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

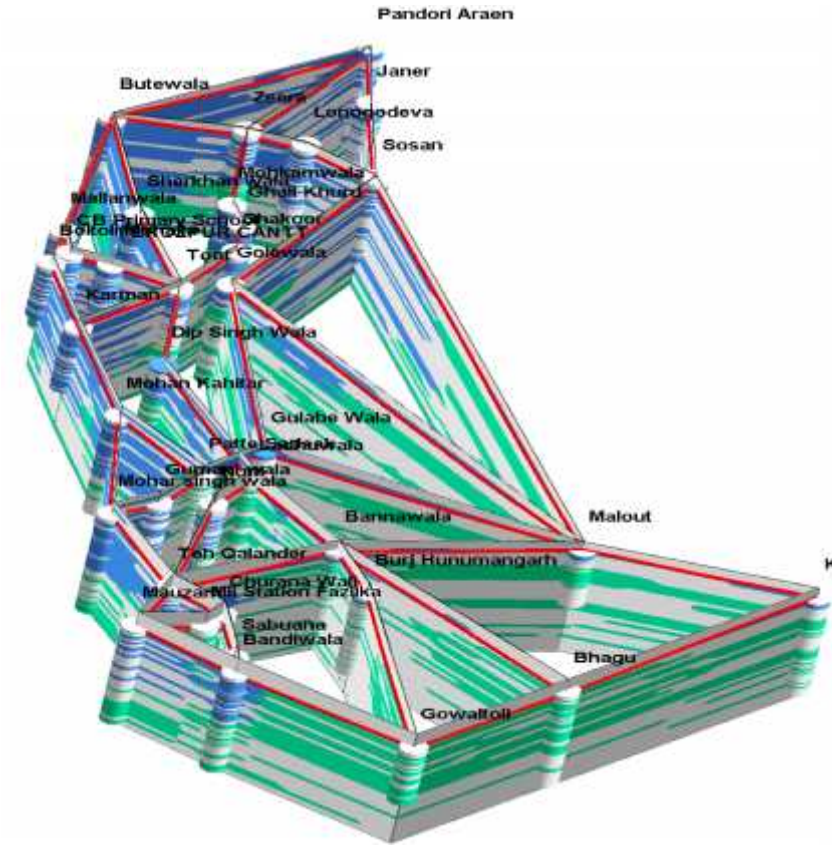
AQUIFER MAPPING AND MANAGEMENT PLAN

Ferozpur and Fazilka Districts, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING & MANAGEMENT PLAN OF FEROZPUR AND FAZILKA DISTRICTS, PUNJAB



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2017

AQUIFER MAPPING AND MANAGEMENT PLAN
FEROZPUR AND FAZILKA DISTRICTS
(5850 Sq Km)

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1.0 INTRODUCTION

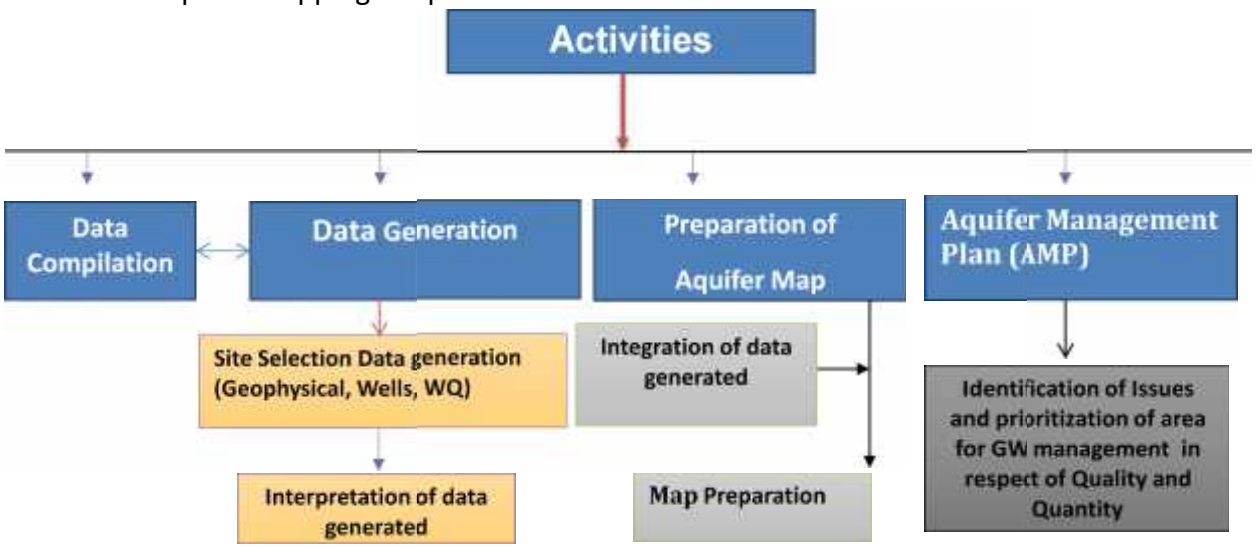
The primary objective of the Aquifer Mapping can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the Government and the Community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

1.2 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 manual attempts to evolve uniform protocols for these activities to facilitate their easy integration for the district as whole.

1.3 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. The overall activities of aquifer mapping are presented in the flow chart below.



1.4 Location and Geographical Units

Ferozpur, the south western most district of Punjab State with a total geographical area of 5850 sq km. is located between 29^{o} 56' 47" and 31^{o} 0' 7" north latitudes and 72^{o} 52' 4" and 75^{o} 01' 11" east longitudes. The district area falls in Survey of India degree sheet nos. 44 J, 44F, 44I. Administratively, the district is under control of Ferozpur and Fazilka division and is divided into 10 development blocks namely Ferozpur, Fazilka, Abohar, Zira, Jalalabad, Ghall Khurd, Guru Har Sahai, Khuyian Servar, Makhu and Mamdot.

The Ferozpur district forms a part of Sutlej sub basin of main Indus basin and is interrupted by clusters of sand dunes. The district area is almost a flat terrain with a gentle slope towards south west direction.

Physiographically, it is characterized by four distinct features i.e. the upland plain, sand dune tracts, younger flood plain and active flood plain. The river Sutlej that is of perrineal nature mainly drains the area. River Sutlej shows both influent and effluent nature in the area. The area is traversed by a dense network of canals. In irrigation practices, contribution of tubewells are larger as compared to canal system i.e 137 % area irrigated by canal is being irrigated by tubewells.

1.5 Climatic Conditions: Rainfall and Climate

The climate of the district is classified as sub-tropical steppe, semi-arid and hot which is mainly dry except in rainy months and characterized by intensely hot summer and cold winter.

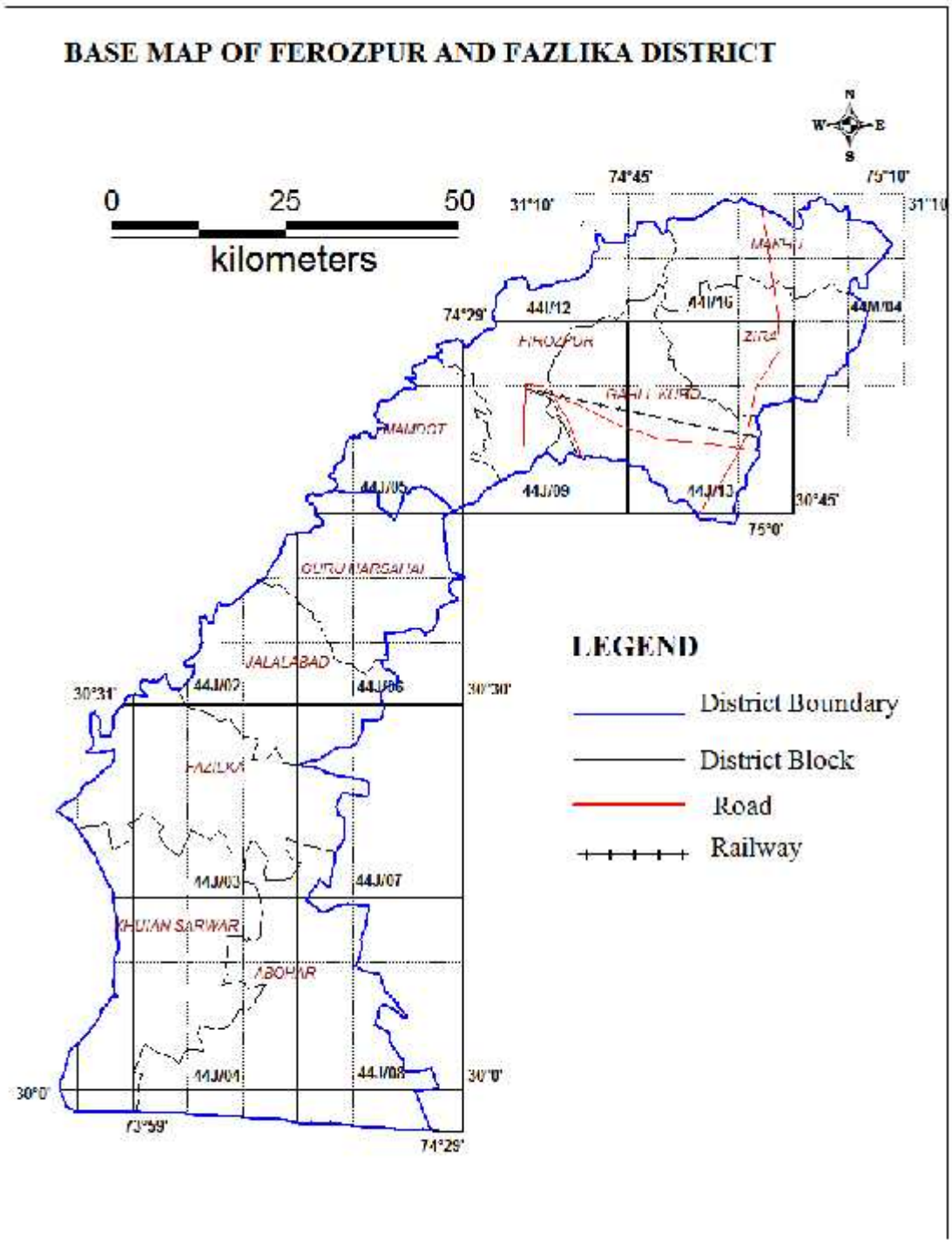
The normal annual rainfall is 449 mm in 24 days which is unevenly distributed over the district. Normal Monsoonal rainfall is 349 mm. The southwest monsoon sets in last week of June and withdraws towards end of September and contributes about 78% of annual rainfall. July and August are the rainiest months. Rest 22% of the annual rainfall occurs during non-monsoon months of the year in the form of thunder storm and western disturbances. Rainfall in the district increases from southwest to northeast.

1.6 Geomorphology & Soil Type

The district area forms a part of Indo-Gangetic plain and Sutlej Sub basin of main Indus basin. The area as a whole is almost flat with a gentle slope towards the south westerly direction. The physiographic of the district is broadly classified from north to south into four distinct features i.e. Upland plain, Sand dune tract, younger flood pain and active flood plain of Sutlej.

The soil of the district is of two types i.e. sierozem (in northern parts) and desert soils (in southern parts)

Fig.1: Base map of Ferozpur and Fazlika District



1.7 Land Use/ Land Cover

Based on the interpretation of topographical data, land use/land classes have been identified. The main classes are Built Up land, Agricultural land, forestland, Land under non agriculture use, current fallows and water body.

Land use pattern of Ferozpur and Fazilka district, Punjab

Type of Land use	Area (hectares)
1. Total Geographical area	585000
2. Forest	2004
3. Land put to non-agricultural use	16719
4. Current Fallows	2239
5. Net area sown	126678
6. Gross cropped area	252989
7. Cropping intensity	189%

1.8 River System and Water Resources

Two major rivers flows the entire study area, Satluj river flows in western part and Beas river in Northern part. There are some drains which flow during heavy rains and serve as natural drainage. Phidda drain, Taroori drain, Chand Bhan drain and Sem Nala are important among them (Fig.3). There is a vast network of canals and their distributaries passess through this area. These are Eastern canal, Bikaner Canal, Jalalabad branch, Ladhuka disty., Golewala disty (Fig.4).

Eastern Canal system is a non-perennial system. Its construction was completed in 1927 and it used to off take from Hussainiwala Headworks. However, after the construction of Harike Headworks, the supply of water to Eastern canal system and Bikaner Canal has been switched over to Harike Headworks, except for a portion of Eastern canal running in a length of about 8.02 Kms which receives water supply from Hussainiwala Headworks for feeding 7 distribution and 8 minors. The authorised discharge of Eastern Canal system is 3197 cs, which has culturable command area of 2.16 lac hect and runs in a length of 856 Kms.

1.9 Agriculture & Irrigation

The two main crop seasons in a year in the district are kharif and rabi which is locally known as 'Sauni'(Summer Harvest Season) and 'Harrhi' (Winter Harvest Season). The principle Kharif crops are Paddy, Maize, Bajra, Cotton, Moong, Mash, Moth, Arhar, Sugarcane, etc., while important Rabi crops are Wheat, Barley, Gram, Sarson, Taramera and Toria, etc. Kharif and rabi is cultivated in this area under two types of soil i.e. loamy sand and sandy loam and the sources of irrigation are canal as well as tubewells.

Irrigation in the district is carried out both by surface water as well as ground water. As southern and southwestern parts of this area are underlain by saline water, so canal water is

major source of irrigation. In some parts where fresh water is available as fresh water lenses, than irrigation is done by skimming wells known as multiple well point system. Conjunctive use of canal water and ground water for irrigation is most prominent in this area.

a. Canal Water Irrigation

Major source of irrigation is canal where water from Eastern canal is utilized for irrigation. Important distributaries are Jalalabad branch, Ladhuka disty., Golewala disty. system.

b. Ground Water Irrigation

With the advent of multiple well point systems, ground water irrigation is also playing an important role in development of agriculture economy of the district. This is not only release the pressure mounted on the canal water supply but also creates the maximum storage in the unconfined aquifer for fresh ground water through by return flow and canal seepage. In irrigation practices, contribution of tubewells are larger as compared to canal system i.e 137 % area irrigated by canal is being irrigated by tubewells.

1.10 Industries

There are no major industries in the area except Agro and sugar mill industries in Fazilka area.

1.11 Mineral Resources

The geological formations identified in the area are: sandy clay with saltpetre encrustations at places, clay with sporadic sandy nodules. Except saltpeter, other mineral occurrences in the Firozpur District are rather rare. The seepage of natural gas and the occurrences of groundwater have also been reported from this area.

Natural Gas --- The seepage of natural gas has been reported from Zira. The details of the seepage are not known.

Saltpetre. ---Saltpetre is essentially a nitrate of potassium and sodium, with minor amounts of chloride, sulphate and carbonate radicals. It occurs as a thin, white encrustation on the surface. The efflorescence appears during the hot months, viz. May and June and even during July in the absence of adequate rains.

1.12 Water Conservation and Artificial recharge:

The north and eastern part of the district where water level decline exists, artificial recharge structures may help in arrest decline in which Recharge Trench with injection well structure is the suitable for artificial recharge. Water conservation methods like change in cropping pattern, change in Irrigation policy, lining of unlined channels, timely plantation of paddy, promotion of sprinkler and drip irrigation etc. may be adopted to overcome the ground water decline in the area.

Fig.2: Drainage and Water Bodies of Ferozpur and Fazlika District

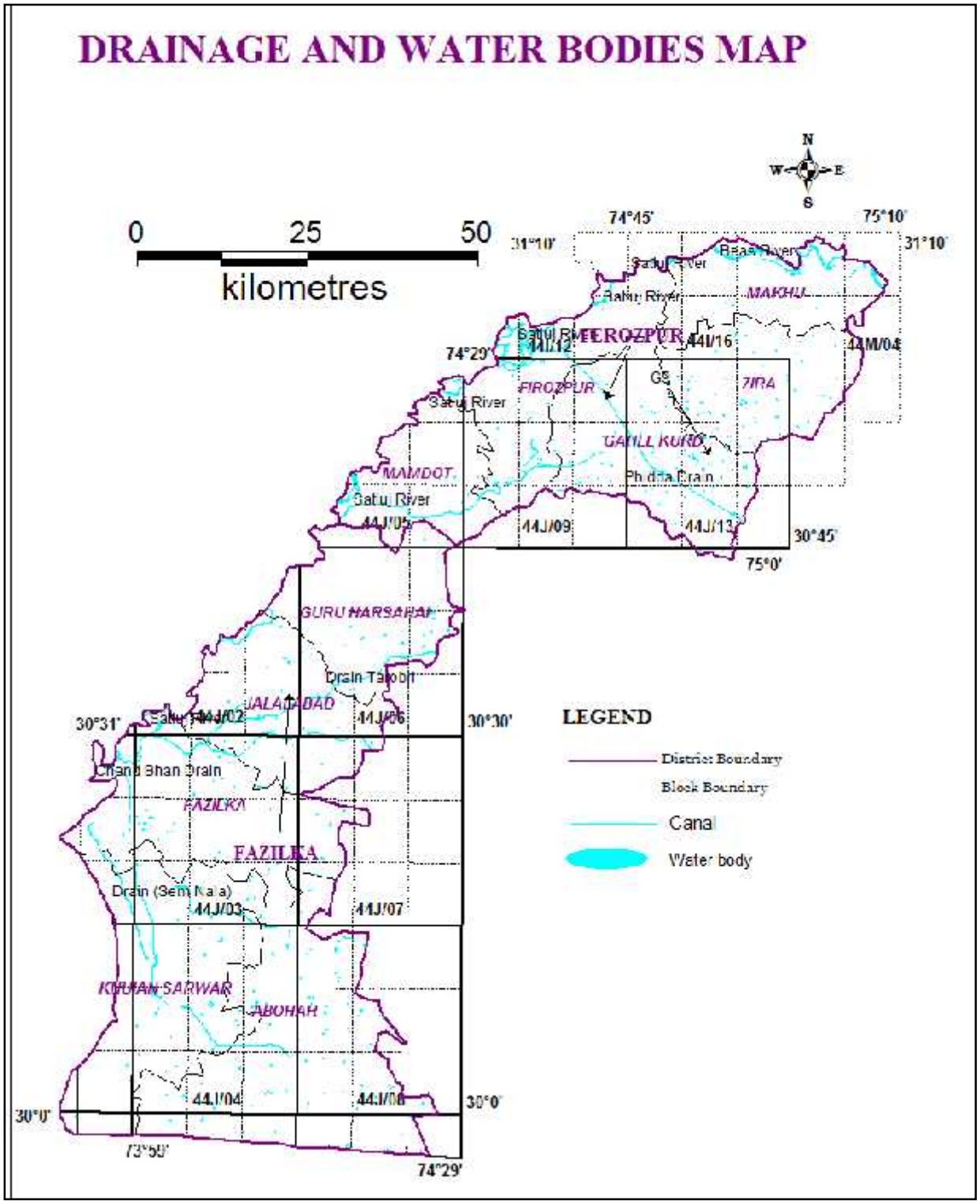
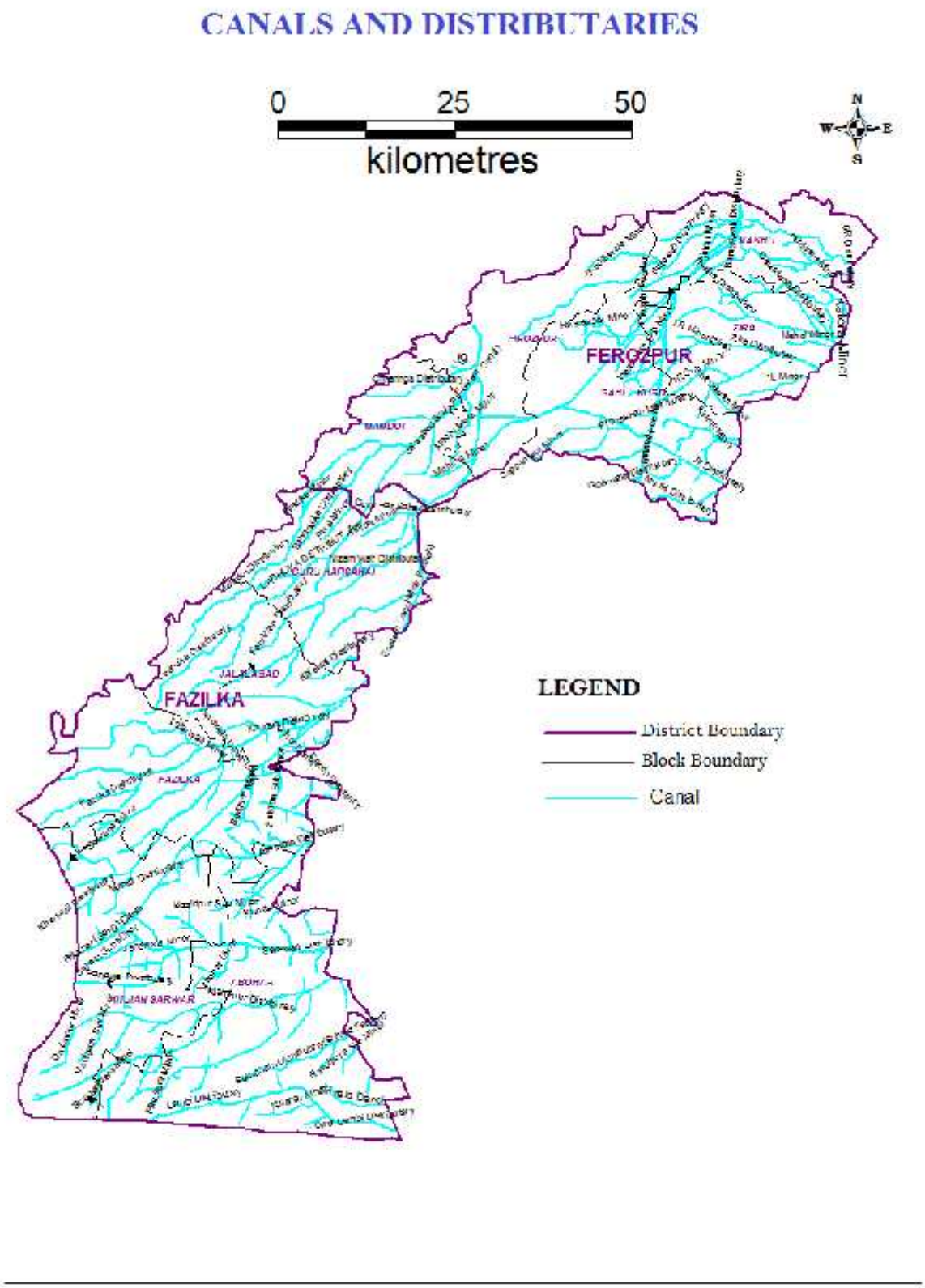


Fig.3: Canal and Distributaries of Ferozpur and Fazlika District



2.0 DATA COLLECTION AND GENERATION

2.1 Geology and Hydrogeological data:

The entire surface is occupied by loose to semi consolidated Quaternary sediments which form part of the Indo-Gangetic alluvial tract. These sediments were deposited by rivers from Himalayas in their present and ancestral forms. Flat surfaces are randomly distributed low relief sand dunes/ridges, scattered all around especially in southern parts of the district.

The alluvial deposits underlying the district form a part of Sutlej/ Saraswati deposits and are located away from the present course of Sutlej River and the alluvial tract composed of fine sands, silt, and silty clay. There are occasional bands and patches of sand with mica flakes. Relative compact bands of silty clay and thin kankar beds are also reported in some of the well sections in the district. Clay occurs in the form of lenticular bodies at various depths. Principal aquifer in the district is Alluvium and major aquifers in the district are older alluvium, Aeolian alluvium and younger alluvium.

The area is fully occupied by flat alluvial plain, of quaternary age. The major hydrogeology in the study area:

1. Major Aquifer is Older Alluvium and Aeolian Alluvium (Fig.5).
2. Principle Aquifer is Alluvium.

Ground water occurs in both water table and confined conditions.

2.1.1 Water Level Behavior

Twenty monitoring stations of CGWB (4 Piezometers and 13 Dugwells) and *eighteen* monitoring stations (18 Piezometers) of State government departments represent first aquifer falls in the district. To represent the second aquifer and third aquifer one monitoring station is exist. The depth to water level ranges from 1.75 to 17.19 m bgl during pre-monsoon period and 1.20 to 20.15 m bgl during post monsoon period. It has been observed that in the eastern part of the district water levels are in the range of 10 to 20 m, in the central part of the district the water levels are in the range of 5 to 10 m bgl and in western part of the district the water levels are shallower in the range of 2 to 5 meters range. Seasonal water level fluctuation shows a rise and fall in the range of 1.10 to (-) 2.00 meters in western and eastern part of the districts respectively during the year 2015. Depth to water level maps is shown in Fig 5& 6.

