0 MANAGEMENT STRATEGIES AND AQUIFER MANAGEMENT PLAN

Aquifer mapping is leads to groundwater management plans to be implemented by including demand side-management and Ground Water Use Efficiency.

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

Artificial recharge plan is less feasible in the Fatehabad District due to very low availability of volume of surplus water (12.91 mcm). 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) in over exploited blocks of the 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 KrishiSinchaiYojna), 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.

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 in the state of Punjab, particularly in overexploited blocks.

There are around 32685 (out of 35814) tube wells (91.26 %) operated by farmers for irrigation through unlined/Kutcha open channel system in study area (Table-12) where water from the tube well is discharge to the agricultural field. In this process, huge (around 25 %) (RKVY, 2015) quantity of ground water is wasted in soil moisture and evaporation losses.

Around 98.80 % of the tube wells are of shallow depth (20 to 70m) and remaining wells are deeper depth (70 to >150 m) existed in the area (Table-11). Thus, majority of wells are tapping shallow aquifer which is under stress.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in the district is estimated at 115758 mcm. It is expected that 70.42 mcm of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby gross draft will be reduced to 70.42 mcm (Table-13a) assuming that there is a need of crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks. The measure if implemented will bring down the ground water overdraft from 185 % to 125%. The category of the blocks will also improve resulting in boosting of agriculture and industrial development otherwise not sustainable in over-exploited blocks (Table-11b).

The tube wells also consume enormous electricity which is subsidized and government incur significant revenue on this account. The measures therefore will result in saving of energy and money. Pollution impact will be reduced whenever diesel engines are used by the farmers. The environmental and ecological condition in the irrigated land will improve. Unwanted weed growth will also be controlled inside the farm land. It is expected to save 1% of the agricultural land occupied by open channels which can be utilized for cultivation purpose. Heavy ground water overdraft can be reduced by these efforts. This will ensure *more crops per drop.*

6.3 Water saving Potential from Crop Diversification-Change Paddy to Maize/Soya-bean:

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

The block wise saving of water in mcm by applying various management strategies such as crop diversification, Under Ground Pipe lines (UGPL) in individual land and artificial recharge methods are given in tables below

Table-13a: Scope of Quantitative Impact on Stage of Development after applying various management strategies in mcm

District Fatehabad	Net Annual Ground Water Availability (mcm)	Total Draft (present) (mcm)	Stage of development (%) as per GWR 2013	Water Saving Method			SOD% afterwards	% paddy area to be converted to maize/ soyabin
				UG(mcm)	AR (mcm)	Maize(mcm)		
Bhattu Kalan	58.32	60.67	104	3.91	0.00	0.00	97	0
Fatehabad	90.51	203.42	225	13.06	2.66	37.22	166	100
Ratia	167.31	373.19	223	23.99	1.90	126.58	132	100
Tohana	156.61	301.78	193	19.38	1.45	91.40	121	100
Jakhal	86.53	156.34	181	10.08	1.20	48.06	112	100

By adopting all the management strategies resulting in total reduction in stage of groundwater development is 91.47%. Hence overall stage of development afterwards is 100 % .

BLOCK WISE

AQUIFER MAPS

AND

MANAGEMENT PLAN

(PART-II)

CHAPTER-4

CGWB exploration and Aquifer Disposition

4.1 Analysis of litho-logs

The exploration has revealed that the occurrence of relatively impermeable fine-grained material is erratic and not regularly extensive. However within the depth of 175 m bgl the probability of their occurrence is very high in the entire area which gives rise to a leaky confined aquifer conditions at depth. The aquifer system in the area can be taken as multilateral unit with possible interconnections. Results of the exploration show that tube wells within the depth range of 50-175 m in can be designed to tap aquifer. However at the time of construction of tubewell quality should be taken into account keeping requirement of water. Shallow tubewell upto depth of 50 m can be constructed in entire area depending upon quality of water in the area.

Tubewells constructed in northern part of district are high yielding and are capable of providing good quality of water whereas tubewells in the southern part of the district are giving lesser yields and poor quality of water.

4.2 Cross section

The cross sections are made to understand the sub surface geology and aquifer disposition of the Aquifer system of the area.The cross-section are made by selecting two to three lithological data of boreholes and the data was interpreted by using the Rockworks software.