Hydrograph of Observation Wells

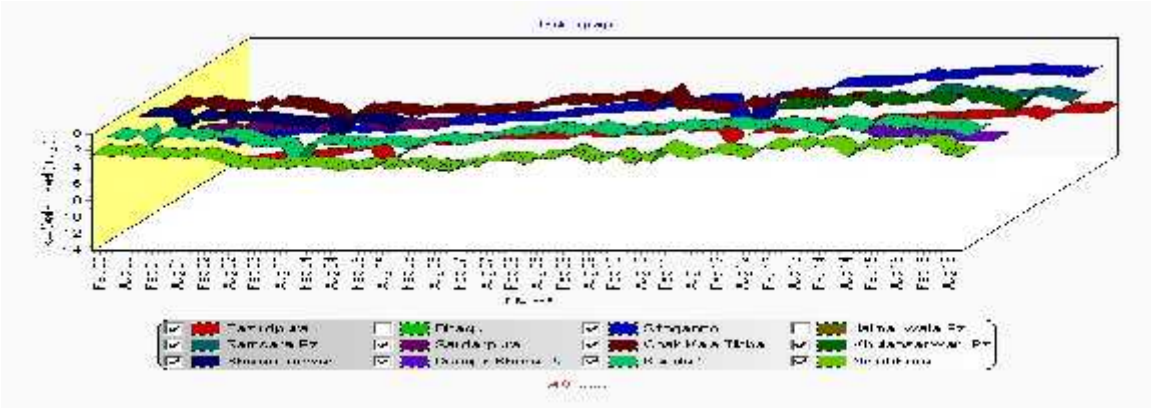


Fig.4: Major Aquifers

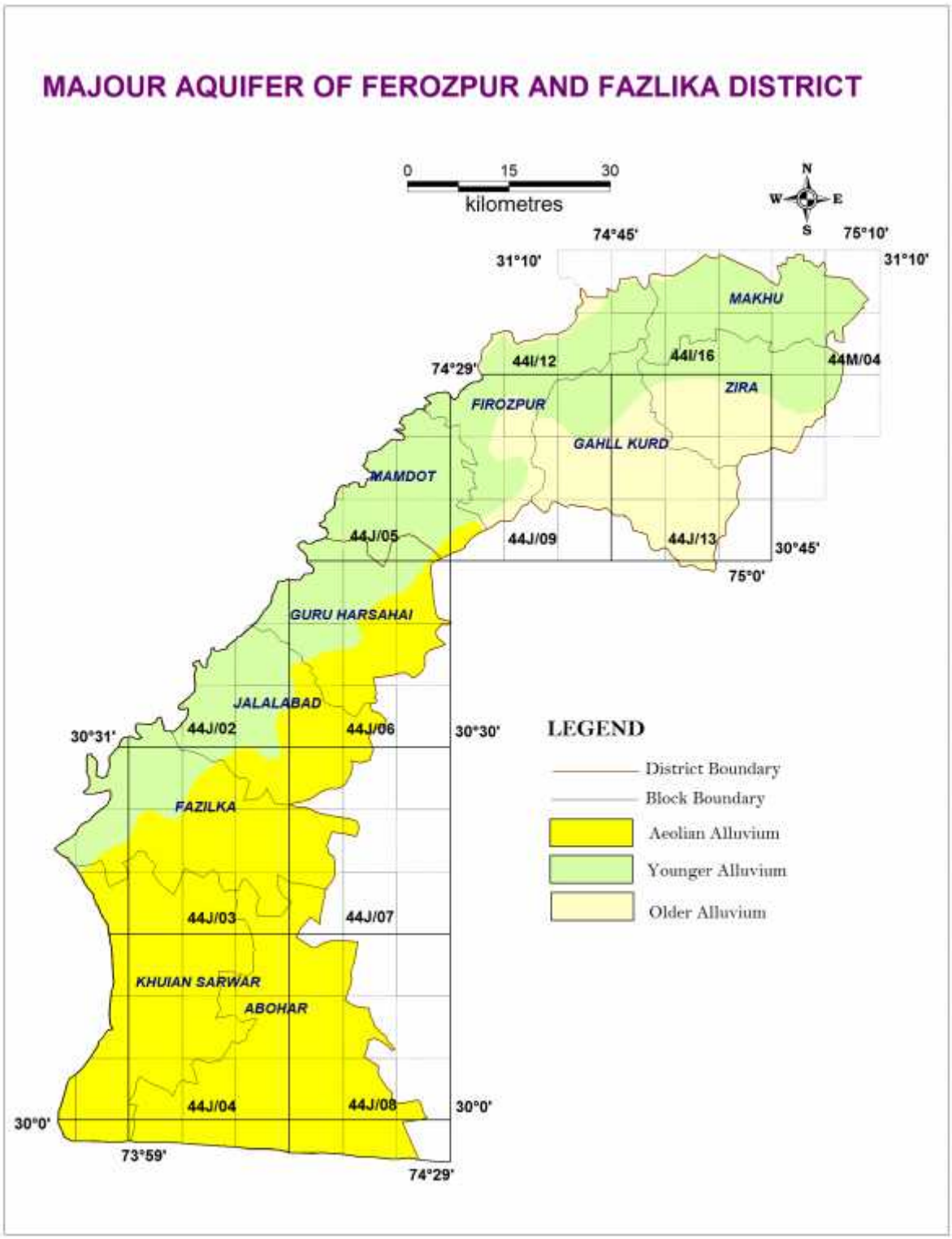


Fig.5: Depth to Pre Monsoon Water level May, 2015

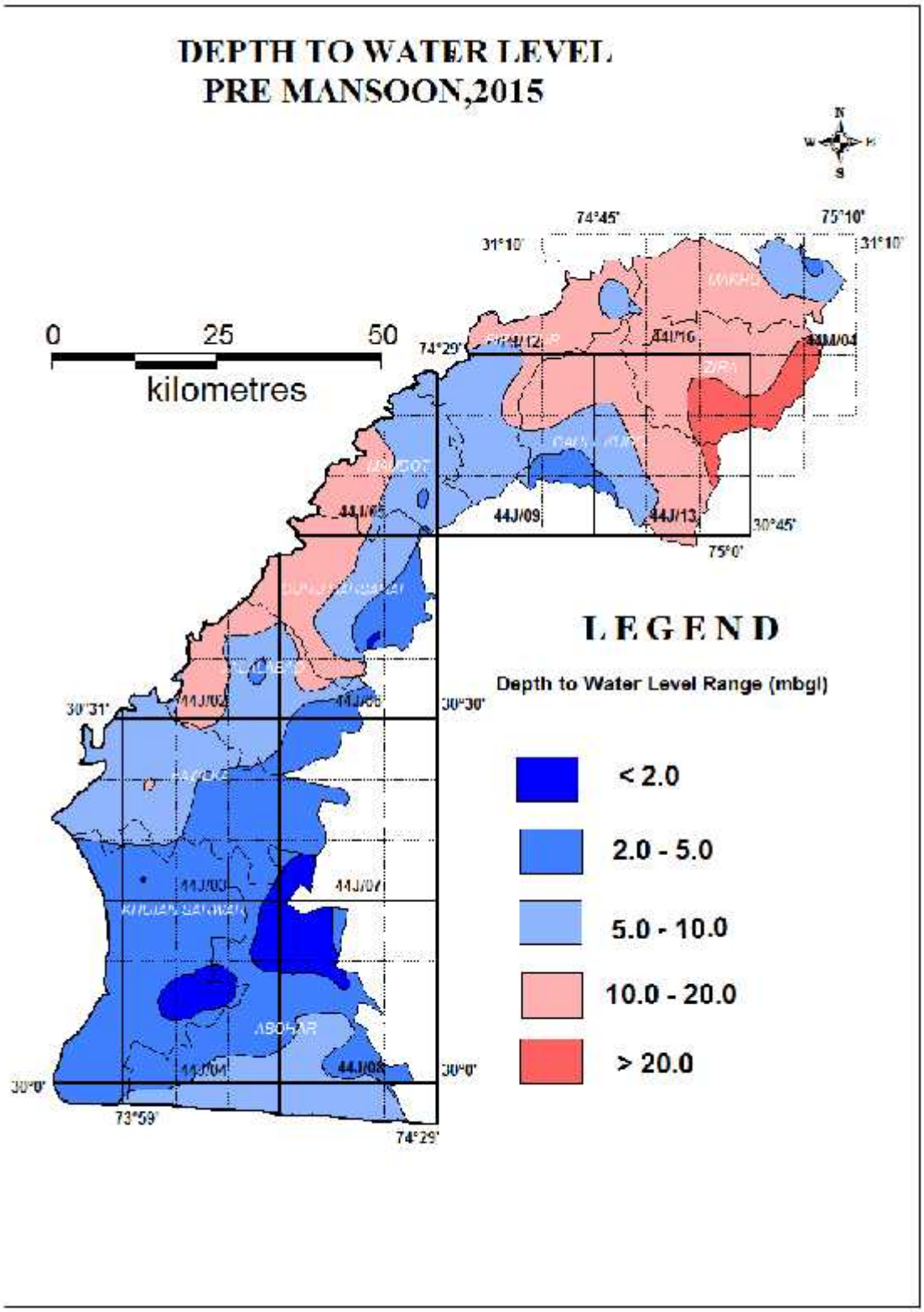
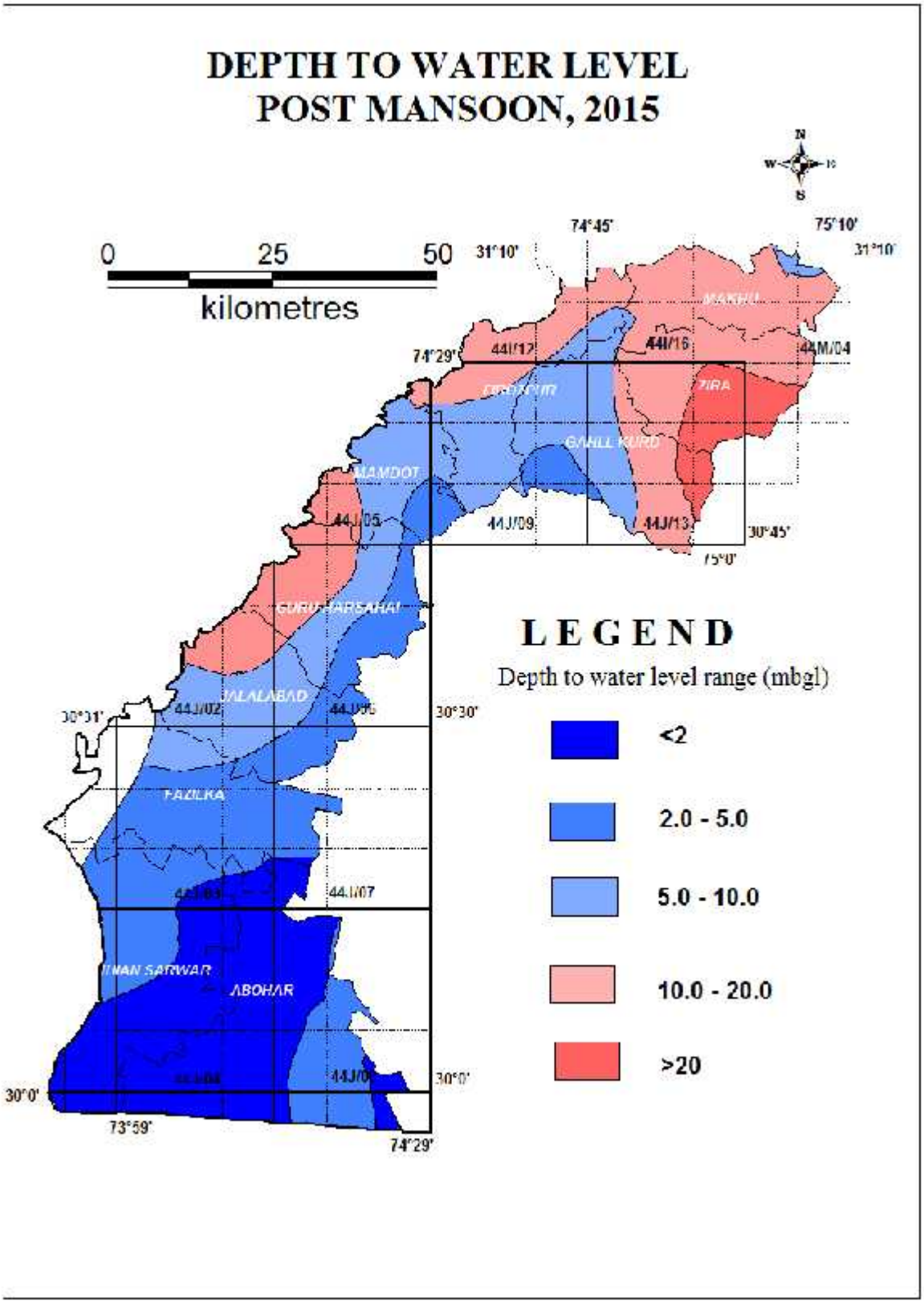


Fig.6: Depth to Post Monsoon Water level November, 2015



2.2 Hydro chemical Data:

Ground water quality of shallow aquifer is assessed based on the chemical data of the ground water observation monitored regularly by CGWB on annual basis (Annexure-I). In addition to that chemical quality of different aquifers has to be assessed during ground water exploration under NAQUIM.

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline, fresh to moderately saline. The electrical conductivity (EC) values are ranges from 393 to 8415 µS/cm at 25^{o}C. The ground water occurring in the southern and south-western parts comprising of Fazilka district is mostly saline and not suitable for drinking uses.

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline, fresh or moderately saline. The electrical conductivity (EC) values are more than 3000 µS/cm, at four locations i.e. Rattewala(sohangarh), Abohar, Danewali and Bannawala, where the EC value is 5790, 8415, 5604 and 5418 µS/cm at 25^{o}C respectively. Generally it is suitable for drinking purposes as chemical parameters are well within the permissible limits for safe drinking water set by Bureau of Indian standard (BIS) except for heavy metals at few places. These places are Malsian (Fe: 5 mg/l), Rattewala(sohangarh) (F: 1.74 mg/l), Abohar (F:1.75 mg/l), Danewali (F : 1.75 mg/l), Among anions, bicarbonate is the dominant anion and among cations, either sodium is the dominant cation (45%) or mixed cationic character prevails.

Analysing mechanism and equipments used for chemical analysis are given in the below table-1.

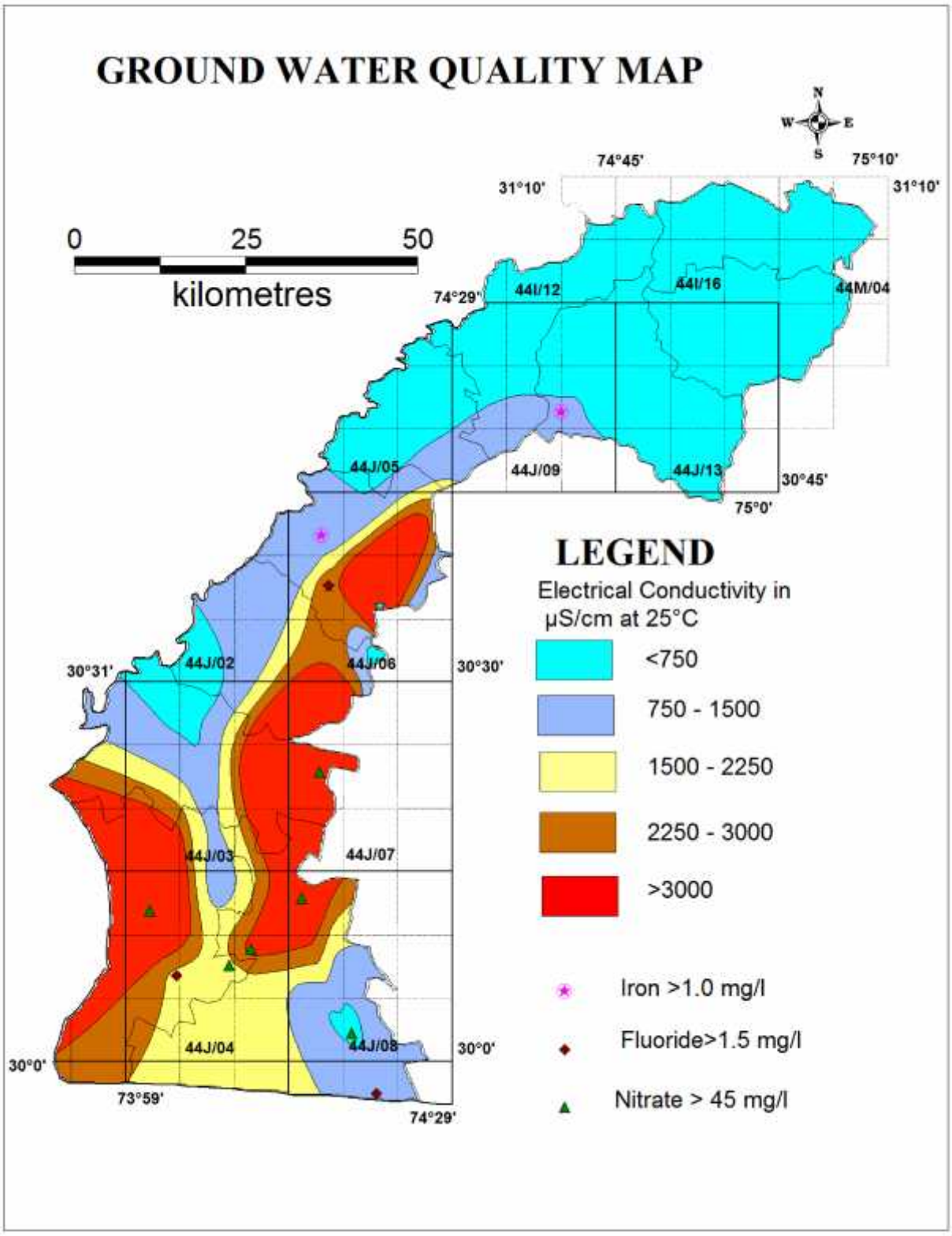
Table-1: Analytical methods and equipments used for chemical analysis.

S. No.	Parameters	Analytical Methods
A.	***Physico-chemical analysis***	
	pH	Electrometric method
	Conductivity (EC)	Electrical conductivity method
	Carbonate & bicarbonate (CO_3,HCO_3)	Titrimetric method
	Chloride (Cl)	Argenotometric method
	Sulphate (SO_4)	Nephloturbidity method
	Nitrate (NO_3)	Spectro-photometric method
	Fluoride (F)	Ion metric method
	Total hardness (T.H)	EDTA-Titri metric method
	Calcium (Ca)	EDTA-Titri metric method
	Magnesium (Mg)	By difference
	Sodium (Na)	Flame photometric method
	Potassium (K)	Flame photometric method
	Total Dissolved Solids (TDS)	Gravimetric
B.	***Trace elements/Heavy metals***	
	Copper (Cu) Cadmium (Cd)	Digestion followed by Atomic Absorption Spectrophotometer

	Chromium (Cr) Lead (Pb) Manganese (Mn) Nickel (Ni) Cyanide (Cn) Iron (Fe)	(AAS) Spectrophotometer method

Test Methods: (Basic Parameters)	
pH:	APHA 22nd Edition; 4500 H^+ B
EC:	APHA 22nd Edition; 2510 BB
Cl:	APHA 22nd Edition; 4500 Cl^- B
$NO_{3:}$	APHA 22nd Edition; 4500 NO_3^- B
F:	APHA 22nd Edition; 4500- F^- D
TH:	APHA 22nd Edition; 2340 C
Ca:	APHA 22nd Edition; 3500 Ca B
Mg:	APHA 22nd Edition; 3500 Mg^+ B

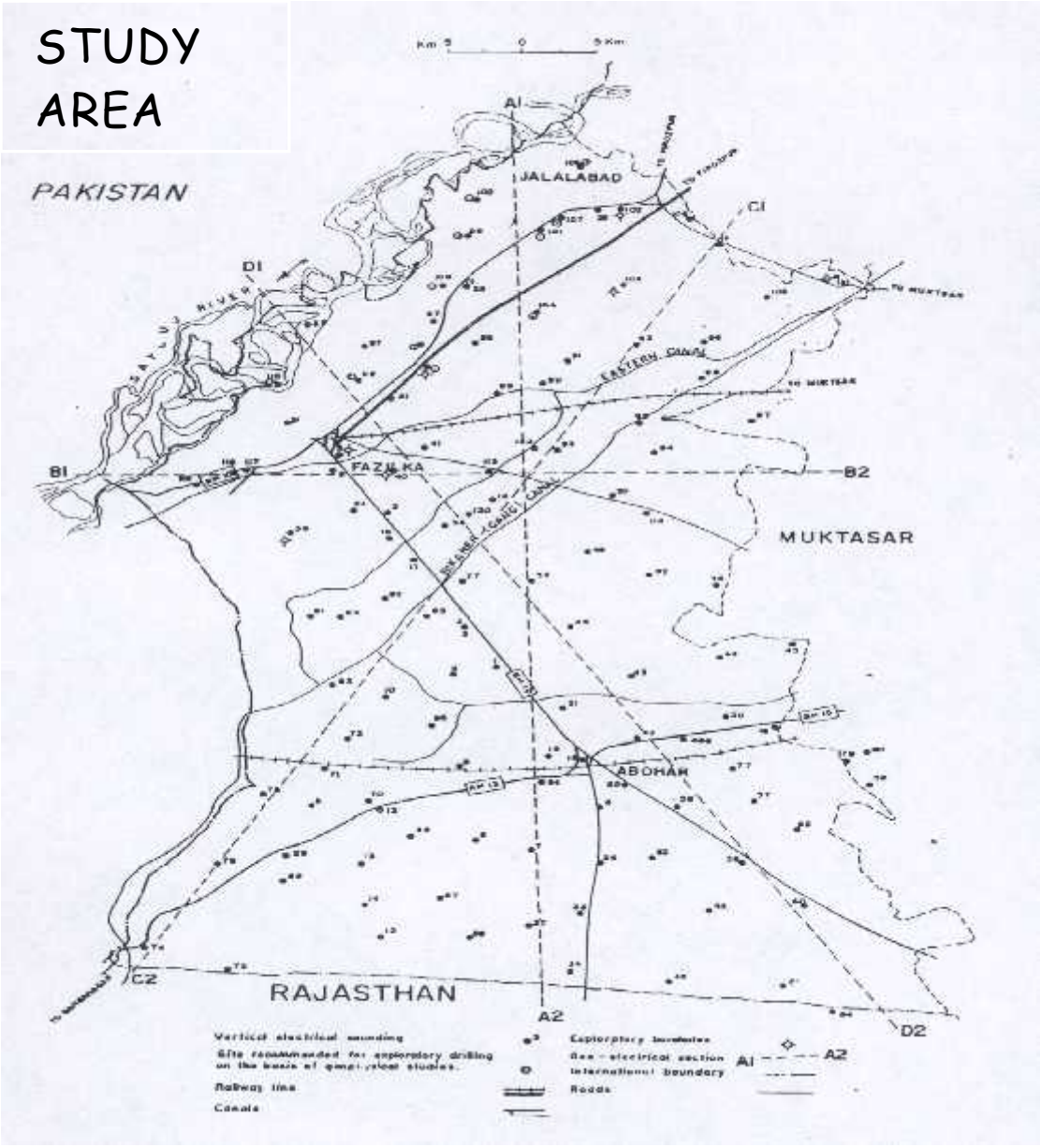
Fig.7: Groundwater Quality, 2015 Ferozpur and Fazilka District



2.3 Geophysical data:

Surface and Subsurface geophysical investigations have been carried out in alluvial tracts over parts of Study area(Ferozpur and Fazlika district). In Surface geophysical investigations, total 44 VES in an area of 1800 sq km were conducted with current electrical separation of 600 to 1000 m and locations of VES are shown in Fig.8. The aim of the survey was to delineate fresh water - saline water interface laterally as well as vertically.

Fig.8: VES Locations in Ferozpur and Fazlika District



Due to inland salinity problem the surface soil has become saline particularly in major parts of Abohar, Khuiyan Sarwar blocks and few parts of Fazilka blocks. The support study

through auger holes drilling at few places provides confirmatory evidence in respect of water logging and shallow ground water salinity. Under the present study the following criteria in respect of ground water quality has been considered being in line with the standards of BSI and present drinking/irrigation water scenario:

Electrical Conductivity (micro Siemens per cm)	**Quality of ground water**
Less than 2500	fresh
More than 2500	saline

The high value of EC of the order of 10,000 to 14,000 micro Siemens per cm was observed at shallow depth in Juradkhera (Abohar block) and Sabuwana (Fazilka block) in the western part of study area (near VES 38 and 39 respectively) showing high salinity of ground water.

Generally K & Q type multi-layered VES curves were recorded. Q type VES curves represent consecutive fall of resistivity and K type VES curves represent initial rise & consecutive fall of resistivity in the latter part of the curves (Plate-XIV).

FINDINGS

An effort has been made to assess the depth-wise potability of water in South-west Ferozpur district through the analysis of iso-resistivity maps at half current electrode separation. The qualitative analysis of apparent resistivity data provides the depth-wise potability of ground water in entire South-west Ferozpur district. The following table depicts the feature in South-west Ferozpur.

Depth wise interpretation of South-west Ferozpur based on VES

Depth	**Area bearing fresh water (EC<2500)**		**Area bearing saline water (EC>2500)**	
	%	**Sq.Km.**	**%**	**Sq.Km.**
within 10m	87	2153	13	317
within 20m	60	1480	40	990
within 30m	43	1070	57	1400
within 40m	36	886	64	1584
within 50m	25	620	75	1850
within 80m	19	477	81	1993
within 150m	12	305	88	2165
within 200m	8	185	92	2285
Within 250m	0	0	100	2470

More than 15 ohm m resistivity corresponds to the granular zones bearing fresh quality of ground water. This zone mainly consists of sand. Less than 15 ohm m resistivity corresponds to the geological formation consisting mainly of clay with sand and kankar bearing saline to brackish quality of ground water (EC above 2500 micro Siemens per cm). According to the present study, ground water is saline at all levels in 13% of the total area studied. 46 to 75% of the area bears saline to brackish quality of ground water at shallow depth within 50m. This area includes mainly the northern and north-western parts. Only 8 to 19% of the area is available with fresh water within 80 to 200 m depth. This area includes few locations mainly the northern parts. As an overall conclusion of the present study, it is evident that no fresh ground water occurs below 200m depth almost over the entire south-west Ferozpur District.

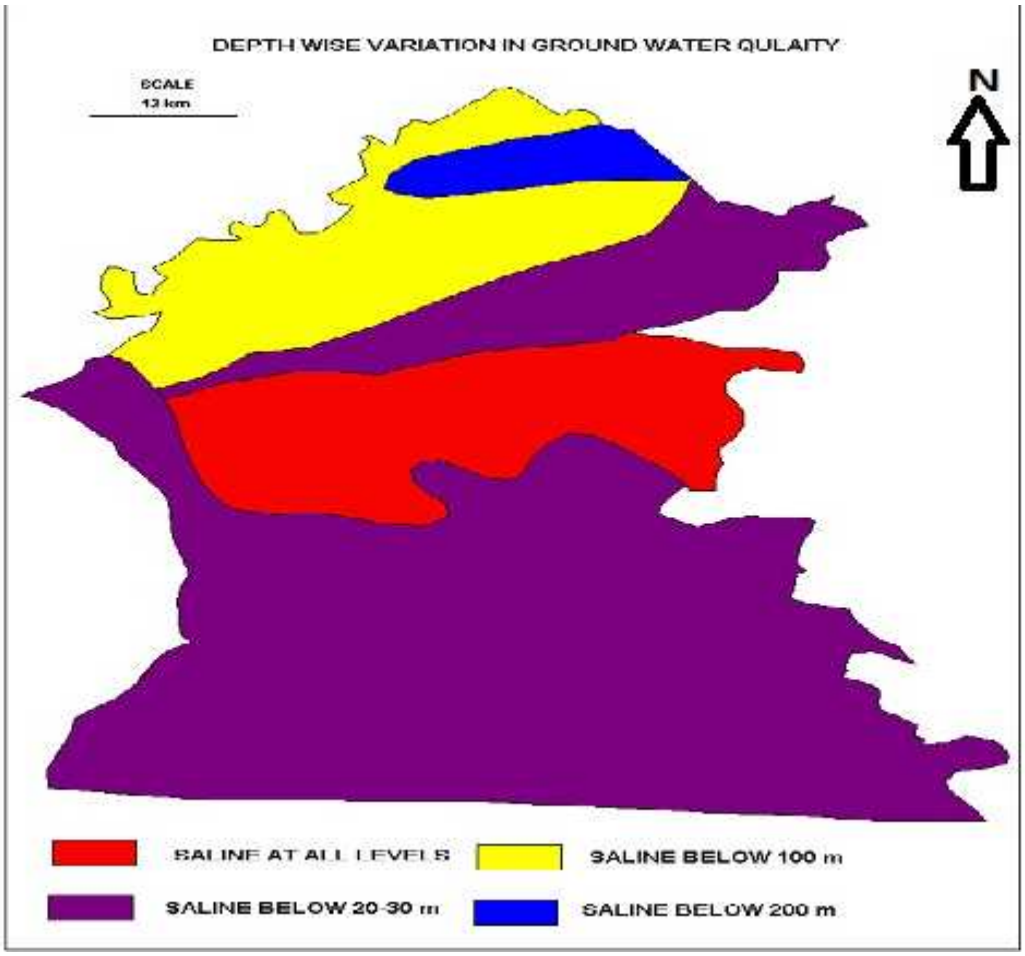
Areas where possibility of fresh water within 20 to 50 m depth is expected are Dangar-khera (VES 1), Dewan-khera (VES 30), Rajpura (VES34), Dodewala (VES33), Juradkhera (VES 38), Narainpur (VES 61), Bajidpur (VES 64), Rukanpura (VES 67) in the South, Hasta-kalan (VES 87), Nakerian (VES 95), Salem-shah (VES 31) and Chak-saidake (VES 111) in the North.

The present study and exploratory drilling conducted by CGWB has revealed that ground water quality slightly improves vertically in some of the area around north. Areas where possibility of fresh water in the depth range of 80 to 150m is expected, are Bahak-khas, Jhugge-gulabsinghde, Bhamba-wattu, Chak-Bandiwala, Gumaniwalam and Muazzam. Only at one place i.e. Mukundsinghwala (VES 72) in the extreme North, the quality of ground water improves in a deeper depth in the interval of 126 to 234 m where 108 m thick granular zone containing fresh water has been inferred. The ground water above and below this fresh water zone is saline. The EC value of ground water in a 135 m deep tube-well (tapping part of this aquifer) was 600 micro Siemens per cm showing fresh quality of water. The EC value of water in a 13m shallow hand-pump was 4000 micro Siemens per cm showing ground water salinity at shallow depth. The interpreted results of VES at this particular place indicate saline quality of ground water below 234m depth.

33% of the area below 10m depth is available with marginally saline ground water. The areas where marginally saline ground water has been inferred at shallow depth within 30 m are Nandgarh (VES59), Ramgarh (VES 75), Thandewala (VES 64), Harike-kalan (VES 79), Ganiana (VES 57), Dingana (VES 47), Aulakh (VES 50), Rathania (VES 1), Peori (VES 34), Lalbai (VES 26), Badal (VES 29), Fatuhiwala (VES 39), Domwali (VES 7), Birk-khera (VES 52), Qubrewala (VES 24), Killanwali (VES 42) and Shahkot (VES 59).