(a) Block:-BhattuKalan

Hydro-Geological Cross Section

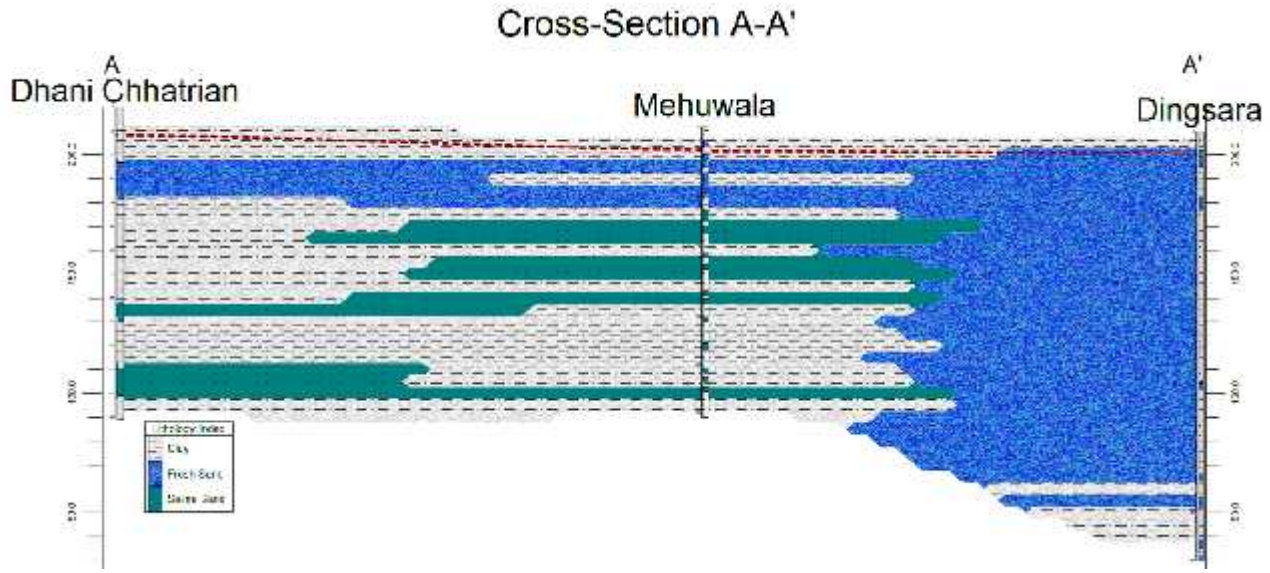


Figure 4.1 Hydro-Geological Cross Section A-A` of BhattuKalan Block

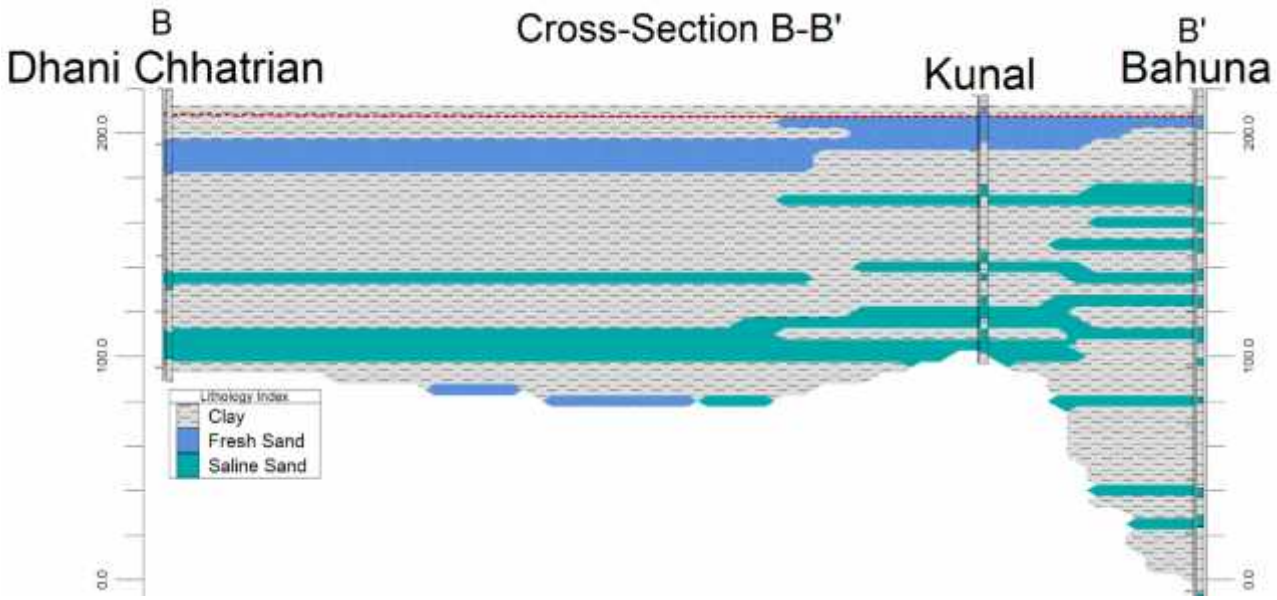


Figure 4.2 Hydro-Geological Cross Section B-B` of BhattuKalan Block

.