In order to prevent deterioration of ground water quality in areas affected with inland salinity, some preventive measures are to be taken, such as (i) installation of proper drainage system to stop accumulation of flood water and (ii) Proper management of water resources by the users especially the ground water and surface water.

On the basis of results of surface geophysical investigation and conclusions drawn, exploratory drilling down to 150m to 250m has been recommended in some locations of South-west Ferozpur district, Punjab namely Bahak Khas, Teh-quallander, Rana, Muazzam, Bhjanbawattu and Jhugge-gualabsinghde.



2.4 Exploratory drilling State - Data Availability:

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB, Punjab State Tubewell Corporation (PSTC) and private wells have been collected and those supported electrical logs have been validate for aquifer map preparation. The details are shown in Table-1.

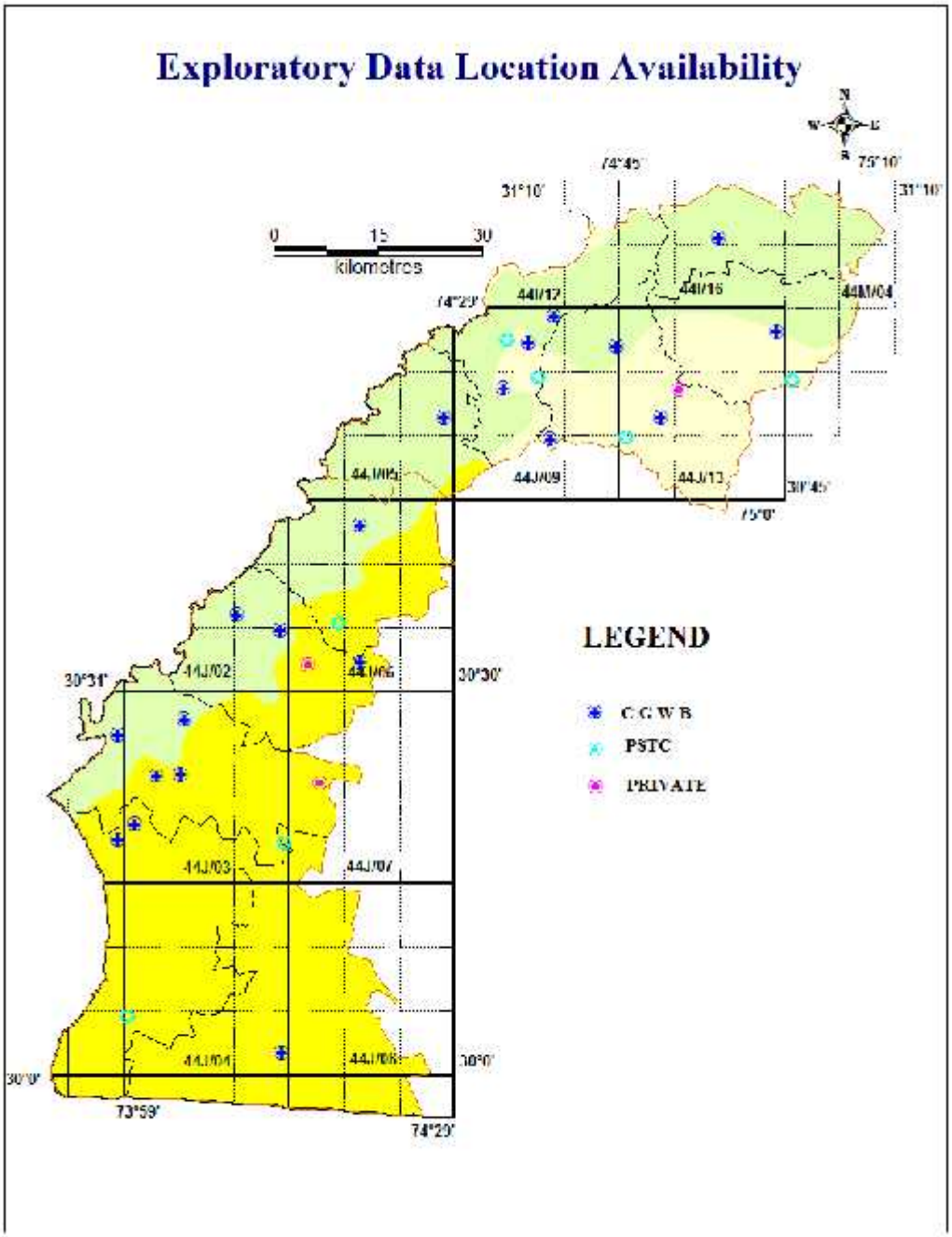
Table-2: Data Availability of Exploration Wells of Ferozpur and Fazilka district

Source of Data	No. Of tubewells as per Depth Range				Total Wells
	<100	100-200	200-300	>300	
PRIVATE	0	4	3	0	7
CGWB	0	0	4	16	20
PSTC	0	0	2	0	2
TOTAL	**0**	**4**	**9**	**16**	**29**

2.5 Spatial Data Distribution

The actual data of all the wells in the area are plotted on the map of 1:50000 scale with 5'X5'grid (9 x 9) km and is shown in Fig. 9. The exploration data shows that majority of tube wells falls in the Aquifer-I and the depth more than 300m. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation. The locations of availability of exploration data in grid wise distribution of respective blocks is shown Annexure-II.

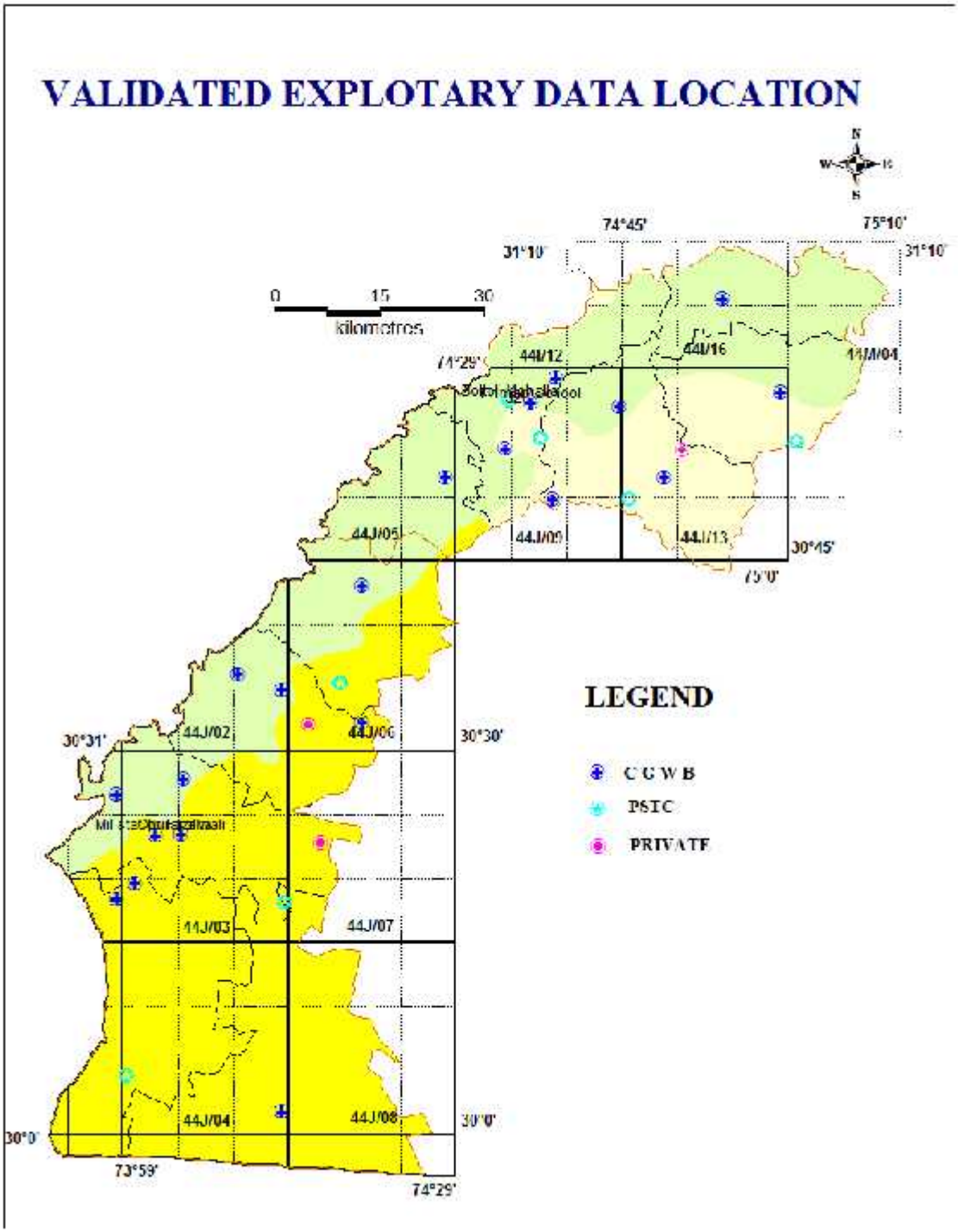
Fig.9: Locations of Exploration Data Availability



3.0 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.10.

Fig.10: Locations of Validated Exploration Data



The optimized wells of CGWB, Punjab State Tubewell Corporation (PSTC) now as Punjab Water Resources Development and Management (PWRDM), WRED (Water Resources and Environment Directorate), Water Supply and Sanitation (WSS) and private wells used to prepare the elevation or collar elevation map to identify the topographic variations on the ground surface so that it can give the synoptic picture of gradient variations in the water levels. The topographic elevation values have been plotted to prepare the elevation contour map and is in Fig.11. The locations of validated wells in quadrant and toposheet wise distributions in respective blocks are shown in Table-3.Three dimensional location of validated exploratory wells with litholog are given in Fig.12

Fig.11: Elevation contour map

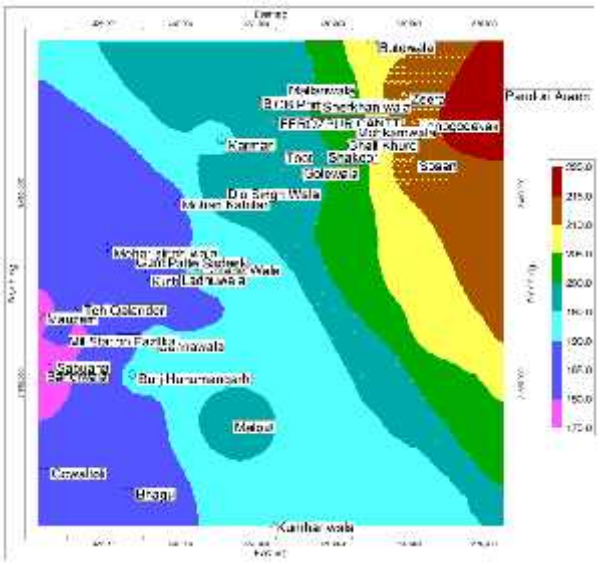


Fig.12: Three dimensional locations of validated exploratory wells with litholog

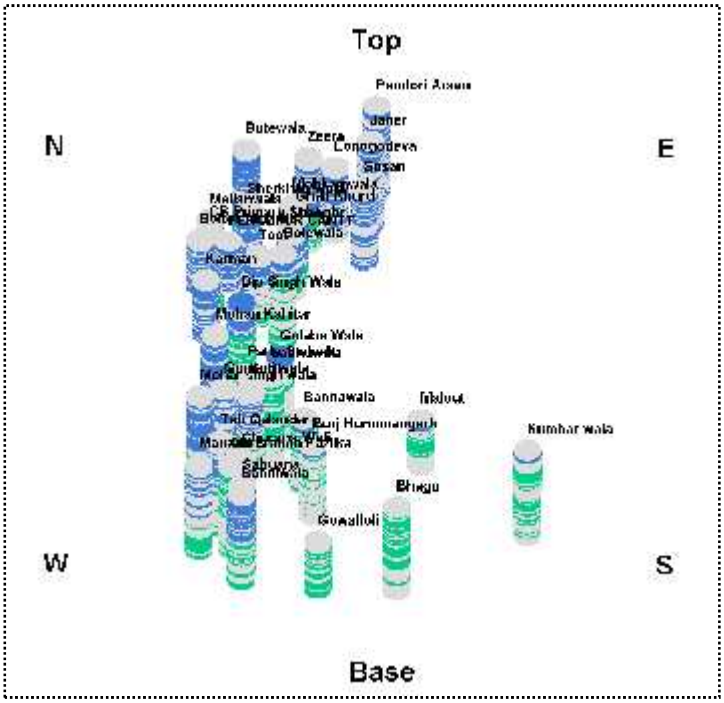


Table -3: Summary of optimized exploration wells

TOPOSHEET / QUADRANT	DEPTH RANGE (m)								ELEVATION (mamsl)	SOURCE OF DATA
	LOCATION	<100	LOCATION	100-200	LOCATION	200-300	LOCATION	>300		
3A 44J/ 04			Gowaltoli	167					180	Private
2A 44J/ 06					Patte Sadeek	225			185	Private
3C 44J/ 03					Burj Hunumangarh	247			192	CGWB
2A 44J/ 07					Bannawala	255			192	PSTC
3C 44J/ 04					Bhagu	292			186	CGWB
3C 44J/ 02							Gumani wala	300	184	CGWB
3B 44J/ 06							Ladhuwala	300	188	CGWB
							Mauzam	300	179	CGWB
2A 44J/ 03							Mil Station Fazilka	300	182	CGWB
1B 44J/ 06							Mohan Kahitar	300	189	CGWB
3A 44J/ 03							Sabuana	300	177	CGWB
1B 44J/ 03							Teh Qalander	300	181	CGWB
2B 44J/ 09			FEROZPUR CANTT	152					197	Private
1A 44J/ 09			Boltoli Mohalla	163					197	Private
1B2 44J/ 09			CB Primary School	163					202	Private
3A 44J/ 13					Shakoor	200			198	Private
2A 44J/ 13					Ghall Khurd	202.7			203	CGWB
3B 44J/ 09					Toot	217			196	CGWB
2A 44N/ 01					Lonogodeva	233			212	Private
3A 44J/ 06					Kutti	252			185	CGWB
							Bandiwala	300	178	CGWB
2B 44I/ 16							Butewala	300	207.46	CGWB
2B 44J/ 03							Churana Wali	300	178	CGWB

2C 44J/ 05							Karman	300	193	CGWB
1B1 44J/ 09							Mallanwala	300	196	CGWB
2C 44J/ 02							Mohar singh wala	300	184	CGWB
2B 44J/ 13							Mohkamwala	300	203	PSTC
1C 44J/ 09							Sherkhan wala	300	201	CGWB
1C 44J/ 13							Zeera	300	214	CGWB

3.1 Sub Surface Disposition

3.1.1 Previous Work:

The area represents almost flat alluvial plain with sand dunes with maximum height of 5.5 m above general land surface. The alluvial deposits under laying the district are parts of Sutlej and Ravi river deposits. Ground water at shallow depth occurs under unconfined to semi confined and confined conditions in deeper aquifers.

Exploratory drilling was conducted by CGWB at 20 locations in the district includes 05 exploratory wells and 2 PZ hole through in-house activities and 19 exploratory wells Data Collected from Private and PSTC, to delineate and determine the potential aquifer zones, evaluation of aquifer characteristics etc. The drilling has been done to a maximum depth of about 448 m (Mohar Singh wala) and revealed the presence of 4 to 11 prominent permeable granular zones. The granular zone consists of fine to medium sand.

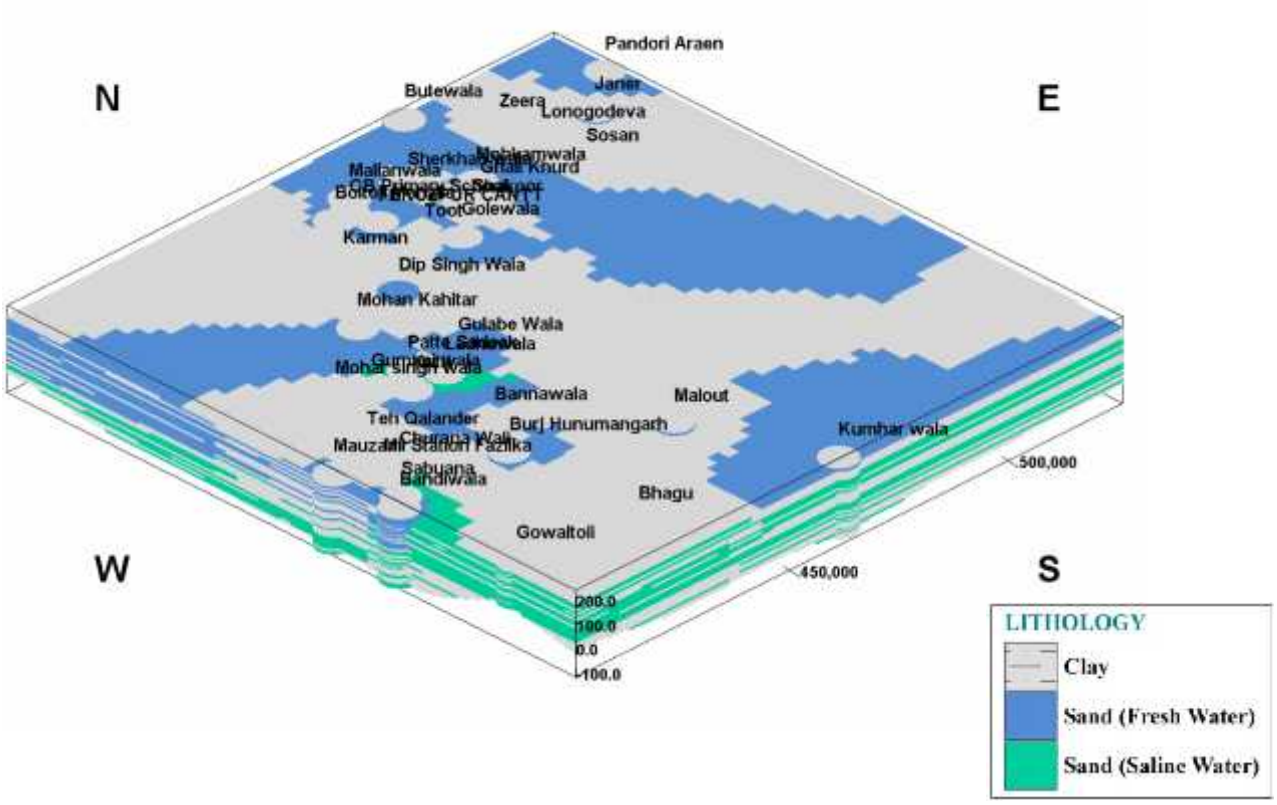
Further, the study of exploratory boreholes drilled in the district revealed the presence of multiple aquifer groups up to the maximum drilled depth of 448 m. The first aquifer group forms the very shallow water table aquifer occurs down to 23.5 m bgl and below that clay layer starts getting thickened about 8-10m separating Aquifer IB to depth of 165m bgl. The second and third aquifer behaves as semi-confined to confined and consisting of thin sand layers alternating with thicker clay layers. Overall flow of ground water is towards south-west direction.

3.1.2 Present NAQUIM Study:

To understand the sub surface disposition in the district, 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, PSTC and Private Agencies are plotted using the RockWorks15 software and a 3D lithological model has been prepared and is shown in Fig.13. The 2D lithology sections and 3D lithological fence diagram and has been prepared using lithology model and are shown in Fig.14a, b, c & 15 respectively. The aquifers are composed of fine to medium sand with clay intercalations. The granular zones are extensive. The aquifer occurring below 195 depth is composed of very fine to medium sand with silt.

Based on geophysical borehole logging and use of resistivity profiling followed by the depth soundings at few selected places, fresh-saline water zones are demarcated. This analysis is extremely important for the present study and will be referred from time to time as it is obviously the higher resistivity beds represents freshwater zone in contrast in low resistive beds indicating saline groundwater zone.

Fig.13: 3-Dimension Lithological Model



The major aquifer system of the study area is Quaternary alluvial deposits having Older, Younger and Aeolian alluvium which mainly comprises of sand, silt and clay. The top surface layer and soil is mainly silty clay. The lithology along SW-NE direction shows the variation in lithology thickness i.e. thin clay layers inter bedded with sand except at location Janer and Pandori Arean where thick clay layers were identified at depths 105mbgl. There is inter-layering of sand and clay with thick clay at Golewala towards Northeastern side at a depth below 100m to 175m bgl.

Fig.14a: 2-Dimension Lithological Section along SW-NE

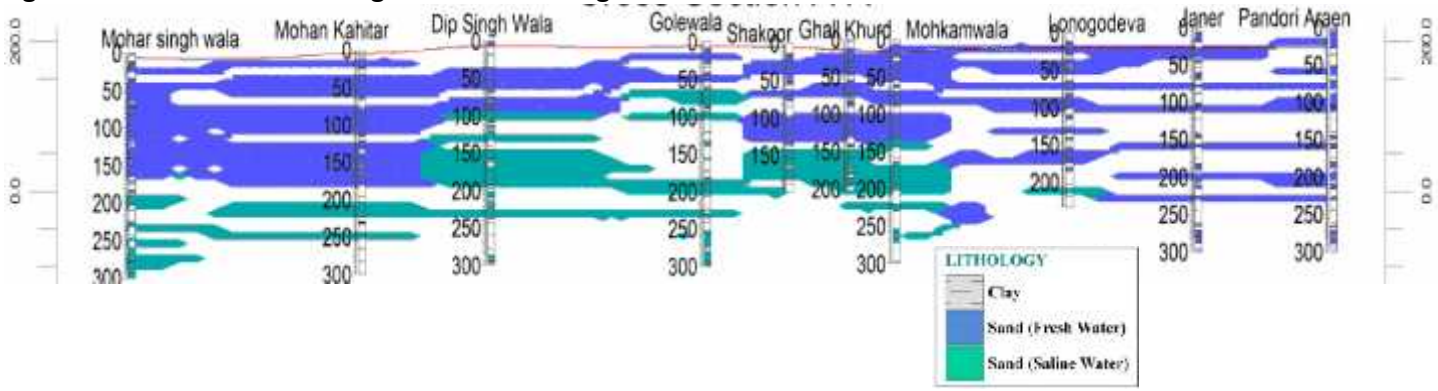


Fig.14b: 2-Dimension Lithological Section along S - N

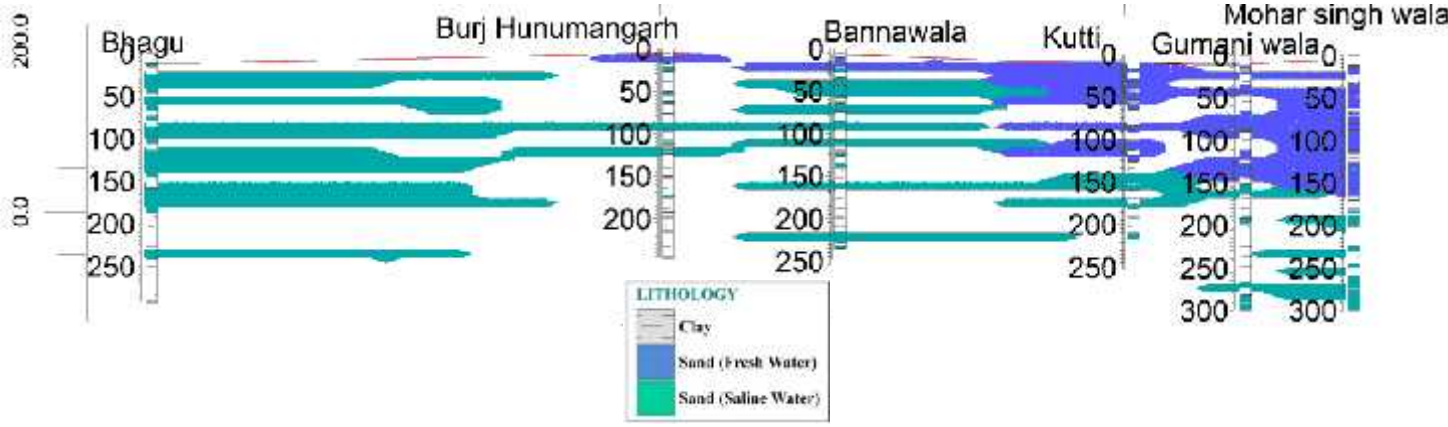
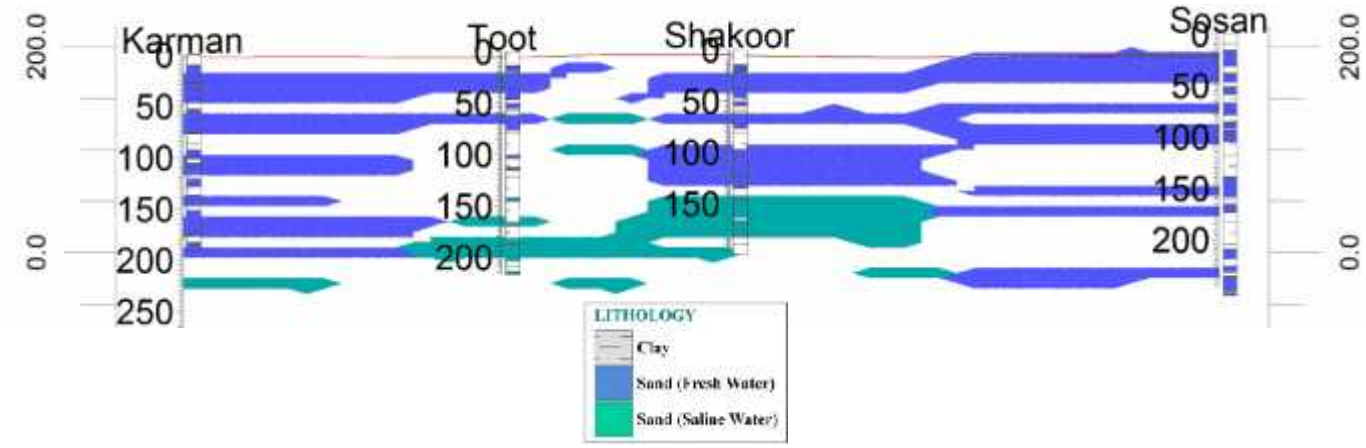


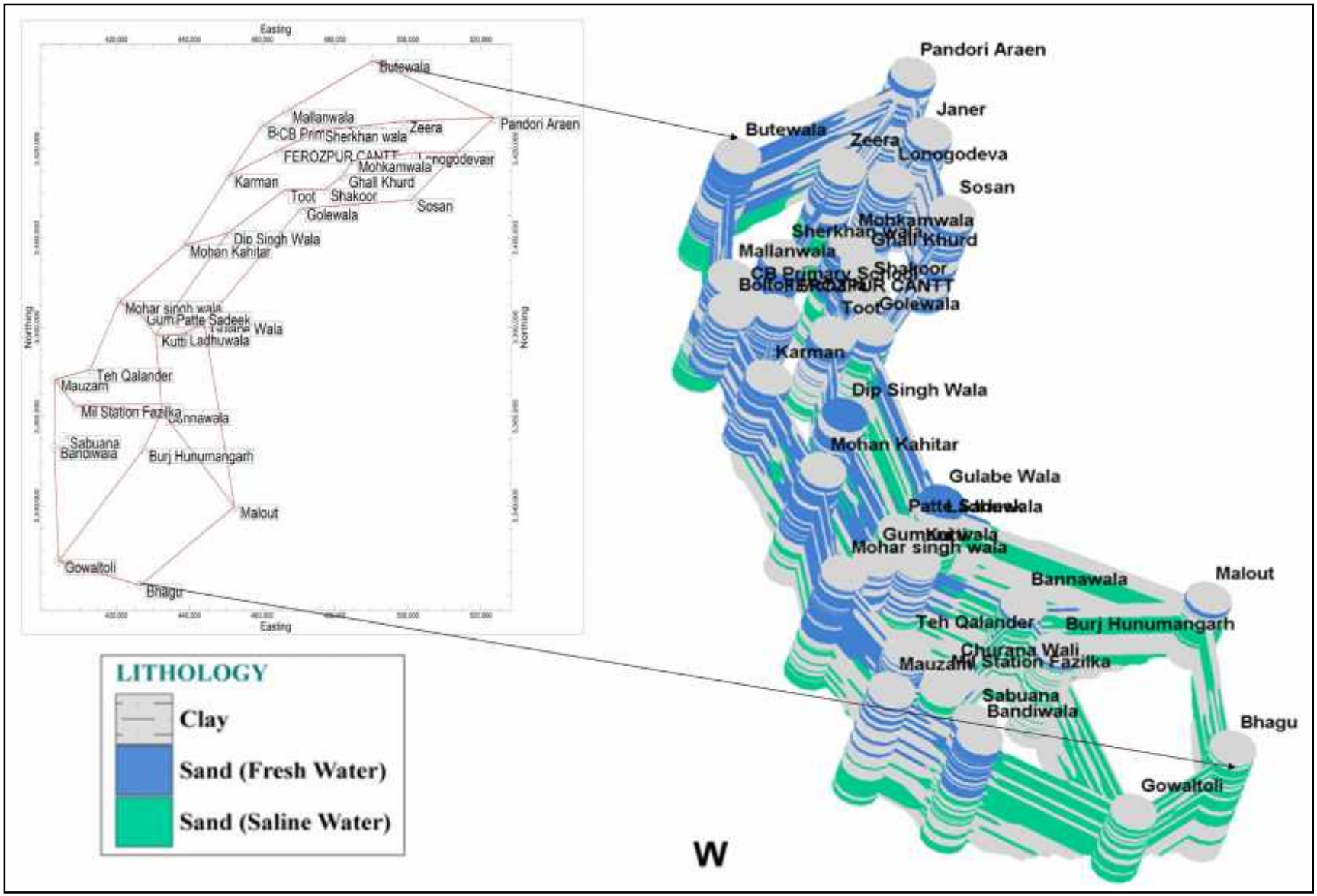
Fig.14c: 2-Dimension Lithological Section along W-E



The geological section along S-N direction shows the variation in lithology thickness i.e. thin clay layers inter bedded with sand except at location Burj hanumangarh where thick clay layers were identified at depths 103mbgl. The southern side is having saline water granular zones and northern side having fresh granular zones. The fresh saline interface is clearly depict in this section. There is inter-layering of sand and clay with thick clay at Bannawala and Bhagu towards Southern side at a depth below 150m and 175m bgl.

The geological section along W-E direction shows the variation in lithology thickness i.e. thin clay layers inter bedded with thick sand except at location Toot where thick clay layers were identified at depths 52 mbgl. This section has fresh granular zones up to depth of 200m except Toot and Shakoor where saline granular zones are observed at depth of 150m bgl. The 3D lithological fence will represent the much more clear representation of sub-surface lithology in space.

Fig.15: 3-Dimension Lithological Fence



3.2 Aquifer Geometry:

The aquifer group embodies a number of granular layers alternating with thick or thin clay lenses. A few clay layers intervening these aquifer groups pinch out against the sand zones at a few places. The marker horizons are traced all over the area by connecting their tops and bottoms. Sandy clay layer occurs at the surface covering the unconfined aquifer which is in turn underlain by prominent clay zone. It is composed of mainly of medium sand with thin beds of fine sand.

Aquifer IA (Very Shallow Aquifer) extends maximum upto 103 m of depth and below that clay layer starts getting thickened about 10-12m separating Aquifer IB to a maximum depth of 176 m. Multi aquifers are exists and separated by highly thick clay zones of 25 to 40 m thickness upto 300m depth (Table-4). Based on the same criteria, to know the broad picture of the aquifer disposition, inter-relationship of granular zones, nature, geometry and extension of aquifers in the Ferozpur and Fazlika district, the aquifer grouping (Annexure-IV)has been done using the sub-surface lithology and a three-dimensional aquifer model has been prepared shown in Fig.16 and aquifer disposition 3D fence diagram was also prepared using the aquifer model and is shown in Fig.17. It is very difficult to differentiate the aquifer groups after Aquifers-(IA &IB), so the whole lithology is considered to be a single aquifer group system. The first aquifer is water table aquifer and extends all over the area. The aquifer is mainly composed of fine to coarse grained sand.

Table-4: Aquifer Grouping in Ferozpur and Fazlika District

Aquifer Group	Range		Thickness	
	From	To	Min	Max
Aquifer IA	4	103	14	101
Aquifer IB	83	176	9	84
Multiple Aquifers	84	300	36	177

Fig.16: 3D Aquifer disposition Model

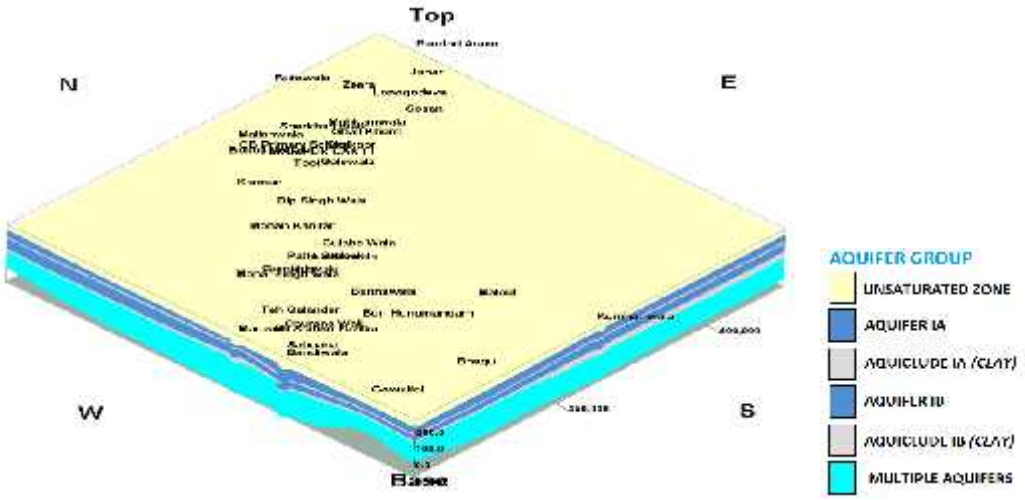
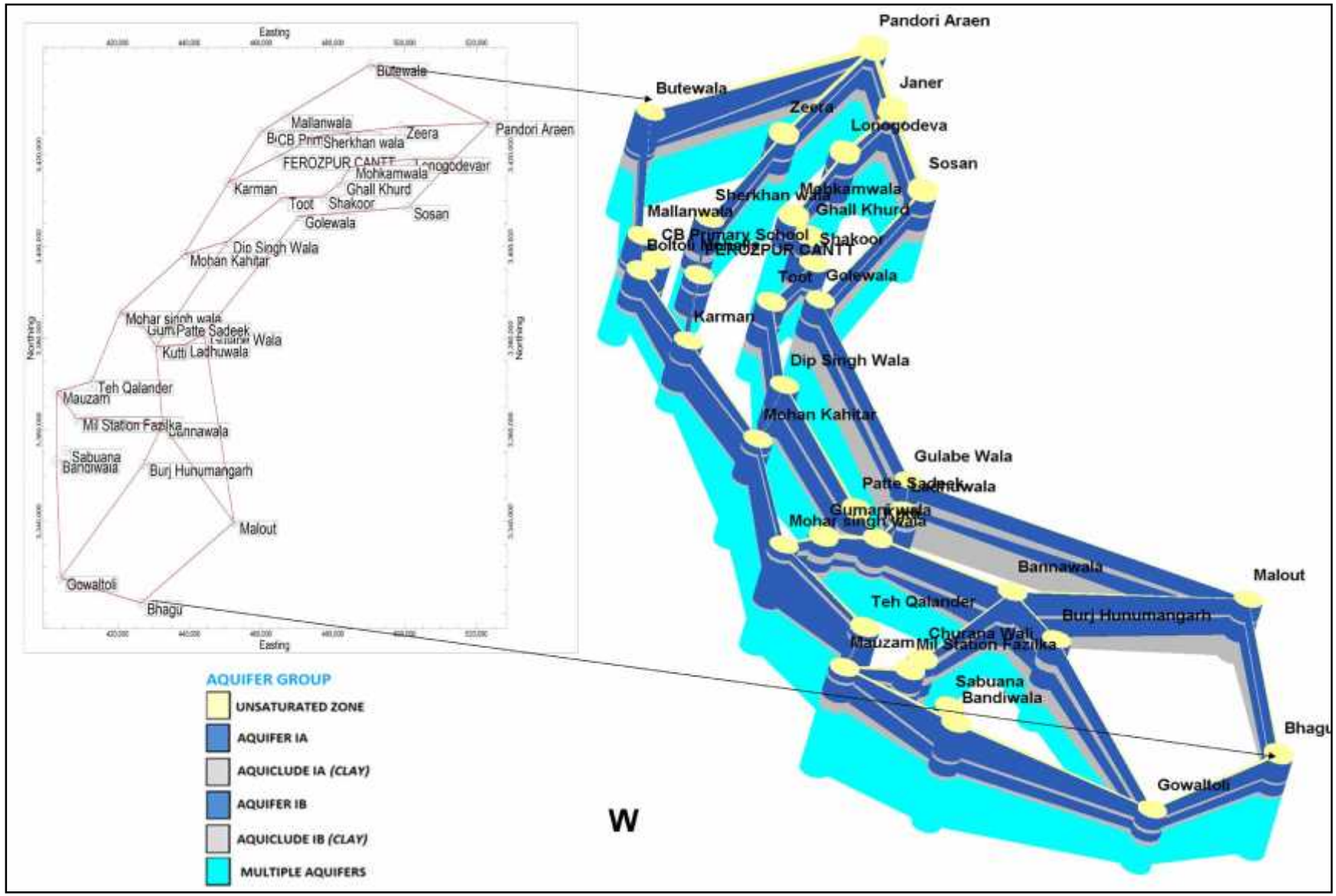


Fig.17: 3D Aquifer Disposition



4.0 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 aquifers present upto 300m depth. The assessment of dynamic ground water Resources of the study area have been carried out jointly by CGWB and Water Resources and Environment Directorate (WRED), Department of Irrigation, Punjab on the basis of Ground Water Estimation Committee (1997) methodology.

The occurrence of potential aquifers (productive granular zones) upto 300 m depth has been demarcated on basis of aquifer wise subsurface mapping. The total saturated thickness of granular zones was derived from the exploratory borehole data of a particular block. The granular zones occurring below the zone of water level fluctuation up to the first confining layer has been considered as static unconfined zone. The specific yield value for the unconfined aquifer has been taken as 60% of 0.12 which comes as 0.072 whereas for the confined aquifer, the storativity value has been considered. Since the specific yield is likely to reduce with increase in depth due to compaction of overlying sediments.

Hence, the major data elements considered in this estimation are thickness of granular zones, specific yield/storativity, and area of both fresh water and saline/brackish water. It has been observed that in some of the blocks sufficient data on probable occurrence of granular zones was not available. In those cases, the existing exploratory data of adjoining block/district has been either extrapolated or interpolated to derive such parameters required for estimation. This assessment of total groundwater resources has been computed based on the available data with CGWB & WRED, Department of Irrigation, and Punjab.

4.1 Groundwater Resources up to depth of 300m

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 available recharge, thus all the blocks have been categorized as over exploited. Stage of ground water development in the Ferozpur & Fazilka districts has been assessed to be 144% and 95 %. The details are explained in below Table-5 & 6.

Table 5: Ferozpur District 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*
FEROZPUR	26742	31775	704	32479	987	-6021	121	Over Exploited
GHALL KHURD	28126	50348	308	50656	416	-22639	180	Over Exploited

MAKHU	14699	21345	124	21469	174	-6820	146	Over Exploited
GURU HAR SAHAI	26711	25136	222	25358	304	1271	95	SAFE
MAMDOT	24938	30863	186	31049	174	-6099	125	Over Exploited
ZIRA	16284	36925	391	37316	533	-21174	229	Over Exploited
TOTAL	**137499**	**196392**	**1935**	**198327**	**2588**	**-61481**	**144**	**Over Exploited**

Table 6: Fazilka District 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*
ABOHAR	29733	9861	954	10815	1331	18541	36	SAFE
FAZILKA	26747	37859	819	38677	1116	-12227	145	OVER-EXPLOITED
JALALABAD	22032	30403	690	31093	955	-9326	141	OVER-EXPLOITED
KHUYIAN SARWAR	14811	7597	344	7941	479	6735	54	SAFE
TOTAL	**93323**	**85719**	**2807**	**88526**	**3882**	**3722**	**95**	SAFE

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 and in-storage unconfined. In case of alluvial area, the in-storage resources of unconfined aquifer have been computed based on specific yield of the aquifer as detailed below.

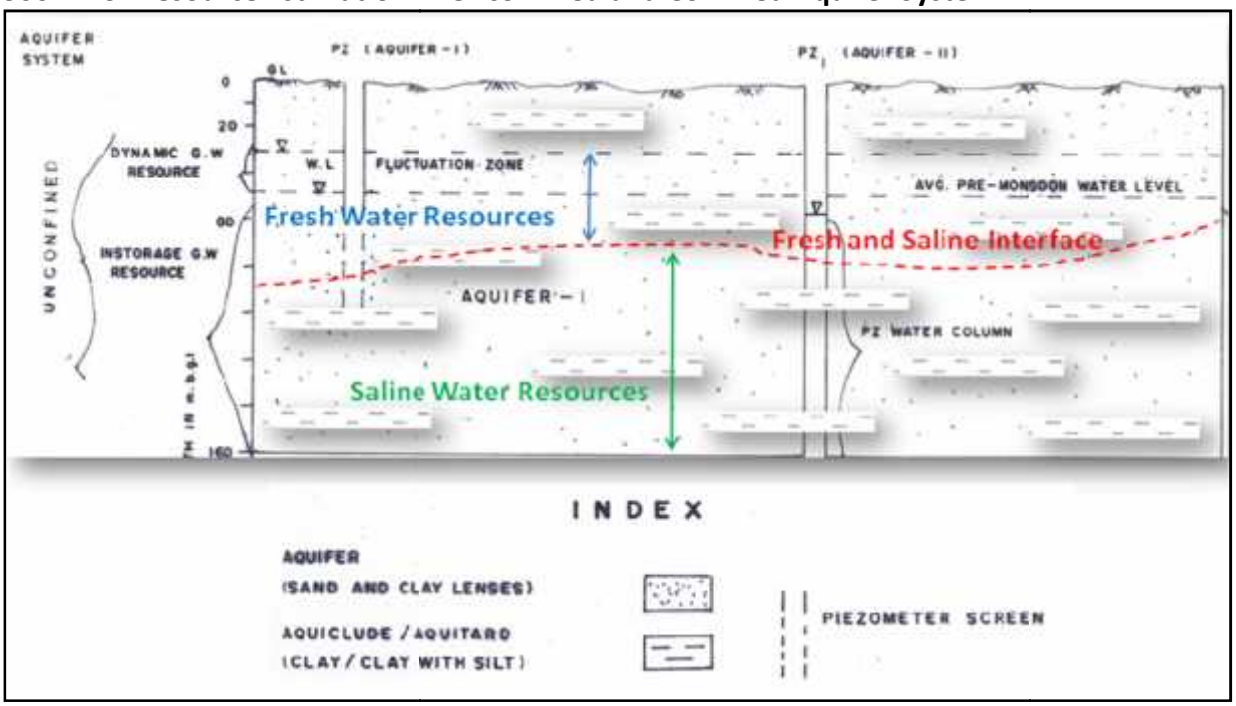
In-storage Ground Water resources (Unconfined Aquifer)	=	Thickness of the aquifer (granular/productive zone) below the zone of water level fluctuation down to the bottom layer of unconfined aquifer	x	Sp. Yield of the aquifer	x	Areal extent of the aquifer

The dynamic and in-storage ground water resources estimations have been calculated for single aquifer group upto 300m of each block of Ferozpur and Fazilka districts. In-storage

ground water resources are estimated for fresh water and saline water resources based on the geophysical interpretations of depth of fresh and saline water interface for each block wise. The fresh and saline calculations are made based on the assumptions on aquifer is considered as unconfined aquifer so that the specific yield concept is used for resources estimations (Fig.18). The detailed resources estimations are calculated in detailed table for fresh and saline water resources in the below tables-7, 8, 9, 10, 11 &12.

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

Fig.18: 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 lenses are more dominant in the aquifer and sometimes huge thickness of clay deposits are also observed in the litholog)

Table-7. Block Wise In-Storage Ground Water Resources of Fresh Water Aquifers Upto Average Depth of Ferozpur District

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT FEROZPUR, PUNJAB STATE (2013)												
Type of Ground Water Assessment Unit (Block): FEROZPUR Blocks												
Sr. No.	**Name of Assessment Unit**	**Type of rock formation**	**Areal extent (ha)**		**Average Pre-monsoon Water Level (m bgl)**	**Depth to bottom of Aquifer based on Geophysical Interface & Bore logging (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 Fresh Water Zones (m)**	**Thickness of the unsaturated granular Zones up to Pre-monsoon WL (m)**	**Thickness of the saturated granular Zones up to the depth of Fresh water aquifer below (m) (11-12)**	**Average Specific Yield**	**In-Storage Ground Water Resources up to the depth of Fresh Water Aquifer (ham) 5*13*14**
			Total Geographical Area	Assessment Area Fresh Water								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Ferozpur	Alluvium	46950	46950	6.7	174	167.3	71	3	68	0.072	229867
2	Ghal Khurd	Alluvium	53210	53210	9.68	140	130.32	96	7	89	0.072	340970
3	Makhu	Alluvium	28860	28860	1.75	225	223.25	146	1	145	0.072	301298
4	Mamdot	Alluvium	37580	37580	3.11	190	186.89	134	1	133	0.072	359866
5	Zira	Alluvium	38340	38340	19.3	208	188.7	105	8	97	0.072	267767
Dist. Total(ham)			**204940**	**204940**								**1499768**
Dist. Total(MCM)												**14998**

Table-8. Block Wise In-Storage Ground Water Resources of Saline Aquifers Upto 300 m Depth of Ferozpur District

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT FEROZPUR, PUNJAB STATE (2013)										
Type of Ground Water Assessment Unit (Block): Ferozpur Blocks										
Sr. No.	**Name of Assessment Unit**	**Type of rock formation**	**Areal extent (ha)**		**Depth to bottom of Aquifer based on Geophysical Interface & Borelogging (m bgl)**	**Depth to bottom of Saline Water Aquifer based on Geophysical Interface & Borelogging (m bgl)**	**Total thickness of the Saline Water up to the max depth (m)**	**Total thickness of the Granular Zones up to the depth ofSaline Water Zones (m)**	**Average Specific Yield**	**In-Storage Ground Water Resources up to the depth of Saline Water Aquifer (ham) 5*13*14**
			Total Geographical Area	Assessment Area Saline Water						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Ferozpur	Alluvium	46950	46950	174	300	126	68.7	0.072	232233
2	Ghal Khurd	Alluvium	53210	53210	140	250	110	64	0.072	245192
3	Makhu	Alluvium	28860	28860	225	300	75	55	0.072	114286
4	Mamdot	Alluvium	37580	37580	190	0	0	0	0.072	0
5	Zira	Alluvium	38340	38340	208	300	92	71	0.072	195994
Dist. Total(ham)			204940	204940						**787705**
Dist. Total(MCM)										**7877**

Table-9. Block Wise Total Availability of Fresh and Saline Groundwater Resources upto 300 m Depth and Volume of unsaturated granular zone in the Ferozpur District

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN FEROZPUR DISTRICT								
Sl.No	**BLOCK**	*Volume of Unsaturated Zone (HAM)*	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources UPTO FRESHWATER*	**Groundwater Resources upto FRESH WATER [(3)+(4)] (HAM)**	**Total Saline Groundwater Resources upto (HAM)**	**Total Availabilty of Fresh Groundwater Resources [(5)+(6)+(7)]**	
							ham	**mcm**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	Ferozpur	1690	26742	*229867*	*256609*	*232233*	*488842*	*4888*
2	Ghal Khurd	4470	28126	*340970*	*369095*	*245192*	*614287*	*6143*
3	Makhu	346	14699	*301298*	*315997*	*114286*	*430283*	*4303*
4	Mamdot	451	24938	*359866*	*384804*	*0*	*384804*	*3848*
5	Zira	3681	16284	*267767*	*284051*	*195994*	*480045*	*4800*
Dist.Total (ham)		**10638**	**110788**	**1499768**	**1610556**	**787705**	**2398261**	**23983**
Dist.Total (mcm)		**106**	**1108**	**14998**	**16106**	**7877**		

ham : hectare metre
mcm: million cubic metre

Table-10. Block Wise In-Storage Ground Water Resources of Fresh Water Aquifers Upto Average Depth of Fazilka District

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT FAZILIKA, PUNJAB STATE (2013)												
Type of Ground Water Assessment Unit (Block): FAZILIKA Blocks												
Sr. No.	**Name of Assessment Unit**	**Type of rock formation**	**Areal extent (ha)**		**Average Pre-monsoon Water Level (m bgl)**	**Depth to bottom of Aquifer based on Geophysical Interface & Borelogging (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 Fresh Water Zones (m)**	**Thickness of the unsaturated granular Zones up to Pre-monsoon WL (m)**	**Thickness of the saturated granular Zones up to the depth of Fresh water aquifer below (m) (11-12)**	**Average Specific Yield**	**In-Storage Ground Water Resources up to the depth of Fresh Water Aquifer (ham) 5*13*14**
			Total Geographical Area	**Assessment Area Fresh Water**								
1	**2**	**3**	**4**	**5**	**8**	**9**	**6**	**7**	**8**	**9**	**10**	**11**
	FAZILIKA											
1	Abohar	Alluvium	67290	57090	8.65	18	9.35	9	3	6	0.072	24663
2	Fazilka	Alluvium	85920	80720	11.45	117	105.55	54	7	47	0.072	273156
3	Guru Har Sahai	Alluvium	49060	23460	9.75	204	194.25	118	2	116	0.072	195938
4	Jalalabad	Alluvium	52440	47440	11.2	163	151.8	75	8	67	0.072	228851
5	Khuyan Sarovar	Alluvium	84540	67240	9.56	155	145.44	99	6	93	0.072	450239
Dist. Total(ham)			**339250**	**275950**								**1172847**
Dist. Total(MCM)												**11728**

Table-11. Block Wise In-Storage Ground Water Resources of Saline Aquifers Upto 300 m Depth of Fazilka District

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF DISTRICT FAZILKA, PUNJAB STATE (2013)										
Type of Ground Water Assessment Unit (Block): FAZILKA BLOCKS										
Sr. No.	**Name of Assessment Unit**	**Type of rock formation**	**Areal extent (ha)**		**Depth to bottom of Fresh Water Aquifer based on Geophysical Interface & Boreloggi ng (m bgl)**	**Depth to bottom of Saline Water Aquifer based on Geophysical Interface & Boreloggin g (m bgl)**	**Total thickness of the Saline Water up to the max depth (m)**	**Total thickness of the Granular Zones up to the depth ofSaline Water Zones (m)**	**Average Specific Yield**	**In-Storage Ground Water Resources up to the depth of Saline Water Aquifer (ham) 5*13*14**
			Total Geographical Area	**Assessment Area Saline Water**						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	Fazilka									
1	Abohar	Alluvium	67290	10200	18	300	282	135	0.072	99144
2	Fazilka	Alluvium	85920	5200	117	250	133	57	0.072	21341
3	Guru Har Sahai	Alluvium	49060	25600	204	275	71	39	0.072	71885
4	Jalalabad	Alluvium	52440	5000	163	250	87	47	0.072	16920
5	Khuyan Sarovar	Alluvium	84540	17300	155	300	145	73	0.072	90929
Dist. Total(ham)			**339250**	**63300**						**300218**
Dist. Total(MCM)										**3002**

Table-12. Block Wise Total Availability of Fresh and Saline Groundwater Resources upto 300 m Depth and Volume of unsaturated granular zone in the Fazilka District

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN FAZILKA DISTRICT								
Sl.No	**BLOCK**	*Volume of Unsaturated Zone up to Pre-monsoon WL (ham) 5*7*8*	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources UPTO FRESHWATER*	**Groundwater Resources upto FRESH WATER [(3)+(4)] (HAM)**	*Total Saline Groundwater Resources[(3)+(4)] (HAM)*	**Total Availabilty Groundwater Resources**	
							ham	**mcm**
1	*2*	**3**	*4*	*5*	*6*	*7*	*8*	*9*
1	Abohar	24224	29733	24663	54395	99144	*153539*	*1535*
2	Fazilka	72173	26747	273156	299904	21341	*321245*	*3212*
3	Guru Har Sahai	11774	26711	195938	222649	71885	*294534*	*2945*
4	Jalalabad	50342	22032	228851	250883	16920	*267803*	*2678*
5	Khuyan Sarovar	60869	14811	450239	465050	90929	*555979*	*5560*
Dist.Total (ham)		**219383**	**120035**	**1172847**	**1292881**	**300218**	*1593100*	**15931**
Dist.Total (mcm)		**2194**	**1200**	**11728**	**12929**	**3002**		

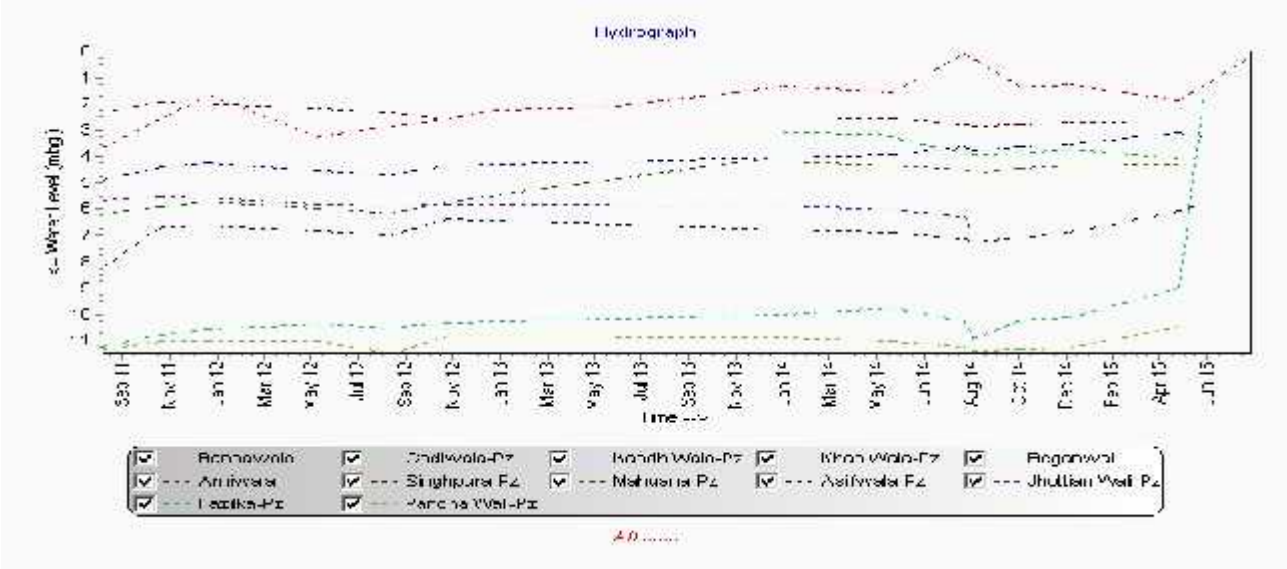
ham : hectare metre
mcm: million cubic metre

5.0 GROUND WATER RELATED ISSUES

5.1 Ground Water Depletion

Ferozpur and Fazilka district is famous for its paddy and non paddy cultivation. The quality of ground water in the district is potable for both the irrigation and drinking purposes therefore, the 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 in all blocks of Ferozpur and All Blocks of Fazlika District saline and shallow so that there water is less using in irrigation and drinking purpose district as the recharge of the groundwater through rainfall and other sources are less than the overall extraction. The hydrographs also shows the declining water level trend over the years in the district (Fig.19) 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 done in these areas to overcome the depletion. Other than the groundwater depletion, quality and rising water table are the other major issues.