(b) **Block:-Bhuna**

Hydro-Geological Cross Section

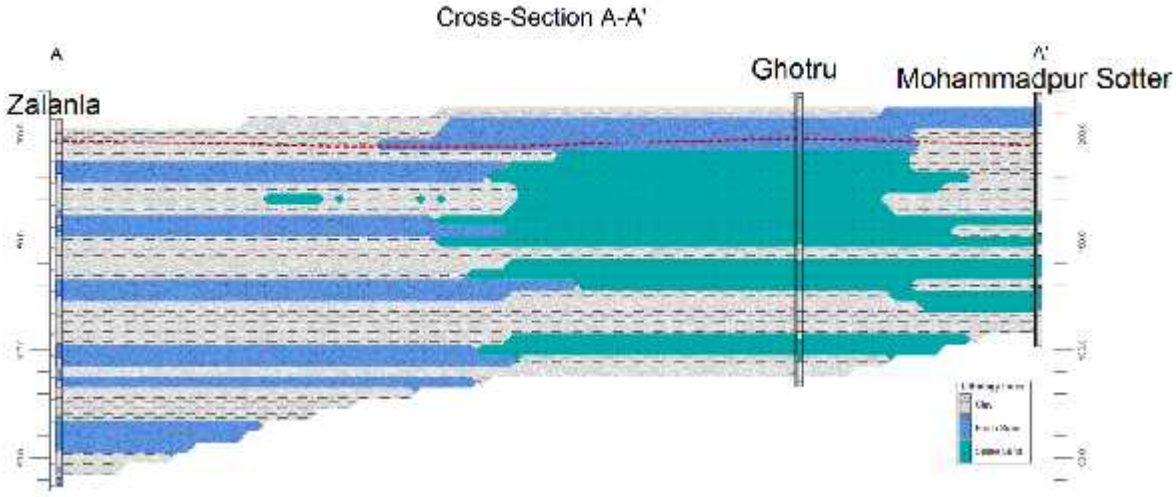


Figure 4.3Hydro-Geological Cross Section A-A` of Bhuna Block

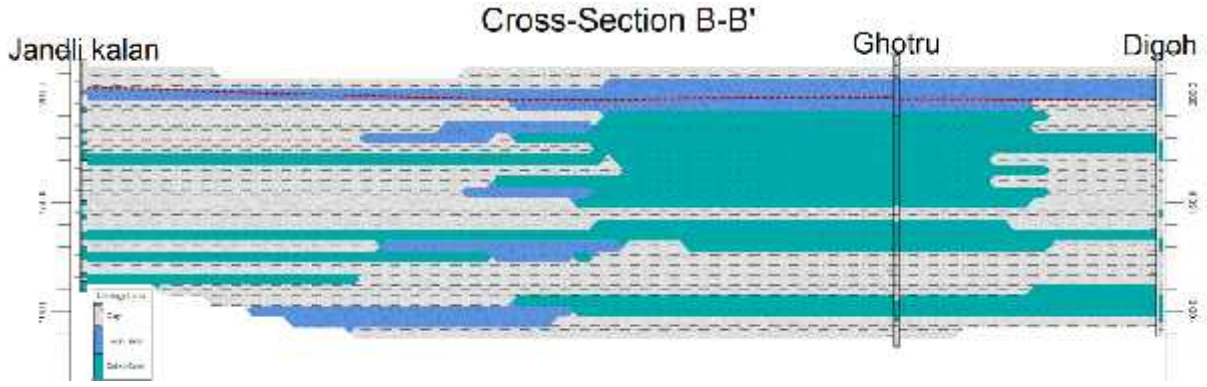


Figure 4.4Hydro-Geological Cross Section B-B` of Bhuna Block

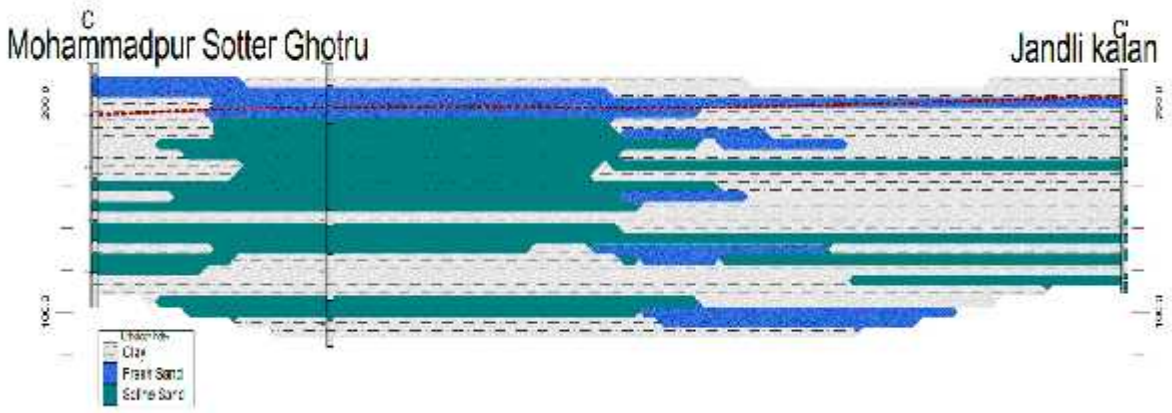


Figure 4.5Hydro-Geological Cross Section C-C` of Bhuna Block

(c) Fatehabad

Hydro-Geological Cross Section

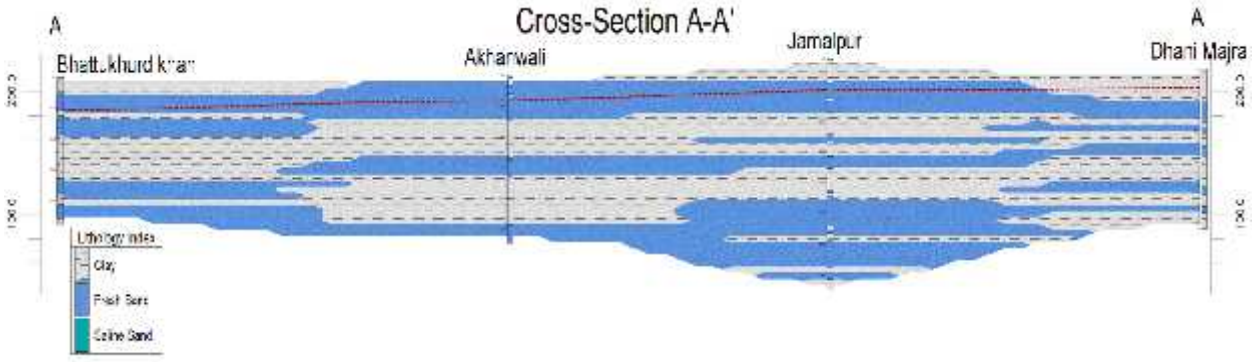


Figure 4.6Hydro-Geological Cross Section A-A` of Fatehabad Block

(d) Ratia

Hydro-Geological Cross Section

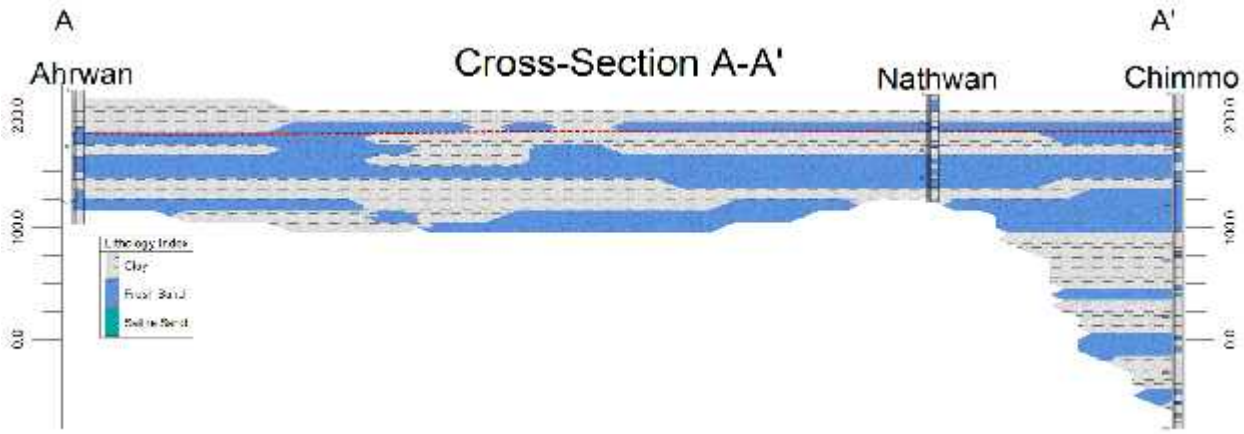


Figure 4.7Hydro-Geological Cross Section A-A` of Ratia Block

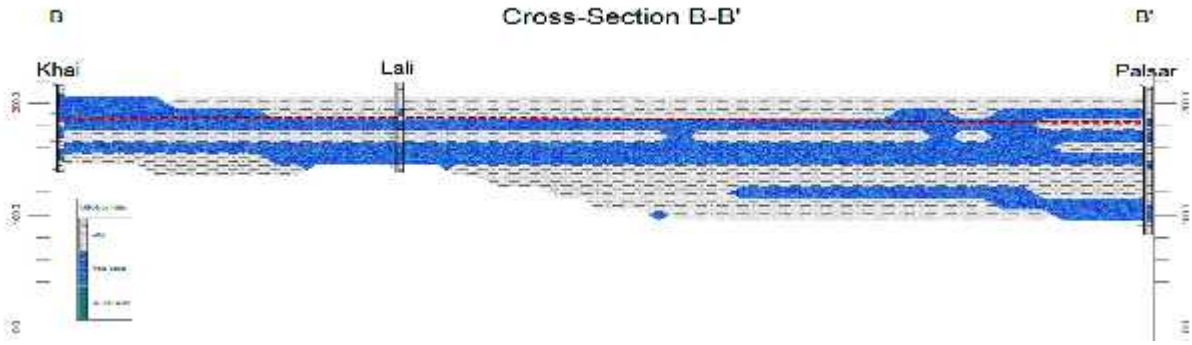


Figure 4.8Hydro-Geological Cross Section B-B` of Ratia Block

(e) Tohana

Hydro-Geological Cross Section