Fig.19: Long term ground water table variation



5.2 Rising Water table

In western parts of the district the water table is rising due to limited/non-extraction of ground water because of its brackish / saline quality and more availability of canal water for domestic and irrigation purposes. The fresh water thickness in this area is less. These areas are likely to get water logged in near future. There is an urgent need to arrest the rising water trend in western part of the district and implement anti-water logging schemes.

5.3 Ground Water Quality

The ground water of the study area is alkaline in nature. Ground water in the area is fresh to marginally saline. Ground water with iron concentration above permissible limit 1.5 mg/l is found mainly in Malsian (5 mg/l) fluoride concentration above permissible limit 1.5 mg/l is found Rattewala(sohangarh) (1.74 mg/l), Abohar (1.75 mg/l), Danewali (1.75 mg/l). The

electrical conductivity (EC) values are more than 3000 µS/cm, at four locations i.e. Rattewala(sohangarh), Abohar, Danewali and Bannawala, where the EC value is 5790, 8415, 5604 and 5418 µS/cm at 25^{o}C respectively. There is growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities.

5.4 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-13, 14 and 15 .

Table-13: 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)***	***Total***
Shallow TW	1990	7701	30872	32420	9489	82472
Deep TW	299	1157	4247	5581	2338	13622
Total	2289	8858	35119	38001	11827	96094

Table-14: 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	
Tubewells	1591	39824	13867	27349	4774	8761	**96269**
Tubewells (%)	2%	41%	14%	29%	5%	9%	100%

Table-15: System of Ground water distribution device

Open Water Channels			
Lined/pucca	*Unlined/kutcha*	*Others*	***Total***
26399	69212	658	**96269**

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 chapter-7. 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 Ferozpur and Fazlika District due to very low availability of volume of surplus water (9.59 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. Scope of quantitative impact on stage of ground water development after applying various management strategies is given in Table-16.

6.1 Scope of Implementation

This plan is focusing on the technical aspects of the ground water recharge through various means so that various implementing agencies may get the appropriate technical guidelines. The existing/ongoing schemes of the central or state govt. like MANERGA, IWSP, PMKSY (Prime Minister Krishi Sinchai Yojna), NABARD funded schemes, Urban Development schemes, departmentally funded projects etc. may be benefitted from the recharge plan by incorporating the input in the operational guidelines/ design and for locating the specific sites.

Agriculture University, engineering Collages, Academic and Research Institution, NGO may also take up the pilot or demonstrative projects in the blocks suitable to them to plan at local level as per local conditions.

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 69212 (out of 96269) tube wells (71.89 %) operated by farmers for irrigation through unlined/Kutcha open channel system in Ferozpur and Fazlika district where water from the tube well is discharge to the agricultural field. In this process, huge (around 25 %) quantity of ground water is wasted in soil moisture and evaporation losses.

Around 85.83 % of the tube wells are of shallow depth (<20 to 70m) and remaining wells are deeper depth (70 to >150 m) existed in the district. Thus majority of wells are tapping shallow Aquifer which is under stress due to over-exploitation.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in the Ferozpur and Fazilka districts are estimated to be 2821.10 mcm. It is expected that around 25 % of over draft can be brought down by switching over to underground/surface pipeline based distribution from the prevailing unlined open channels. Thereby gross draft will be reduced to 717.1 mcm assuming that there is a no crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks. The measure if implemented will bring down the ground water overdraft from 144 % to 113%. The category of the blocks will also improve resulting in boosting of agriculture and industrial development otherwise not sustainable in over-exploited blocks.

The tube wells also consume enormous electricity which is subsidized and government incurs significant revenue on this account. The measures therefore will result in saving of energy and money. Pollution impact will be reduced whenever diesel engines are used by the farmers. The environmental and ecological condition in the irrigated land will improve. Unwanted weed growth will also be controlled inside the farm land. It is expected to save 1% of the agricultural land occupied by open channels which can be utilized for cultivation purpose. Heavy ground water overdraft can be reduced by these efforts. This will ensure ***more 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 crop diversification, UGPL and artificial recharge methods details are given below table. The table shows that how much reduction of stage of development presents to after adaptation of these practices are explained in Table-16a,b &c.

Table-16a: Scope of Quantitative Impact on Stage of Development after applying various management strategies in mcm

Block	*Net Ground Water Availability (mcm)*	*Total Irrigation Draft (mcm)*	*Present Stage of draft (SOD) (%) (As per 2013)*	*Reduction in draft by different water saving method*				*SOD afterwards (%)*	*Change of paddy cultivation area (% of existing)*
				Replace water courses by UG Pipes (mcm)	*Adopt Artificial recharge (mcm)*	*Change Paddy to Maize (mcm)*	*Total (mcm) (2+3+4)*		
			1	2	3	4	5		
Abohar	297.3	98.6	36	27.04	0.0	0	27.04	27.28	*NR*
Fazilka	267.5	378.6	145	96.69	3.5	48.3	148.50	99.83	*NR*
Jalalabad	220.3	304.0	141	77.73	2.6	34.23	114.61	99.91	*NR*
Khuyian Sarwar	148.1	76.0	54	19.85	0.0	0	19.85	40.21	*NR*
Ferozpur	267.4	317.7	121	81.20	2.9	0	84.06	90.02	*NR*
Ghall Khurd	281.3	503.5	180	126.64	3.1	132.09	261.88	99.69	*NR*
Guru Har Sahai	267.1	251.4	95	63.39	2.8	0	66.23	70.14	*NR*
Makhu	147.0	213.4	146	53.67	2.7	27.94	84.33	99.92	*NR*
Mamdot	249.4	308.6	125	77.62	2.2	0	79.79	92.51	*NR*
Zira	162.8	369.3	229	93.29	0.4	139.6	233.24	108	*27.92 (8%)*
Total	**2308.2**	**2821.1**		**717.12**				**100**	

Table-16b: Impact on Stage of Development (SOD) after applying various management strategies in study area

Block	*Present SOD (%) as on 2013*	*Reduction in SOD (%) after unlined channel (%)*	*Resultant SOD (%)*	*Reduction in Stage of development after crop diversification by Maize/Soyabean (%)*	*Resultant SOD (%)*	*Reduction in Stage of development after Artificial recharge (%)*	*Resultant SOD (%)*
			Col.(2 - 3)		*Col.(2 - 5)*		*Col.(2 - 7)*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
ABOHAR	36	5.96	30.41	0.00	36.37	0.00	36.37
FAZILKA	145	25.44	119.16	7.31	137.29	1.31	143.29
JALALABAD	141	24.80	116.32	**4.73**	136.39	1.20	139.92
KHUYIAN SARWAR	54	9.22	44.40	0.00	53.62	0.00	53.62
FEROZPUR	121	21.36	100.10	0.00	121.46	1.07	120.39
GHALL KHURD	180	32.17	147.93	34.27	145.84	1.12	178.99
GURU HAR SAHAI	95	16.91	78.02	0.00	94.93	1.06	93.87
MAKHU	146	26.10	119.96	7.78	138.29	1.85	144.21
MAMDOT	125	22.24	102.26	0.00	124.50	0.87	123.63
ZIRA	229	40.75	188.40	71.80	157.36	0.22	228.94

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 % and is given in Table.16.

Table-16c: Overall Stage of Development (SOD) after reduction

Block	*Present SOD (%) as on 2013*	*Reduction in SOD (%) after unlined channel (%)*	*Reduction in Stage of development after crop diversification by Maize/Soyabean (%)*	*Reduction in Stage of development after Artificial recharge (%)*	*Total Resultant SOD (%)* *Col.(3+4+5)*	
1	**2**	**3**	**4**	**5**	**6**	7
ABOHAR	36	5.96	0.00	0.00	5.96	30
FAZILKA	145	25.44	18.06	1.31	44.81	100
JALALABAD	141	24.80	**15.54**	1.20	41.54	100
KHUYIAN SARWAR	54	9.22	0.00	0.00	9.22	44
FEROZPUR	121	21.36	0.00	1.07	22.43	99
GHALL KHURD	180	32.17	46.96	1.12	80.26	100
GURU HAR SAHAI	95	16.91	0.00	1.06	17.98	77
MAKHU	146	26.10	19.01	1.85	46.96	99
MAMDOT	125	22.24	0.00	0.87	23.11	101
ZIRA	229	40.75	87.76	0.22	128.73	100

BLOCK WISE

AQUIFER MAPS

AND

MANAGEMENT PLAN

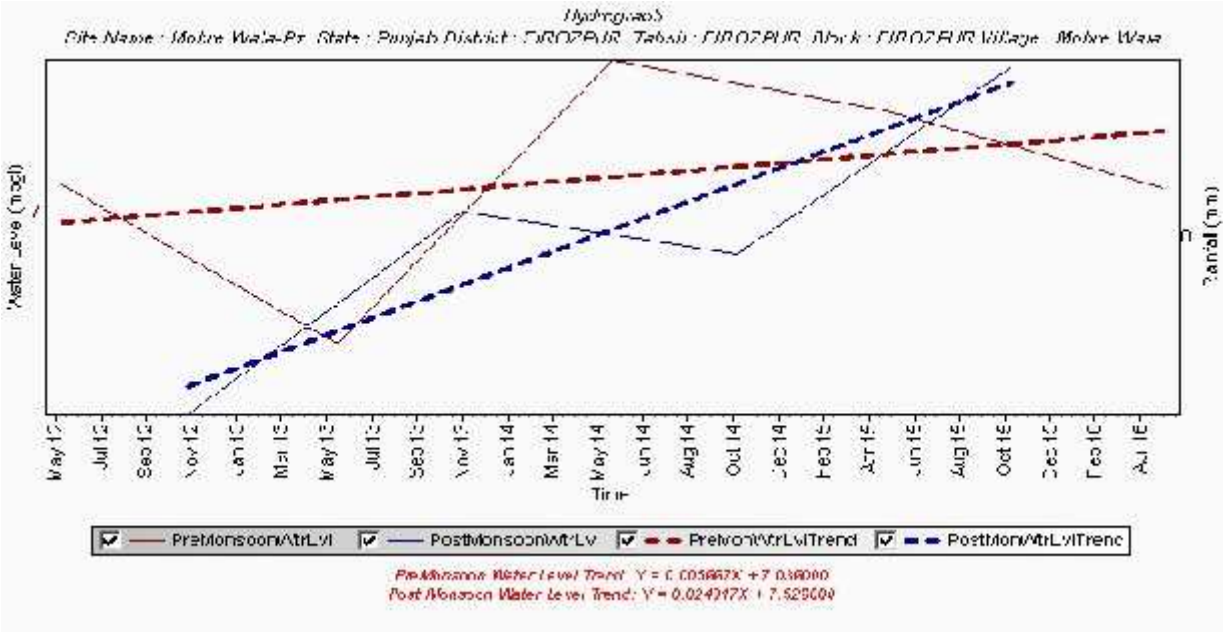
(PART-II)

1.0 Salient Information

Name of the Block and Area	**Ferozpur** **752.10 sq km**
District/ State	Ferozpur, Punjab
Population	Urban Population: 0 Rural Population: 138731 Total population: 138731
Rainfall	Normal Monsoon: 282 mm Non-monsoon Rainfall : 55 mm Annual Average Rainfall: 349 mm
Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 198% Number and types of abstraction structures: 9975 nos. , Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 2566 mcm (fresh and saline water resources) up to the depth of 300m. The fresh water resources are estimated up to the depth of 174m based on geophysical interpretations interface. The potential granular zones are available for fresh water calculated as 71 m. Saline water resources are estimated based on the available depth of wells existed in this block up to 300 m and the granular zones are counted after the depth of 174 m and available zones are 68 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 317.5 mcm Domestic and industrial water supply: 7.04 mcm *Future water demands* Irrigation development potential : -60.21 mcm Domestic and industrial water supply up to 2025 years : 9.87 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 1.45 – 15.22 m bgl Post Monsoon: 1.20 – 13.10 m bgl Mean (10 yrs) : 1.00 – (-)1.01 m/yr *Trends* Pre Monsoon: 0.18 – (-)0.22 m/yr Post Monsoon: 0.24 – (-)0.30 m/yr

HYDROGRAPH SHOWING RISING TREND



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Younger Alluvium, Older Alluvium

Aquifer wise Characteristics

Aquifer Group *	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield/ Discharge (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer-I	Quaternary Alluvial deposits	Unconfined to confined	137	Not Available (NA)	Not Available (NA)	0.0072 (12%)	Not Available (NA)

* Well field proposed in adjacent block

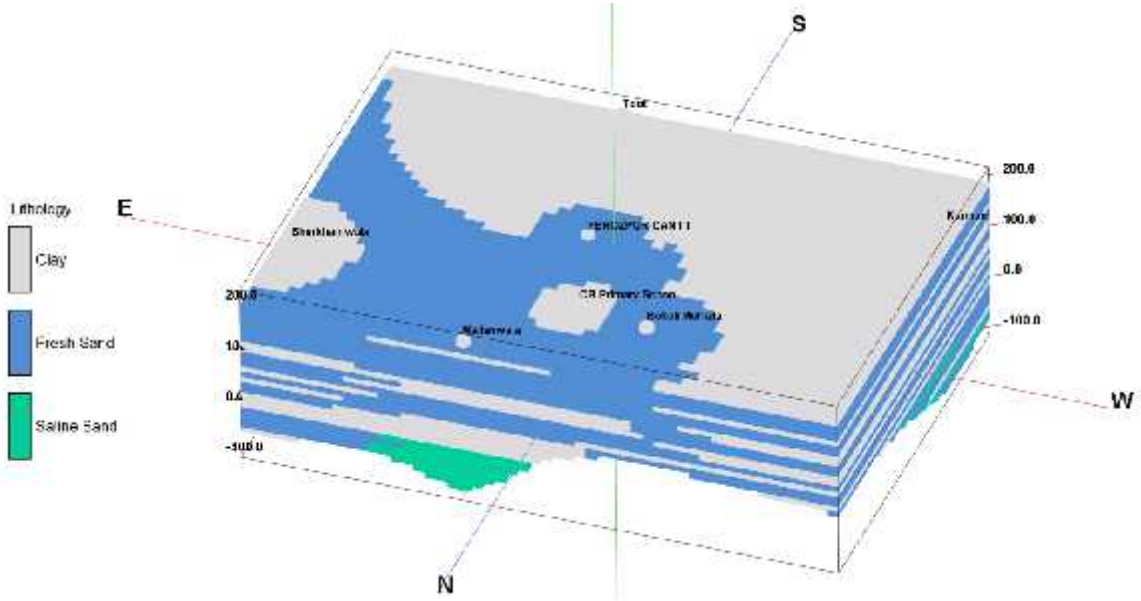
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

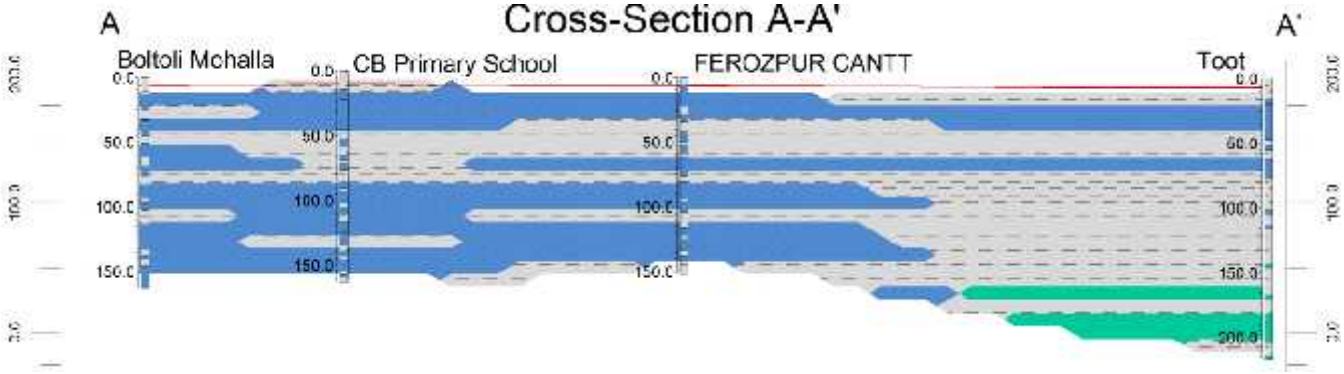
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB		1		2	**3**
PRIVATE		2			**2**
TOTAL					**5**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

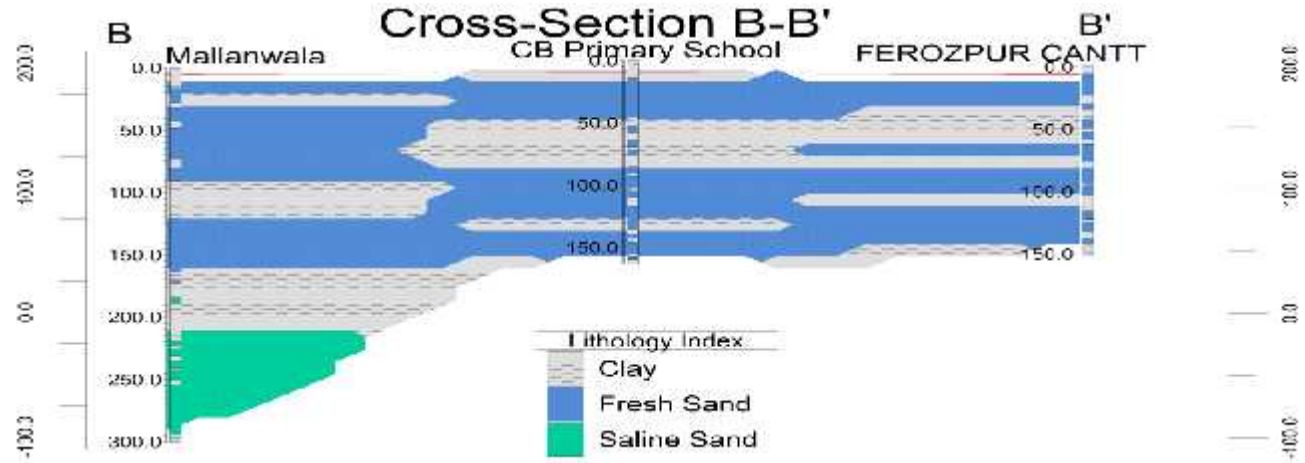
3-D Lithological model of Ferozpur Block



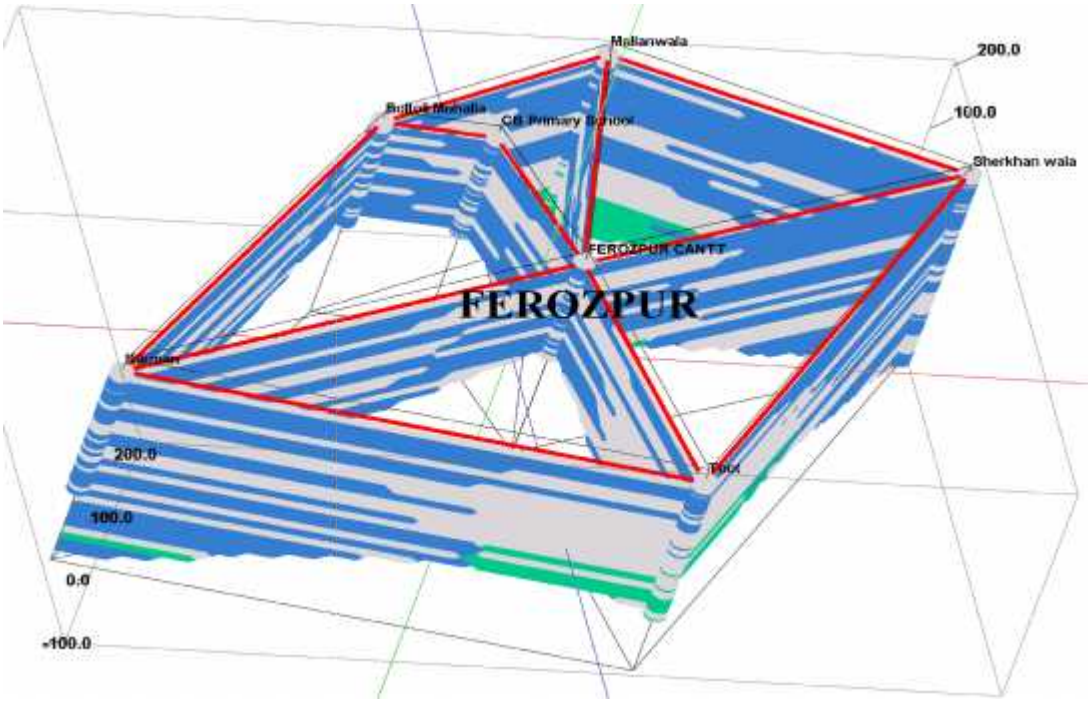
Lithological Cross section from Baltoli Mohalla to Toot



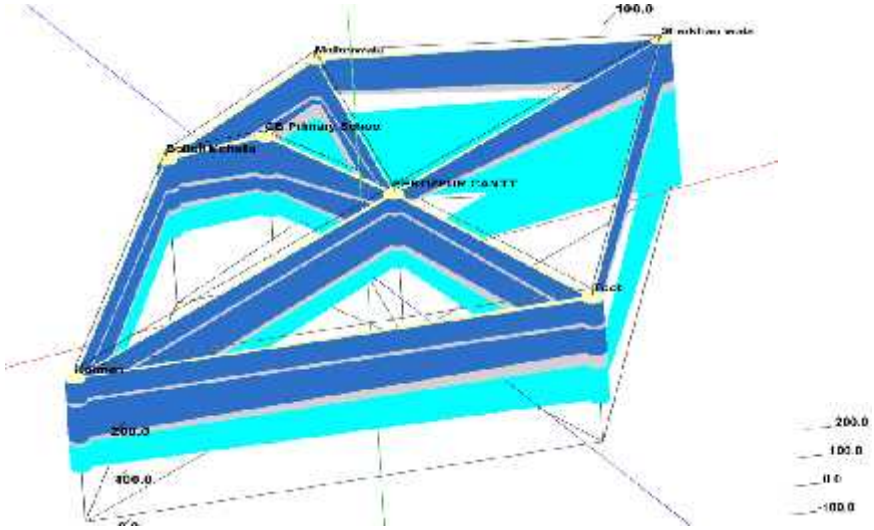
Lithological Cross section from Mallanwala to Ferozpur Cantt



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	264.42 mcm
	In-storage Fresh water resources	2298.67 mcm
	In-storage Saline water resources	2322.3 mcm
	Total	4885.39 mcm
Ground Water Extraction (as per 2013)	Irrigation	317.75 mcm
	Domestic & Industrial	7.04 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		9.87 mcm
Stage of Groundwater Development		121 %
Chemical Quality of ground water		Not Available
Ground water Contamination Issues		Not Available
Other issues		In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems. Salinity Problem in deeper aquifer

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 169.02 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 2.86 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices
Area proposed to be covered: 469.50 sq km (Entire Block)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 57.11mcm

Change in cropping pattern Not required

Area coverage: Not required
Anticipated volume of water to be saved: Not required

2. Salient Information

Name of the Block and Area (in Km^2)	**MAKHU** **288.60 sq km**
District/ State	Ferozpur, Punjab
Population	Urban Population: Rural Population: 77662 Total population: 77662
Rainfall	Normal Monsoon: 328 mm Non-monsoon Rainfall : 61 mm Annual Average Rainfall: 370 mm
Agriculture and Irrigation	Principal crops: Wheat, Cotton and Paddy Gross cropped area: 1334.27 sq km Number and types of abstraction structures: 6927nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 5445 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 225 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 145 m. Saline water resources are estimated based on the available depth of wells existed up to 300 m and the granular zones are counted after the depth of 225 m and available zones are 55 m. Block is categorized as Over-Exploited as aper Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 213.45 mcm Domestic and industrial water supply: 1.24 mcm *Future water demands* Irrigation development potential : -68.26 mcm Domestic and industrial water supply up to 2025 years : 1.74 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr

Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Younger Alluvium

Aquifer wise Characteristics

Aquifer Group *	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (lpm)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	200	1210	4840	0.072	NA

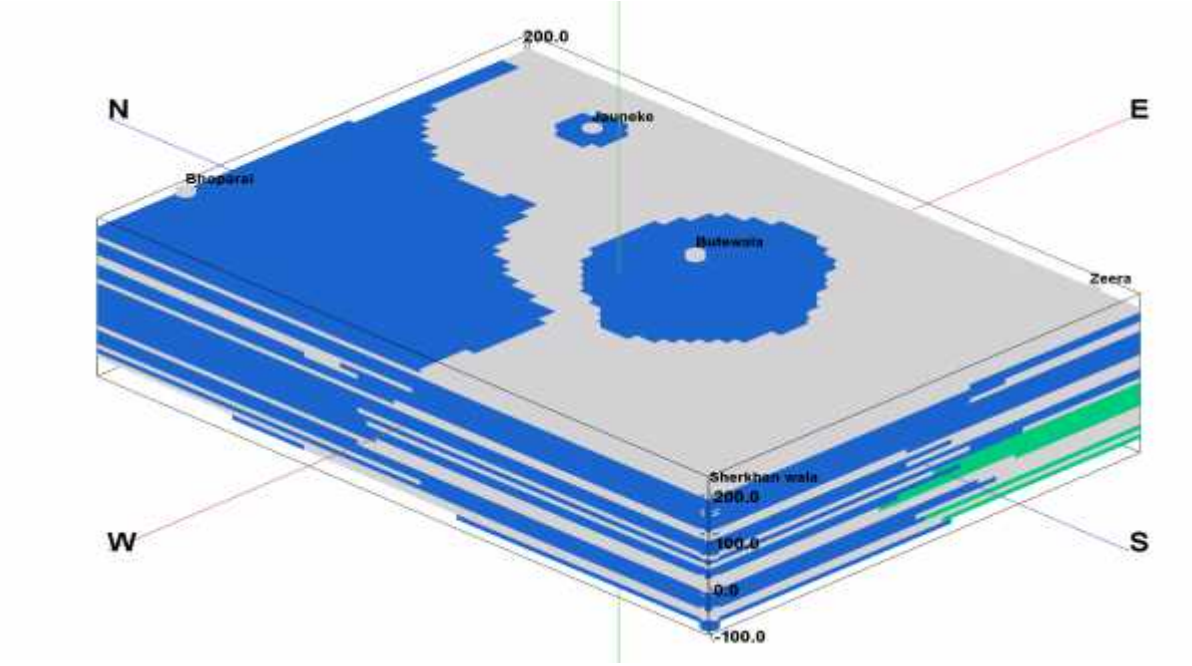
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

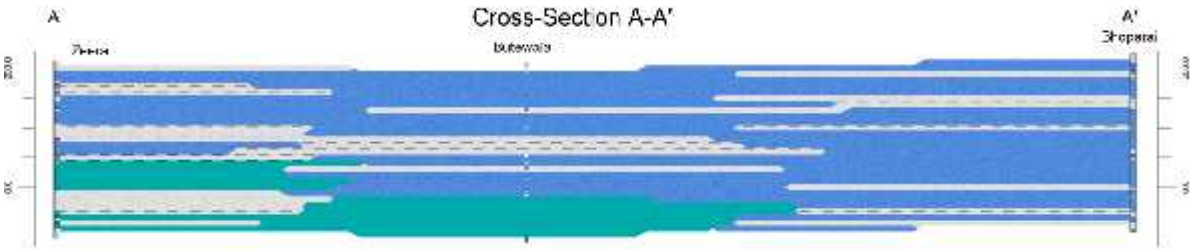
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	0	1	**1**
TOTAL					**1**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

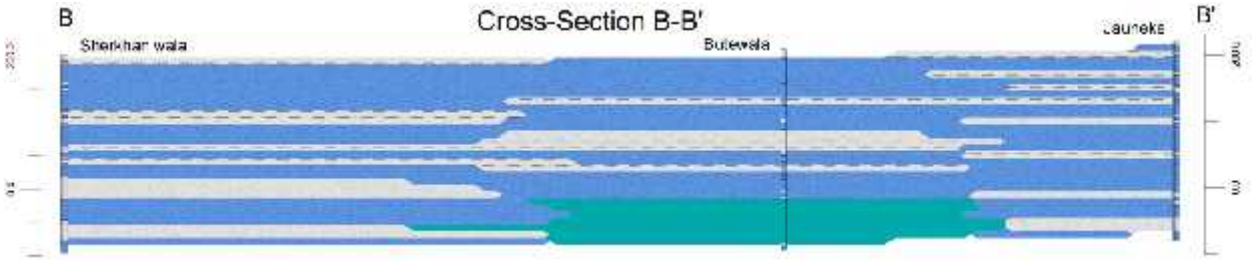
3-D Lithological model of Makhu Block



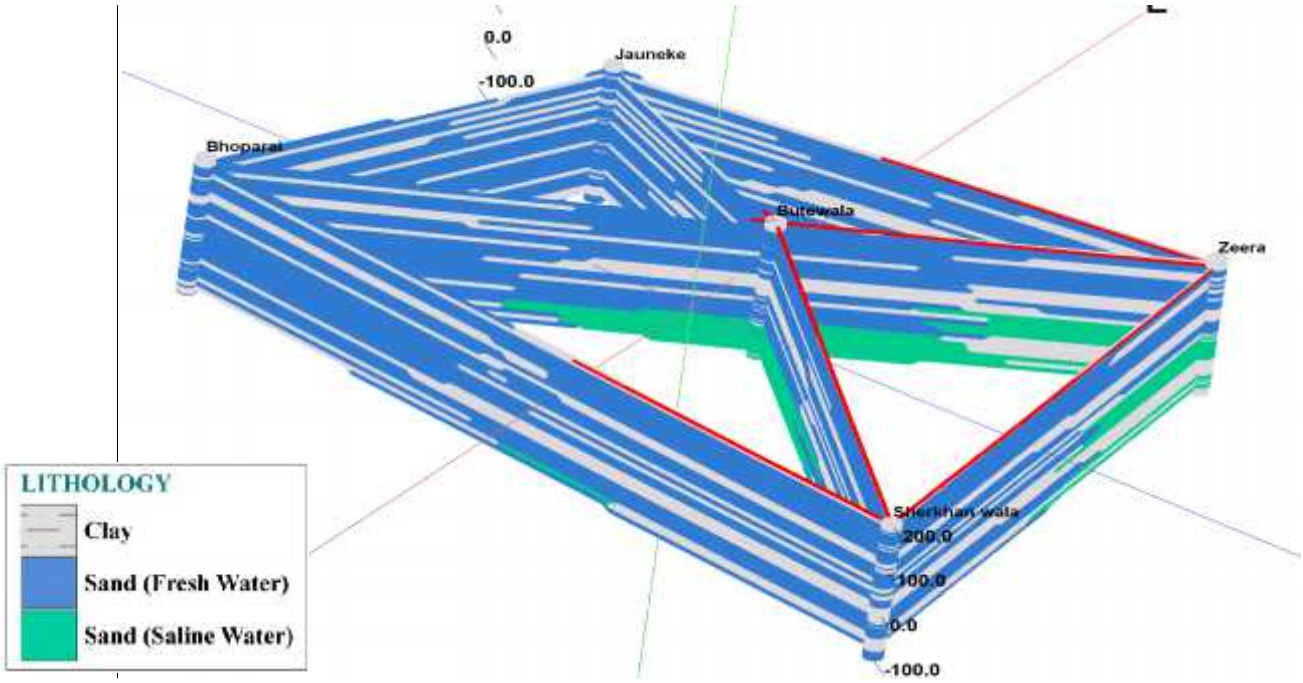
Lithological Cross section from Zeera to Bhoparai



Lithological Cross section from Sherkhanwala to Jauneke



3-D Lithological Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	146.99 mcm
	In-storage Fresh water resources	3012.98 mcm
	In-storage Saline water resources	1142.86 mcm
	Total	4303 mcm
Ground Water Extraction (as per 2013)	Irrigation	420.20 mcm
	Domestic & Industrial	14.02 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		15.11 mcm
Stage of Groundwater Development		162 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.53 to 8.7. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges from 563 µS/cm to 571µS/cm at 25^0C.