Figure 4.9Hydro-Geological Cross Section A-A` of Tohana Block

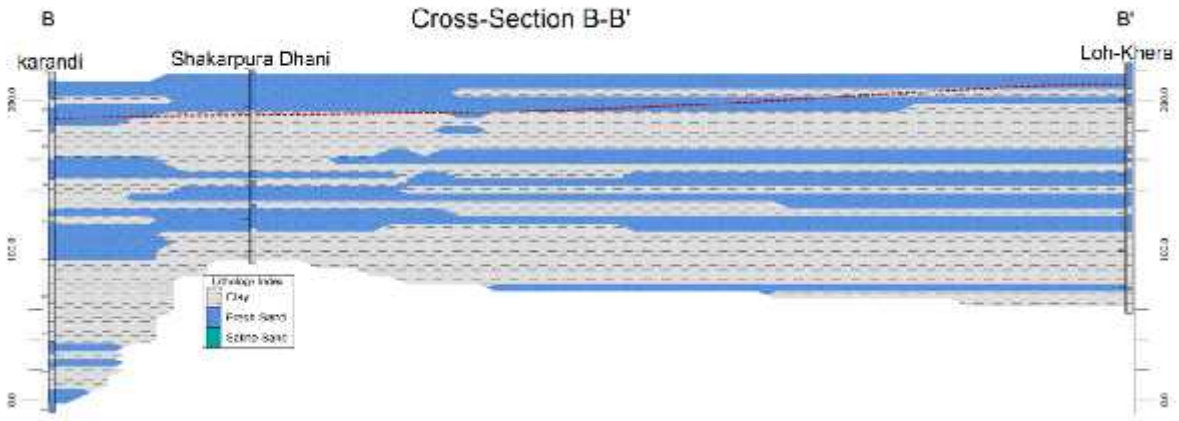


Figure 4.10Hydro-Geological Cross Section B-B` of Tohana Block

4. Fence diagram of district Fatehabad

Fence diagram represents a three dimensional sub-surface geology of the area. The three dimensional aquifer dispositions can be understand by using the fence diagram. The fence diagram of Fatehabad district is shown in figure.