Ground water Contamination Issues	Potable Ground water
Other issues	Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 0.346 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 2.72 mcm volume of water*

Demand side interventions

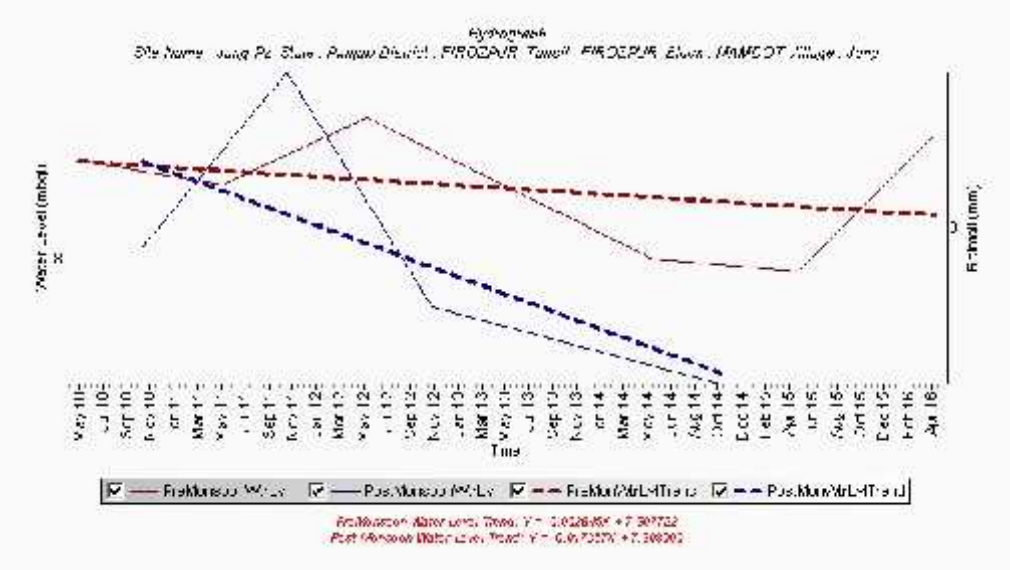
Advanced Irrigation Practices
Area proposed to be covered: 288.6 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 38.36 mcm
Change in cropping pattern
Proposed change in cropping pattern: *Rice to Maize, Soyabean 7.8 % of the total rice area needs to change.*
Area coverage: 11.43 sq km
Anticipated volume of water to be saved: 11.43mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Change Paddy to Maize/ soya bean (Sq km)*	*Reduction in Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize (%)*	*Percentage of Crop Diversified area*
147.0	213.4	1.2	254	11.43	11.43	202.02	146	138	7.8

Alternate Water sources: Groundwater/surface water sources: *Tanks, Ponds*

3.0 Salient Information

Name of the Block and Area (in Km^2)	**MAMDOT** **375.80 sq km**
District/ State	Ferozpur, Punjab
Population	Urban Population: 0 Rural Population: 103234 Total population: 103234
Rainfall	Normal Monsoon: 290 mm Non-monsoon Rainfall : 100 mm Annual Average Rainfall: 398 mm
Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 193% *Area under* Number and types of abstraction structures: 10081 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 3848 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 190 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 133 m. Saline water resources arenot available due to data deficiency. Block is categorized as Over-Exploited as aper Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.
Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 308.63 mcm Domestic and industrial water supply: 1.86 mcm *Future water demands* Irrigation development potential : -60.99 Domestic and industrial water supply up to 2025 years : 1.74 mcm

Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr
HYDROGRAPHS	

Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Younger Alluvium

Aquifer wise Characteristics

Aquifer Group *	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (lpm)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	133	2660	3706	0.72	$6.4*10^{-4}$

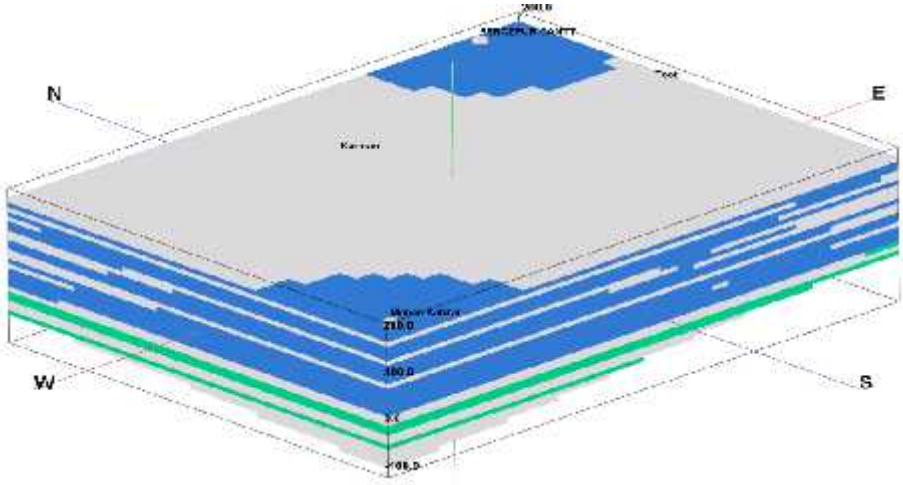
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB				1	**1**
TOTAL				**1**	**1**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

3-D Lithological model of Mamdot Block



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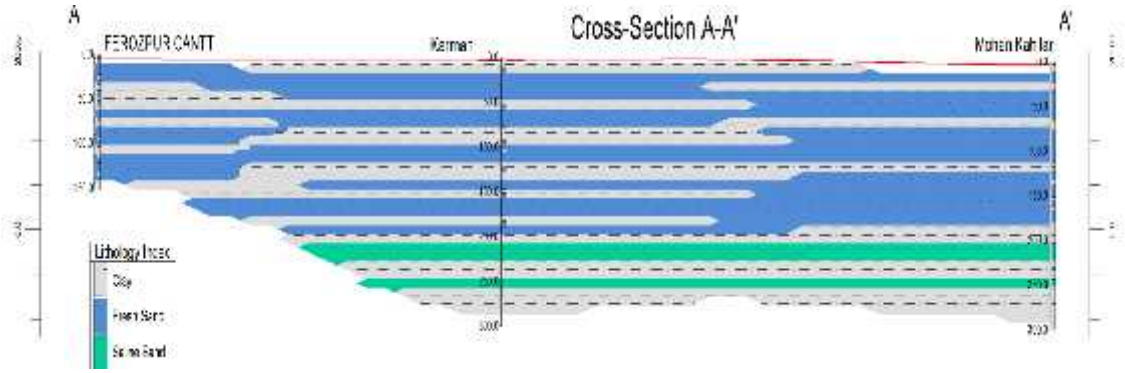
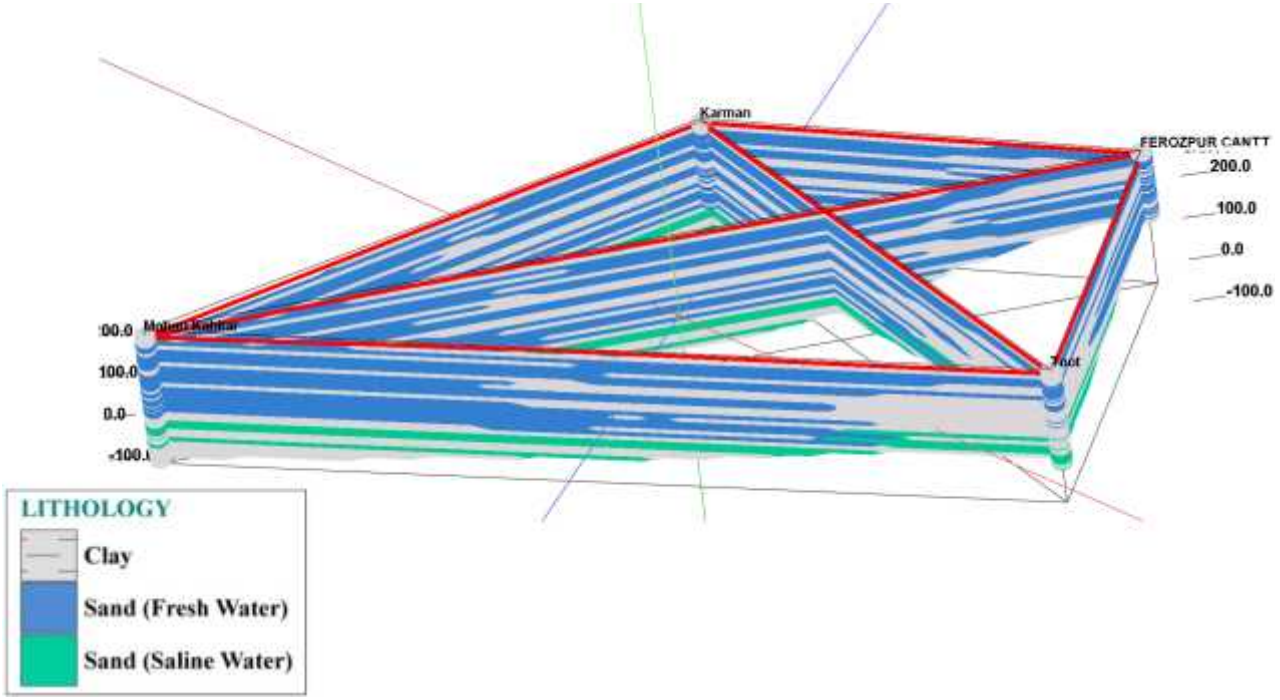
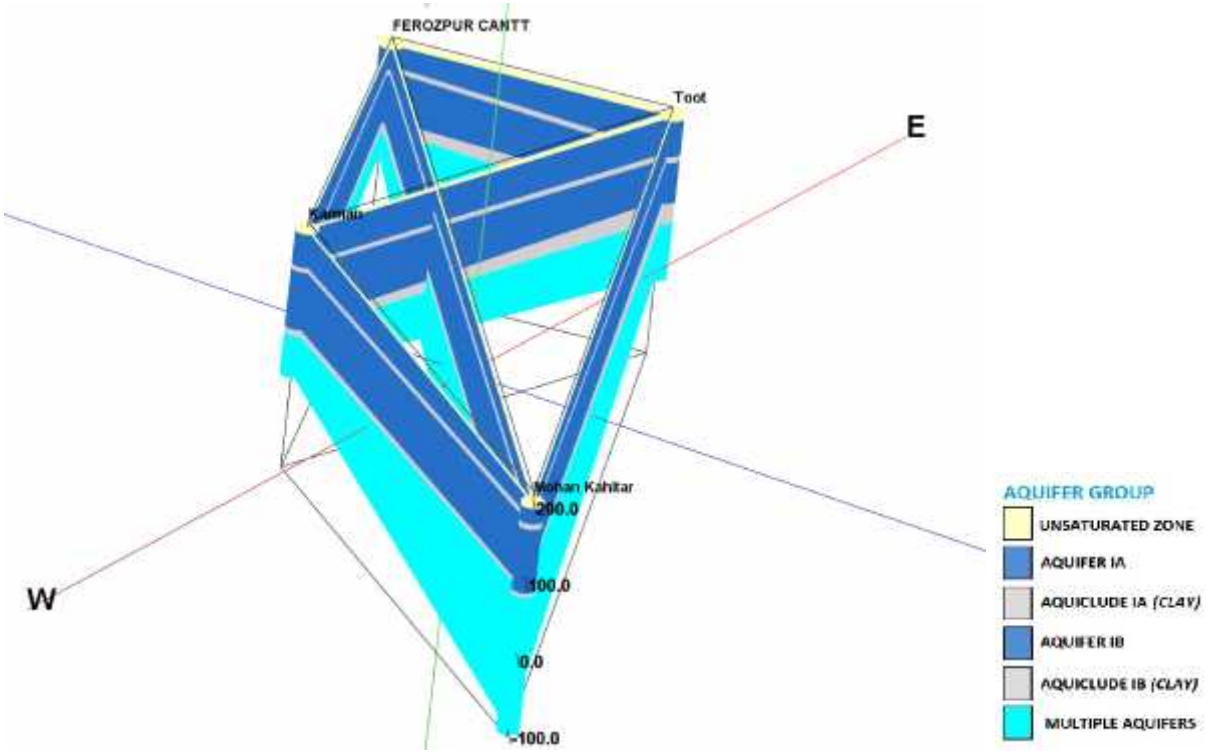
Lithological Cross section from Toot to Mohakamwala



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



3.0 Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	249.38 mcm
	In-storage Fresh water resources	3598.66 mcm
	In-storage Saline water resources	0 mcm
	Total	3848 mcm
Ground Water Extraction (as per 2013)	Irrigation	308.63 mcm
	Domestic & Industrial	14.02 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		1.86 mcm
Stage of Groundwater Development		125 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges near 8.37. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and

	ranges from 545 µS/cm at 25^{0}C.
Ground water Contamination Issues	Potable Ground Water
Other issues	Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 143.96 mcm

Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*

Types and number of structures: --

Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 4.75 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: 666.50 sq km

Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 99.15 mcm

Change in cropping pattern

Proposed change in cropping pattern: Not Required

Area coverage: Not Required

Anticipated volume of water to be saved: Not Required

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Change Paddy to Maize/ soya bean (Sq km)*	*Reduction in Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize (%)*	*Percentage of Crop Diversified area*
249.4	308.6	1.9	227	0	0	308.63	125	125	0.0

Alternate Water sources

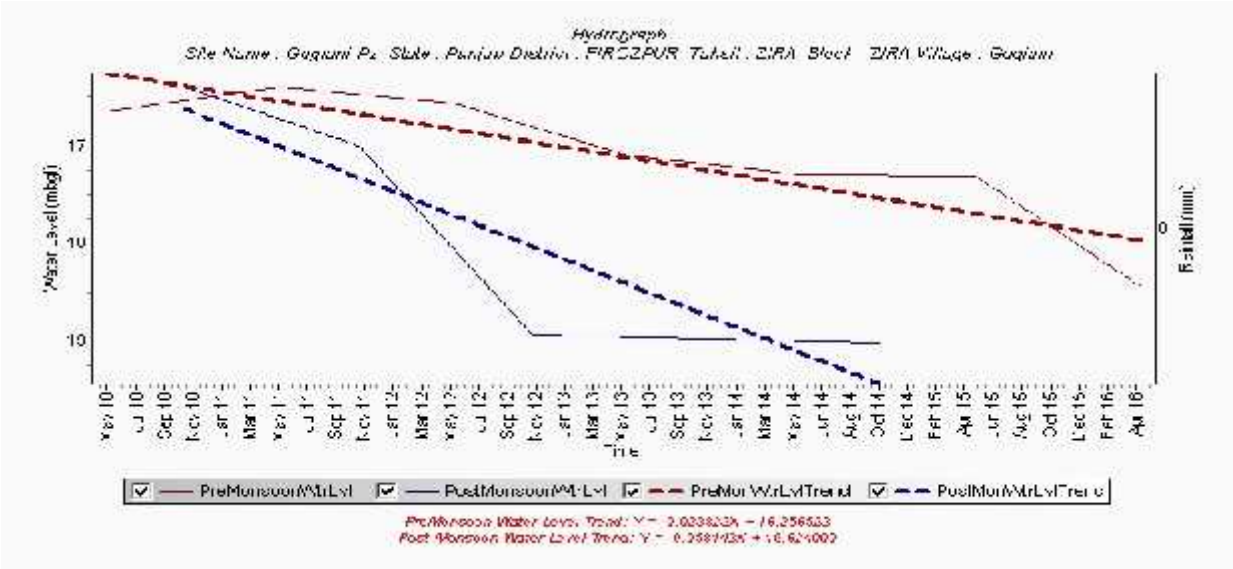
surface water sources: *Tanks, Ponds*

4.0 Salient Information

Name of the Block and Area (in Km^2)	**Zeera** **383.40 sq km**
District/ State	Ferozpur, Punjab
Population	Urban Population: 766 Rural Population: 112437 Total population: 113203
Rainfall	Normal Monsoon: 328 mm Non-monsoon Rainfall :100 mm Annual Average Rainfall: 436 mm
Agriculture and Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 182% Number and types of abstraction structures: 11595 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 4800 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 208 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 97m. Saline water resources are estimated based on the available depth of wells existed up to 300 m and the granular zones are counted after the depth of 208 m and available zones are 71 m. Block is categorized as Over-Exploited as aper Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.
Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 369.25 mcm Domestic and industrial water supply: 3.91 mcm *Future water demands* Irrigation development potential : -211.74 mcm Domestic and industrial water supply up to 2025 years : 5.33 mcm

Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr

HYDROGRAPH



2. 0 Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Younger Alluvium, Older Alluvium

Aquifer wise Characteristics

Aquifer Group *	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	168	NA	NA	NA	NA

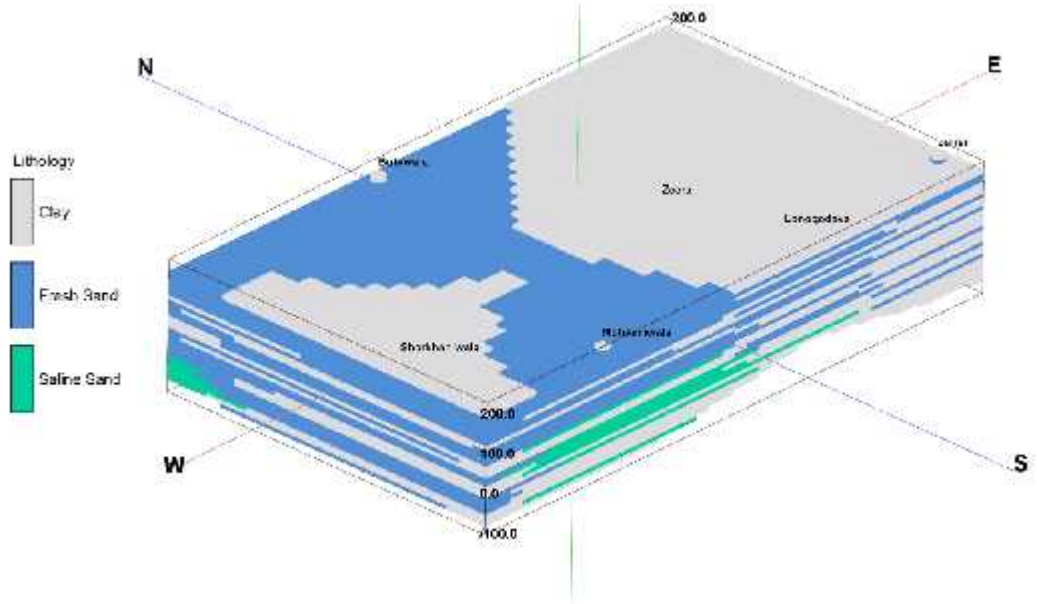
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

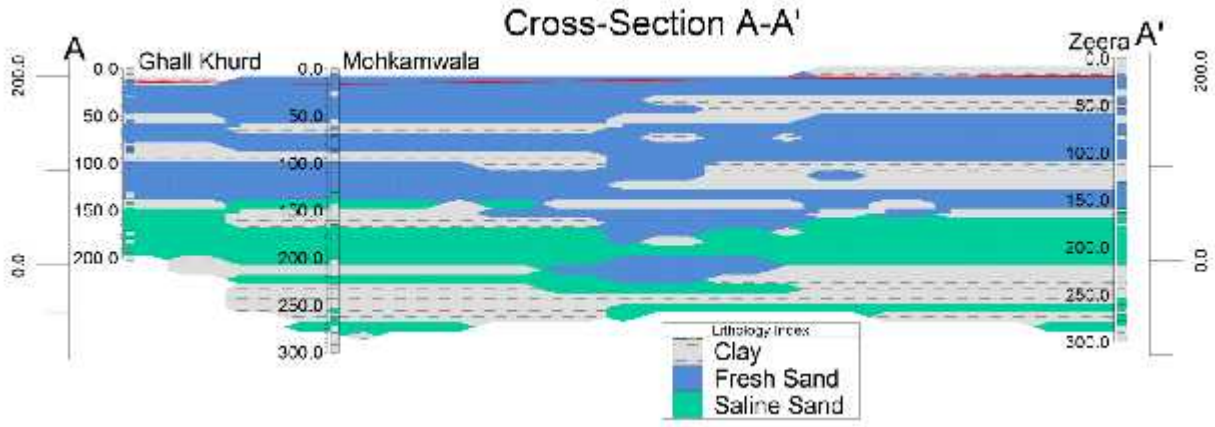
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	1	1	**2**
WRED/PSTC/WSS	0	0	0	1	**0**
PRIVATE	0	0	1	0	**0**
TOTAL	**0**	**0**	**2**	**0**	**2**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

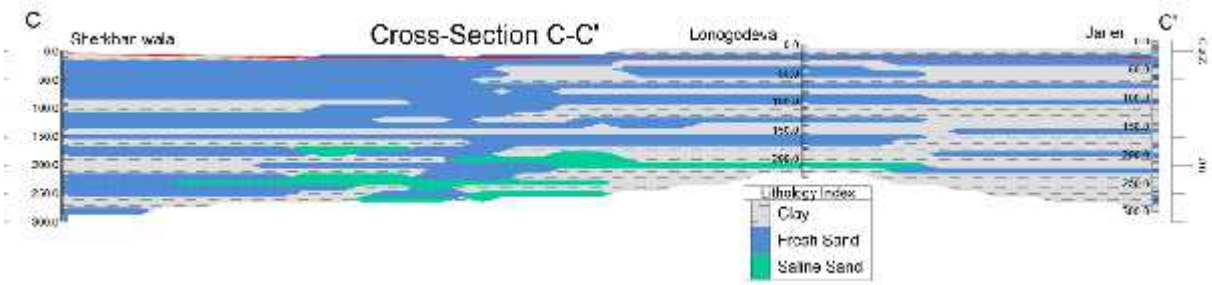
3-D Lithological model of Zeera Block



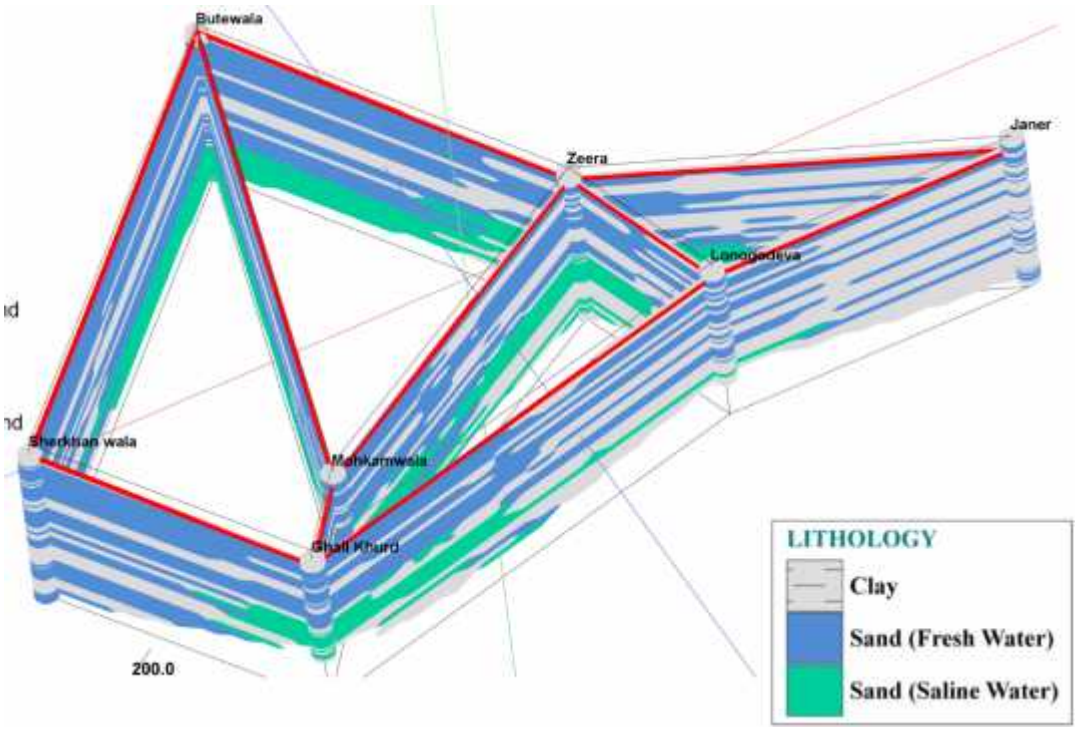
Lithological Cross section from Ghall Khurd to Zeera



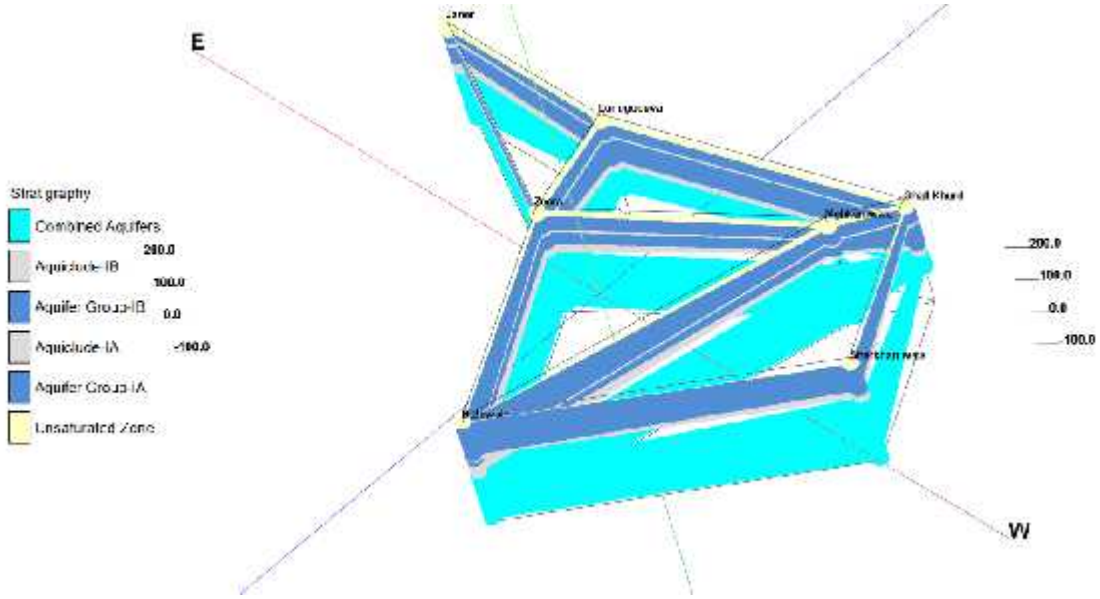
Lithological Cross section from Sherkhan wala and Janer



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	162.84 mcm
	In-storage Fresh water resources	2677.67 mcm
	In-storage Saline water resources	1959.94 mcm
	Total	4800 mcm
Ground Water Extraction (as per 2013)	Irrigation	36.25 mcm
	Domestic & Industrial	14.02 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		5.33 mcm
Stage of Groundwater Development		229 %
Chemical Quality of ground water		Not Available
Ground water Contamination Issues		Not Available
Other issues		Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 36.81 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 0.36 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: 383.4 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc 66.36

Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean 71.8 % of the total rice area needs to change.*
Area coverage: 116.915sq km
Anticipated volume of water to be saved: 116.915 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Change Paddy to Maize/ soya bean (Sq km)*	*Reduction in Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize (%)*	*Percentage of Crop Diversified area*
162.8	369.3	3.9	349	116.915	116.91	252.34	229	157	71.8

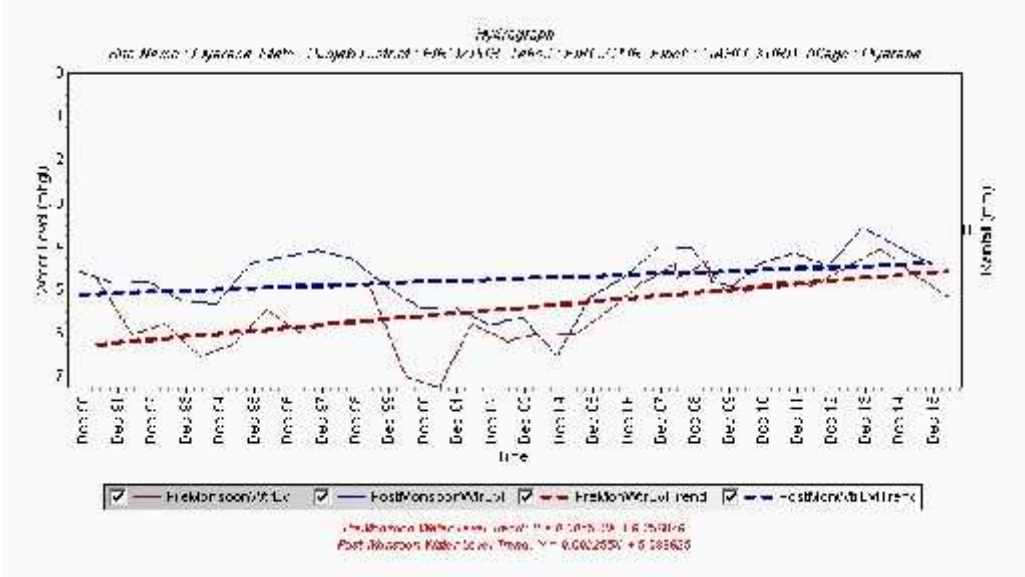
Alternate Water sources

Groundwater/surface water sources: *Tanks, Ponds*
Location, details and availability from such sources outside the area: --

Regulation and Control: Punjab Sub Soil Act, 2009 regarding plantation of paddy cultivation.

5. Salient Information

Name of the Block and Area (in Km^2)	**GHALL KHURD 532.10 sq km**
District/ State	Ferozpur, Punjab
Population	Urban Population: **8724** Rural Population: **134028** Total population: **142752**
Rainfall	Normal Monsoon: 298 mm Non-monsoon Rainfall : 117 mm Annual Average Rainfall: 422 mm
Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 190% *Area under* Number and types of abstraction structures: 15960 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 6143 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 140 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 89 m. Saline water resources are estimated based on the available depth of wells existed up to 300 m and the granular zones are counted after the depth of 140 m and available zones are 64 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 503.48 mcm Domestic and industrial water supply: 3.08 mcm *Future water demands* Irrigation development potential : -226.39mcm Domestic and industrial water supply up to 2025 years : 4.16 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr
HYDROGRAPH	

2. 0 Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Younger Alluvium

Aquifer wise Characteristics

Aquifer Group *	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	153	1890	NA	12	NA

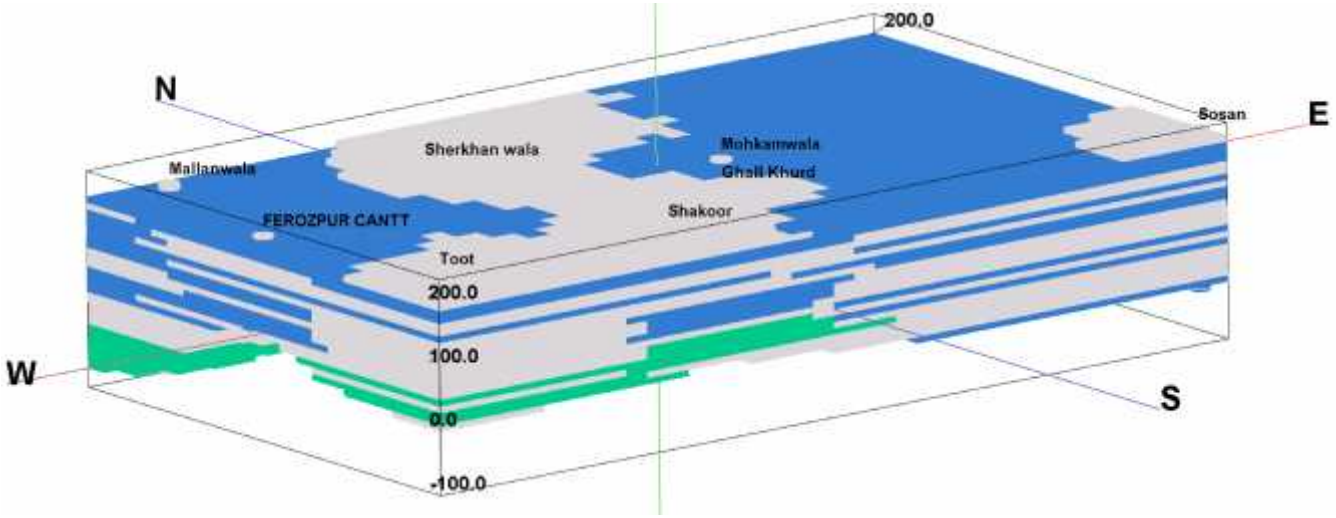
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

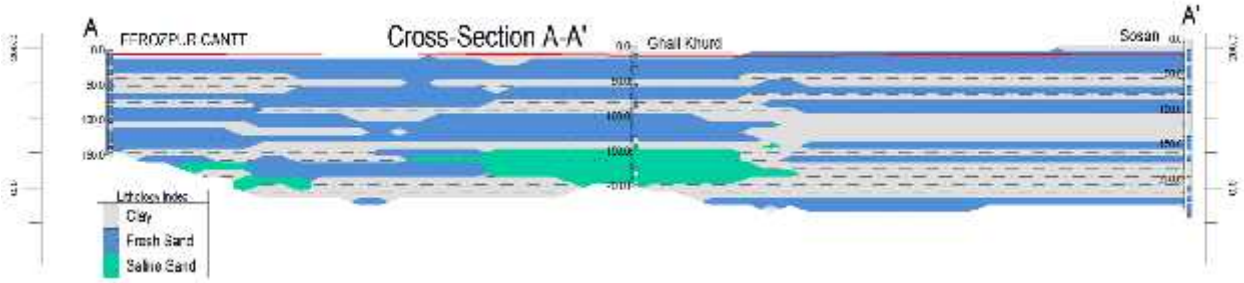
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB			1	2	**3**
WRED/PSTC/WSS				1	**1**
PRIVATE			1		**1**
TOTAL			**2**	**3**	**5**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

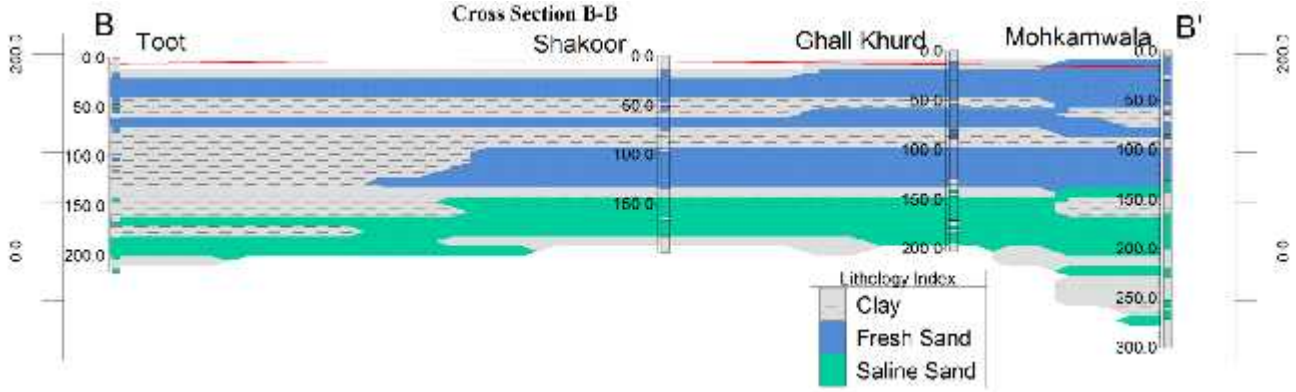
3-D Lithological model of Ghal Khurd Block



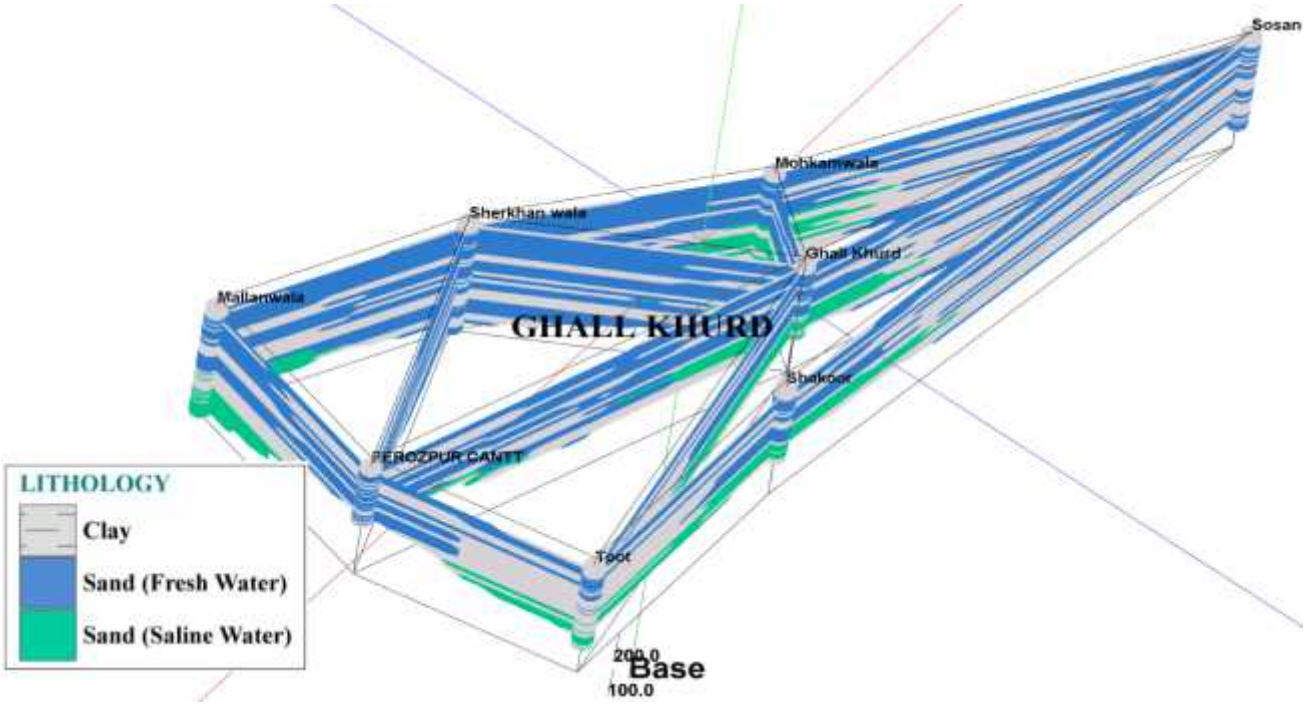
Lithological Cross section from Ferozpur Cantt to Sosan



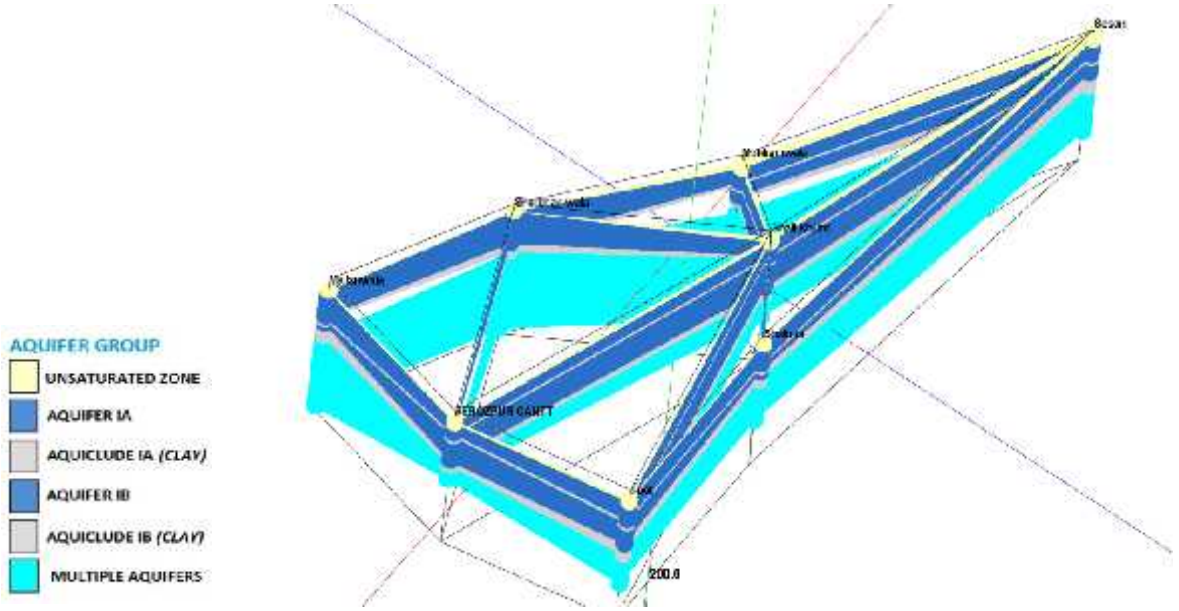
Lithological Cross section from Toot to Mohakamwala



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	281.26 mcm
	In-storage Fresh water resources	3409.70 mcm
	In-storage Saline water resources	2451.92 mcm
	Total	6143 mcm
Ground Water Extraction (as per 2013)	Irrigation	503.48 mcm
	Domestic & Industrial	3.08 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		4.16 mcm
Stage of Groundwater Development		180%
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges near 9.15. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges near to 761 at 25^0C.
Ground water Contamination Issues		Potable Water for drinkimg
Other issues		Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 44.7 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 3.15 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: 532.10 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 90.49 mcm

Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean* 34.3*% of the total rice area needs to change.*
Area coverage: 96.39 sq km
Anticipated volume of water to be saved: 96.39 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Change Paddy to Maize/ soya bean (Sq km)*	*Reduction in Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize (%)*	*Percentage of Crop Diversified area*
281.3	503.5	3.1	357	96.39	96.39	407.09	180	146	34.3

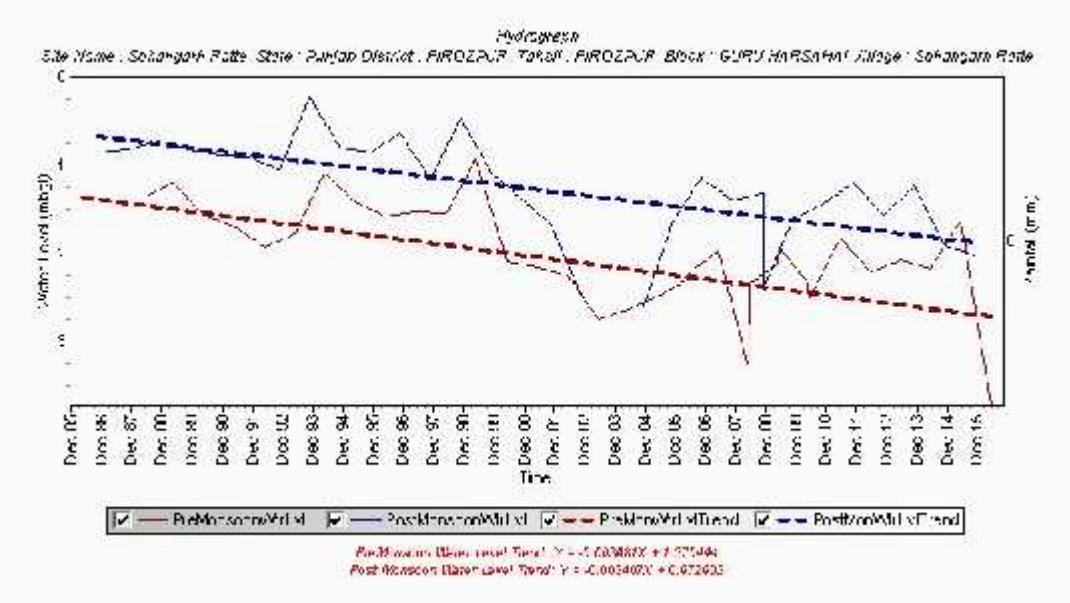
Alternate Water sources
surface water sources: *Tanks, Ponds*

5.0 Salient Information

Name of the Block and Area (in Km^2)	**GURU HARSAHAI 490.6 sq km**
District/ State	Fazilka, Punjab
Population	Urban Population: - Rural Population: 151315 Total population: 151315
Rainfall	Normal Monsoon: 210mm Non-monsoon Rainfall : 30 mm Annual Average Rainfall: 384 mm
Agriculture and Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 196 % Number and types of abstraction structures: 9828 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 2945 mcm (fresh and saline water resources) up to the depth of 275 m. The fresh water resources are estimated up to the depth of 204 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 116 m. Saline water resources are estimated based on the available depth of wells existed up to 275 m and the granular zones are counted after the depth of 204 m and available zones are 39 m. Block is categorized as Critical as aper Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 251.36 mcm Domestic and industrial water supply: 2.22 mcm *Future water demands* Irrigation development potential : 12.71 mcm Domestic and industrial water supply up to 2025 years : 3.04 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr

HYDROGRAPHS



2. 0 Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Younger Alluvium, Aeolian Alluvium

Aquifer wise Characteristics

*Aquifer Group **	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	155	NA	NA	NA	NA

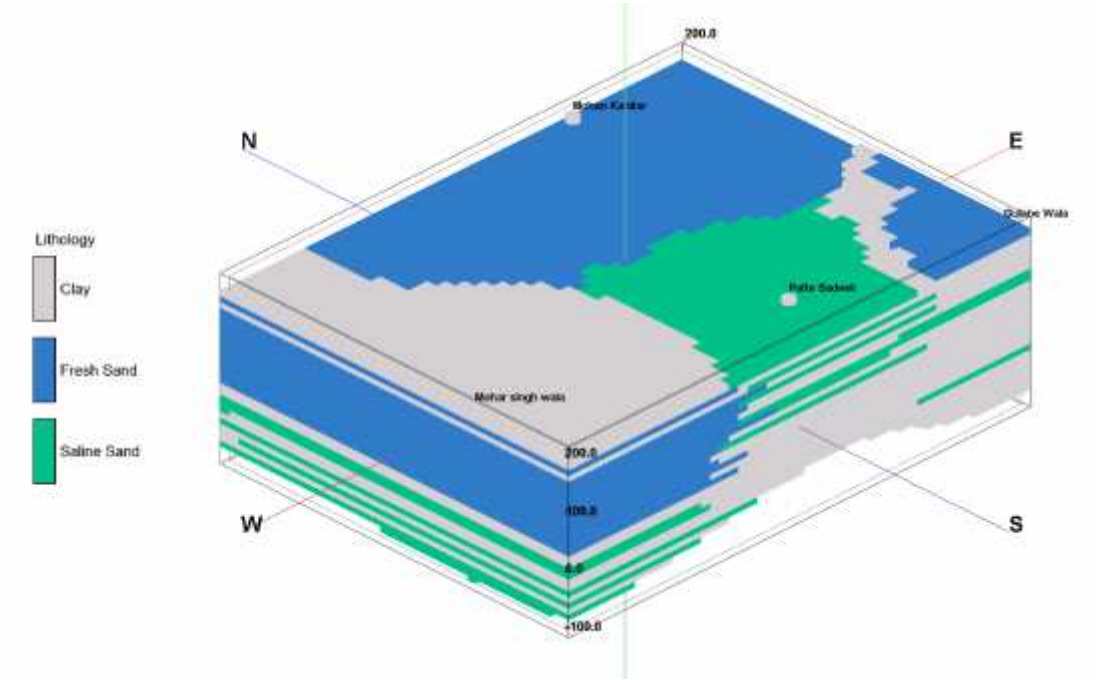
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

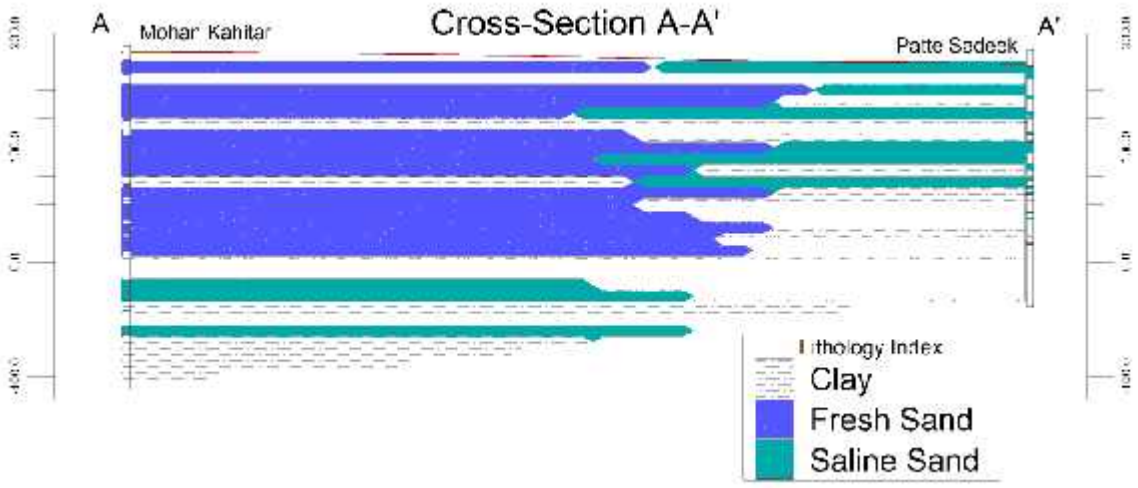
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	1	1	**2**
WRED/PSTC/WSS	0	0	0	1	**0**
PRIVATE	0	0	0	0	**0**
TOTAL	**0**	**0**	**0**	**0**	**2**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

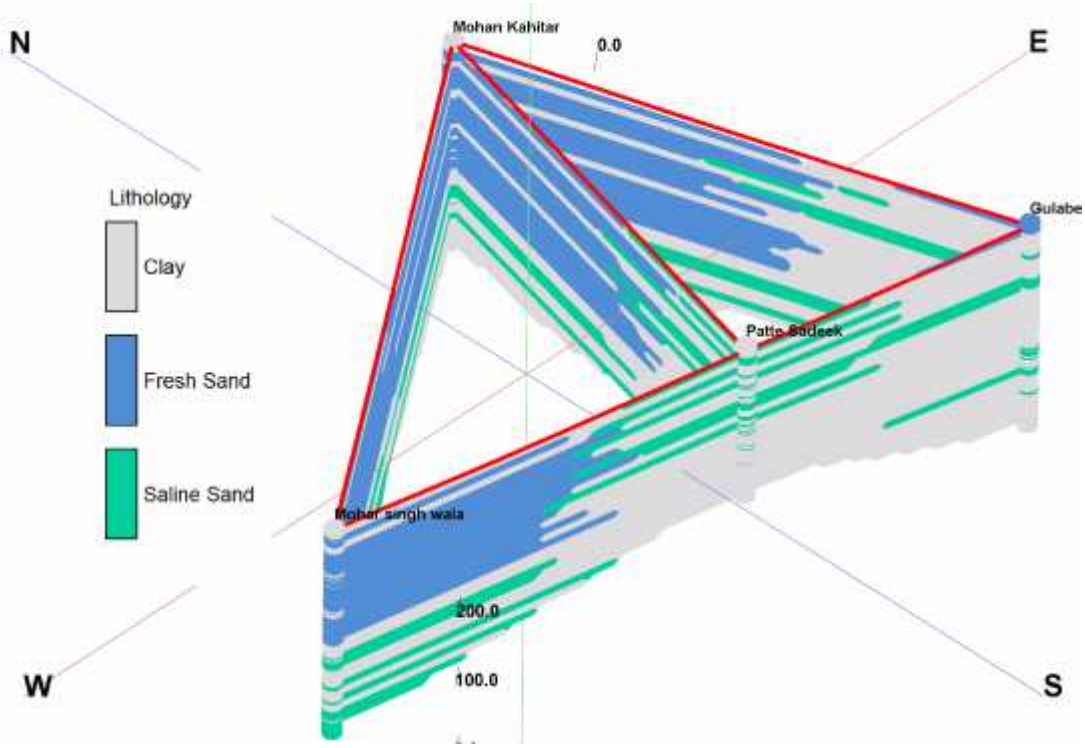
3-D Lithological model of Guru Har Sahai Block



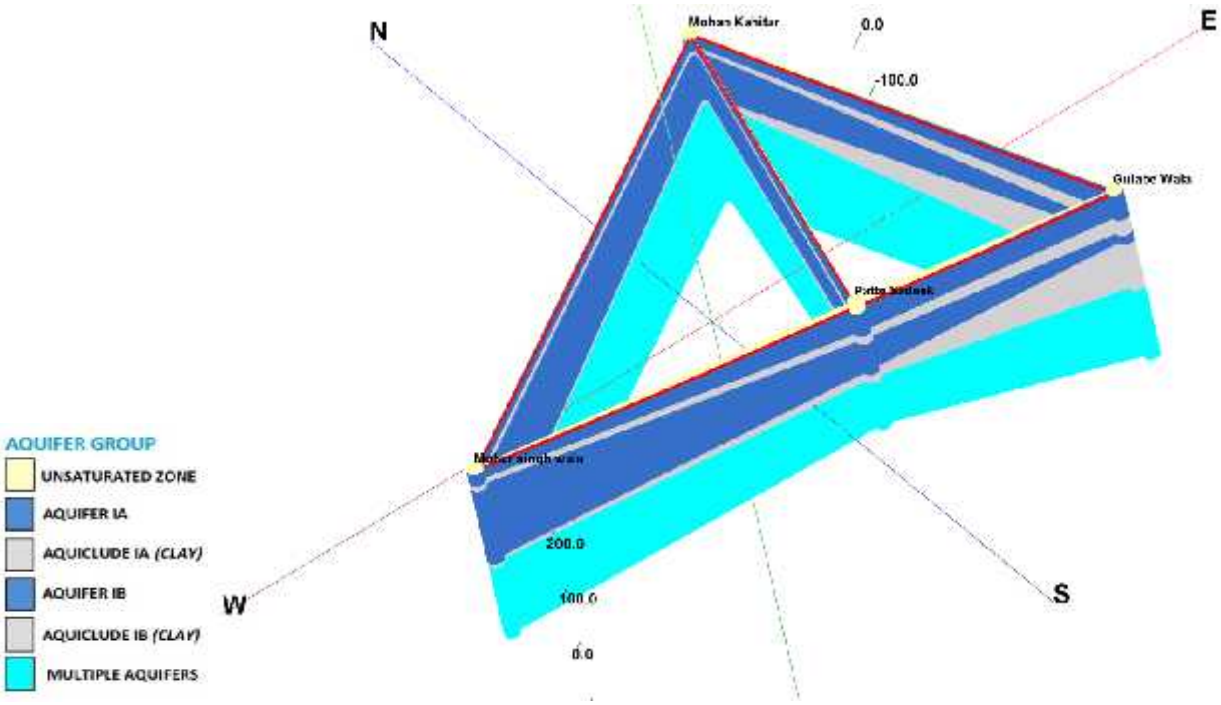
Lithological Cross section from Mohan Kathiar to Patte Sadeek



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	267.11 mcm
	In-storage Fresh water resources	1959.38 mcm
	In-storage Saline water resources	718.85 mcm
	Total	2945 mcm
Ground Water Extraction (as per 2013)	Irrigation	251.36 mcm
	Domestic & Industrial	2.2 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		12.71 mcm
Stage of Groundwater Development		95 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.41 to 9.01. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges from 750 μS/cm to 7592 μS/cm at 25^0C.
Ground water Contamination Issues		*Fluoride (mg/l):* Swah Vala (3.39), *Nitrate (mg/l):* Banna Wala (374), Sohangarh (93), Swah Vala(61)
Other issues		Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 117.74 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 2.84 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: 490.60 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 45.18mcm

Change in cropping pattern

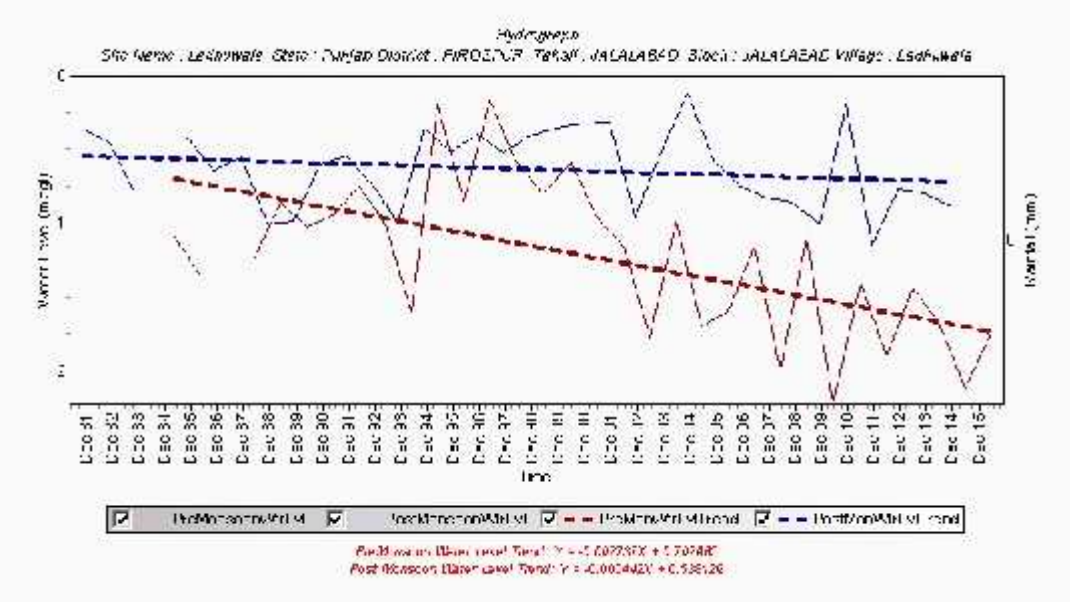
Proposed change in cropping pattern: *Not Required*
Area coverage: *Not Required*
Anticipated volume of water to be saved: *Not Required*

7.0 Salient Information

Name of the Block and Area (in Km^2)	**JALALABAD** **524.4 sq km**
District/ State	Ferozpur, Punjab
Population	Urban Population: 560 Rural Population: 173012 Total population: 173572
Rainfall	Normal Monsoon: 272 mm Non-monsoon Rainfall : 57 mm Annual Average Rainfall: 333 mm
Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 100% Number and types of abstraction structures: 10228nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 2678 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 163 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 67 m. Saline water resources are estimated based on the available depth of wells existed up to 250 m and the granular zones are counted after the depth of 163 m and available zones are 46 m. Block is categorized as Over-Exploited as aper Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.
Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 304.03 mcm Domestic and industrial water supply: 6.9 mcm *Future water demands* Irrigation development potential : -93.26 mcm Domestic and industrial water supply up to 2025 years : 9.55 mcm

Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr **Aquifer-II & III:** No Monitoring Stations

HYDROGRAPHS



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Younger Alluvium, Aeolian Alluvium

Exploratory Data Availability

Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	0	3	**0**
WRED/PSTC/WSS	0	0	1	0	**0**
PRIVATE	0	0	0	0	**0**
TOTAL	**0**	**0**	**0**	**0**	**4**

Aquifer wise Characteristics

*Aquifer Group **	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	114	2450	3478	0.72	$1.38*10^{-3}$

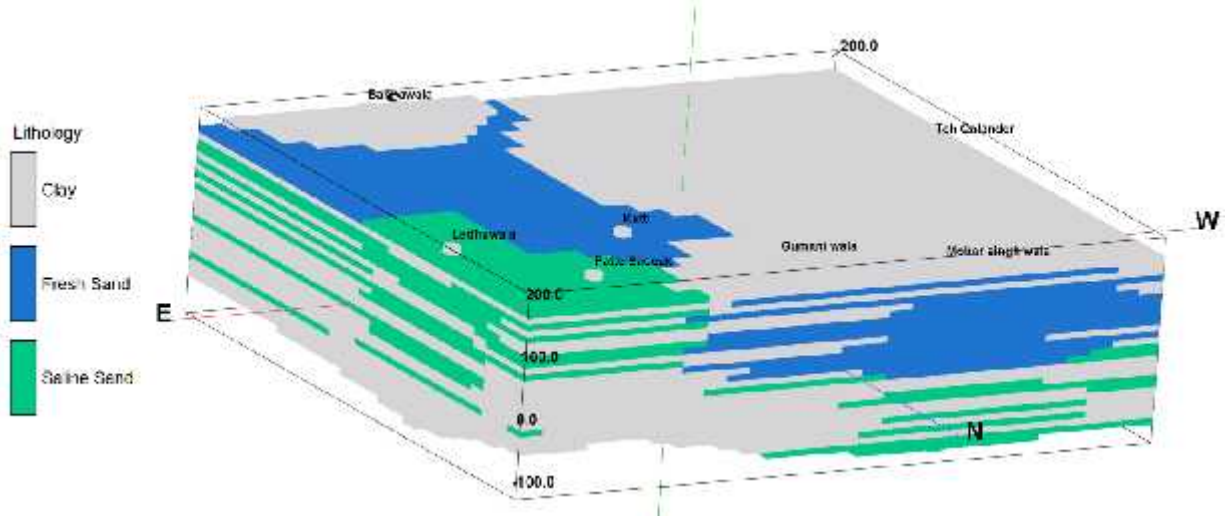
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

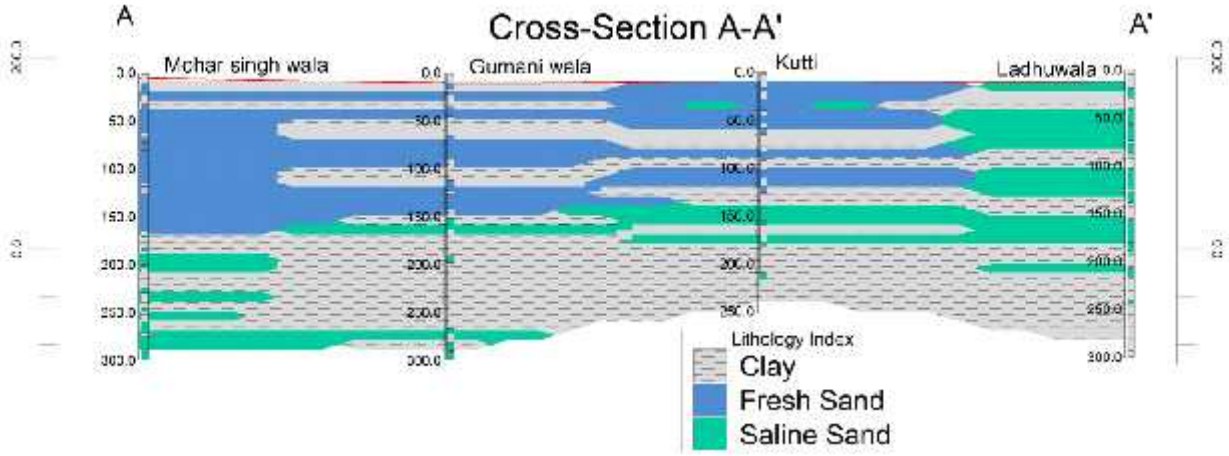
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	0	3	**0**
WRED/PSTC/WSS	0	0	1	0	**0**
PRIVATE	0	0	0	0	**0**
TOTAL	**0**	**0**	**0**	**0**	**4**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

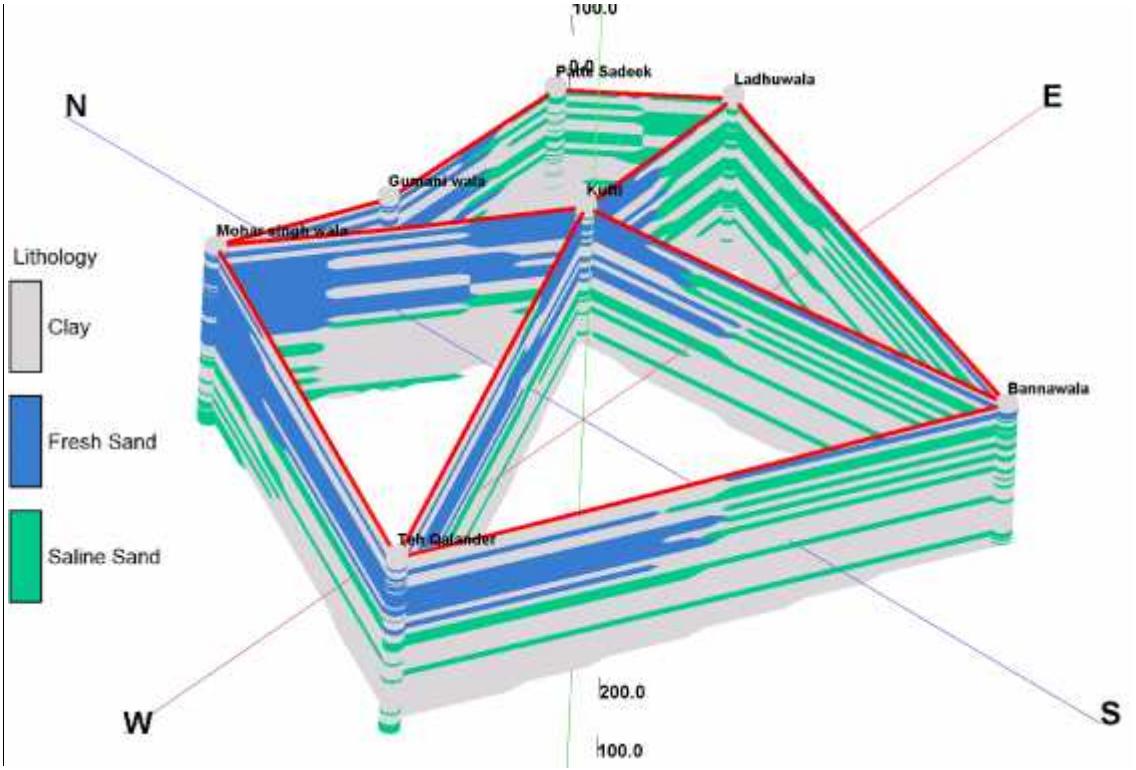
3-D Lithological model of Jalalabad Block



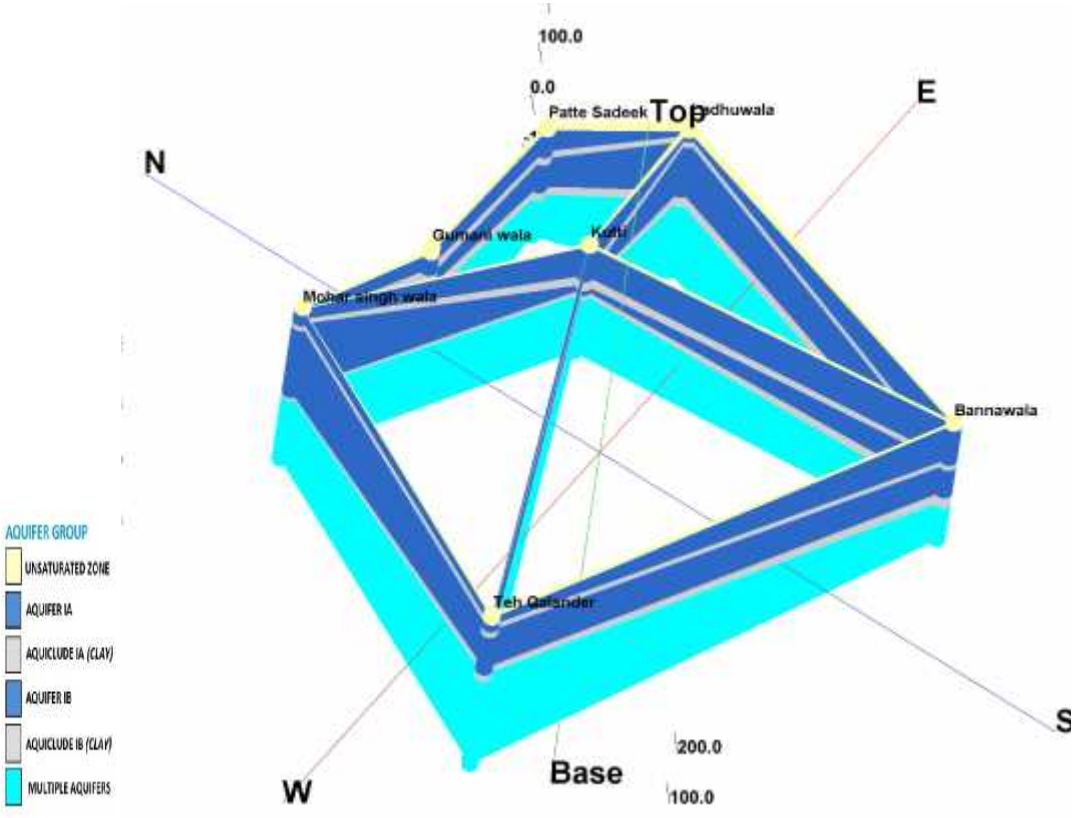
Lithological Cross section from Mohar Singh Wala to Saduwala



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	220.32 mcm
	In-storage Fresh water resources	2288.51 mcm
	In-storage Saline water resources	169.20 mcm
	Total	2678.03 mcm
Ground Water Extraction (as per 2013)	Irrigation	304.03 mcm
	Domestic & Industrial	6.9 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		9.55 mcm
Stage of Groundwater Development		141 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges near to 8.53. Ground water in the area is fresh to marginal saline. EC value of

	the ground water show wide variations and ranges from 555 μS/cm to 3774μS/cm at 25^0C.
Ground water Contamination Issues	NA
Other issues	Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 503.42 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 2.65 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered 522.4 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 54.64 mcm

Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean 3 % of the total rice area needs to change.*
Area coverage: 10.432 sq km
Anticipated volume of water to be saved: 10.432 mcm

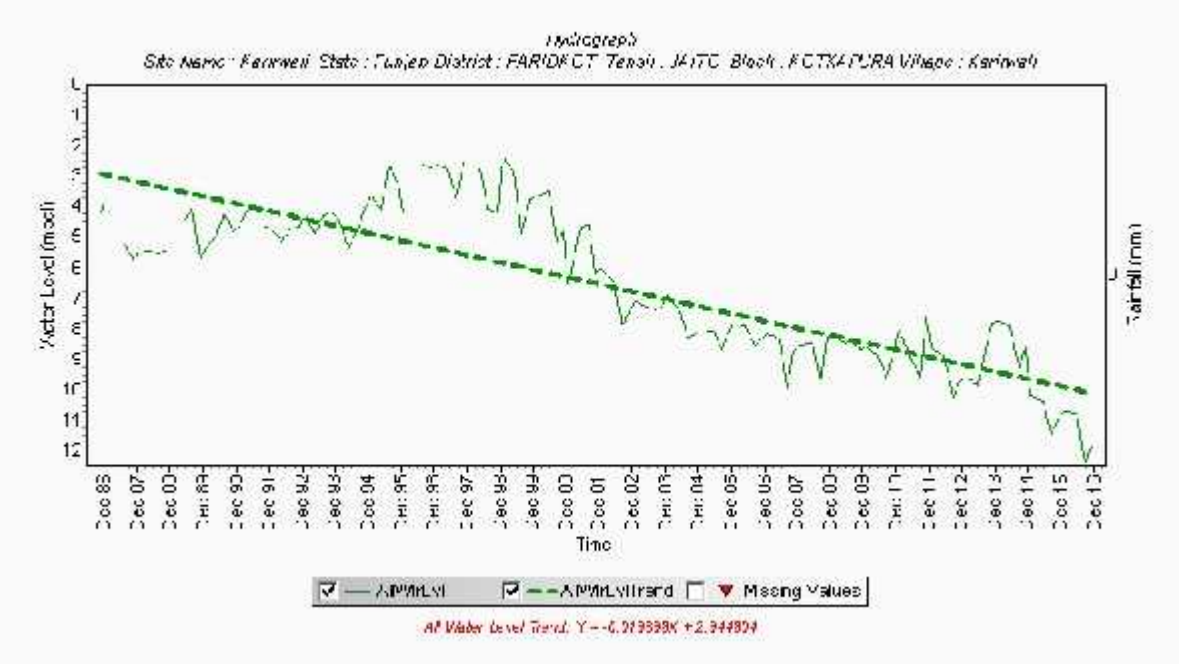
Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Change Paddy to Maize/ soya bean (Sq km)*	*Reduction in Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize (%)*	*Percentage of Crop Diversified area*
220.3	304.0	6.9	326	10.432	10.432	293.59	141	4.7	3

8. Salient Information

Name of the Block and Area (in Km^2)	**FAZILIKA** **859.2 sq km**
District/ State	Fazilika, Punjab
Population	Urban Population: 5770 Rural Population: 181209 Total population: 186979
Rainfall	Normal Monsoon: 272 mm Non-monsoon Rainfall : 50 mm Annual Average Rainfall: 326 mm
Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 100% Number and types of abstraction structures: 13771 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 3212 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 117 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 47 m. Saline water resources are estimated based on the available depth of wells existed up to 250 m and the granular zones are counted after the depth of 117 m and available zones are 57 m. Block is categorized as Over-Exploited as aper Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 378.59 mcm Domestic and industrial water supply: 8.19 mcm *Future water demands* Irrigation development potential : -122.27 mcm Domestic and industrial water supply up to 2025 years : 11.16 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr

HYDROGRAPHS



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Younger Alluvium, Aeolian Alluvium

Aquifer wise Characteristics

Aquifer Group *	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	104	NA	NA	NA	NA

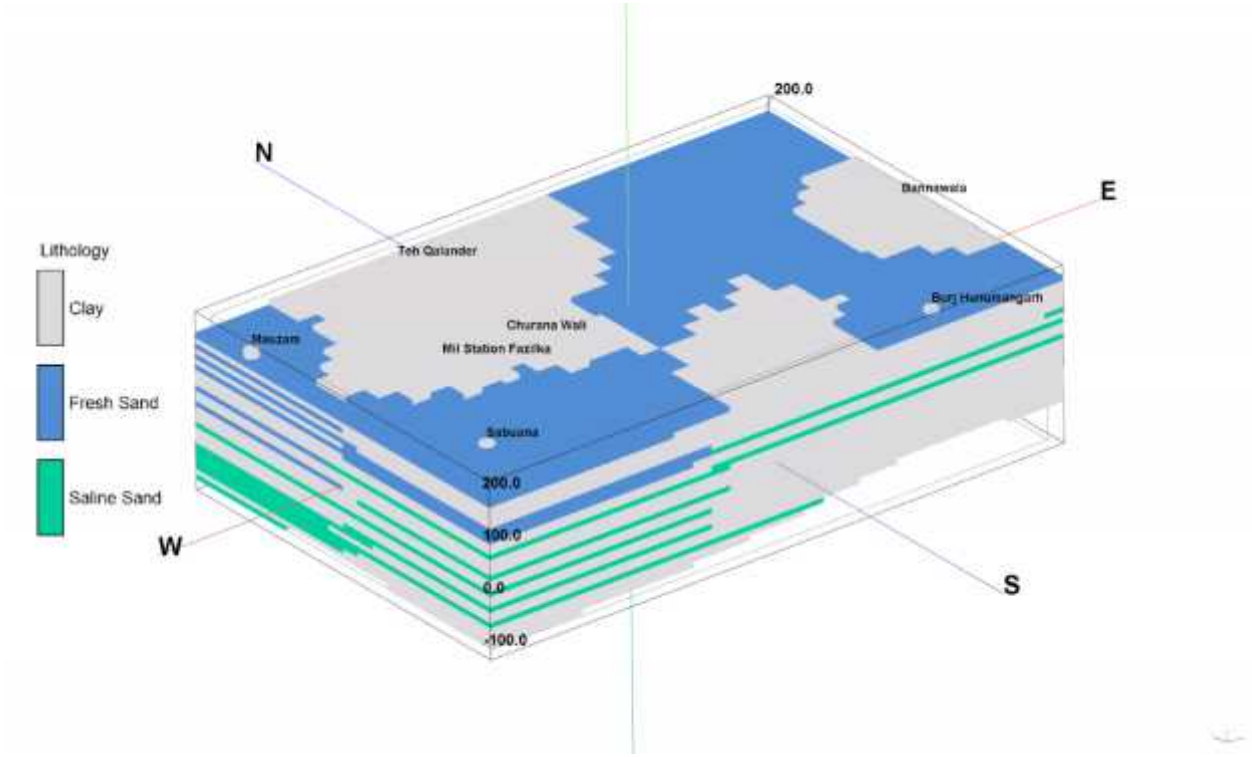
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

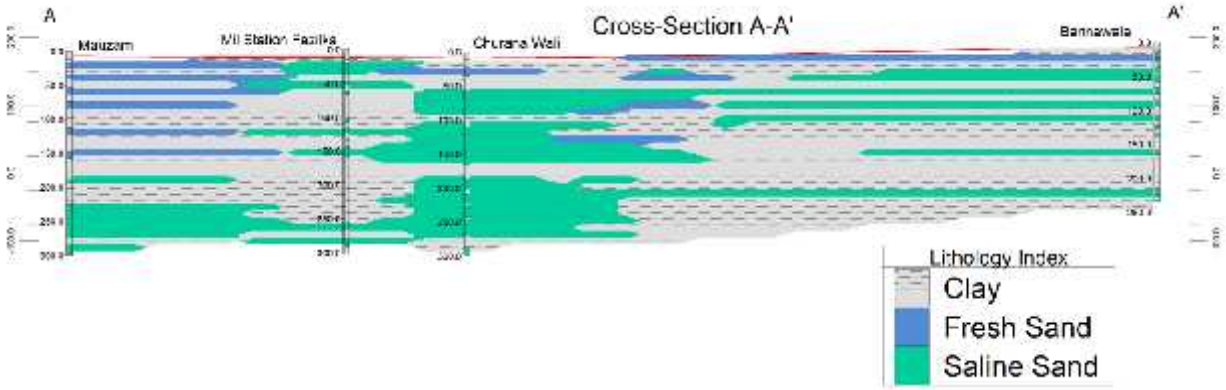
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB	0	0	0	4	**4**
WRED/PSTC/WSS	0	0	2	0	**2**
PRIVATE	0	0	0	0	**0**
TOTAL	**0**	**0**	**2**	**4**	**6**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

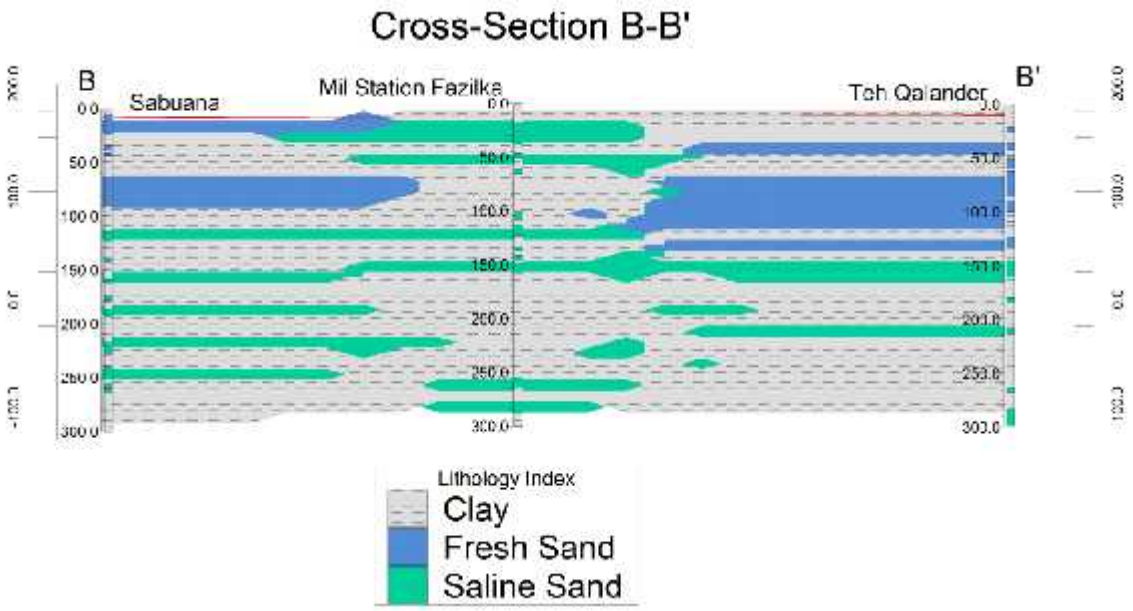
3-D Lithological model of Fazlika Block



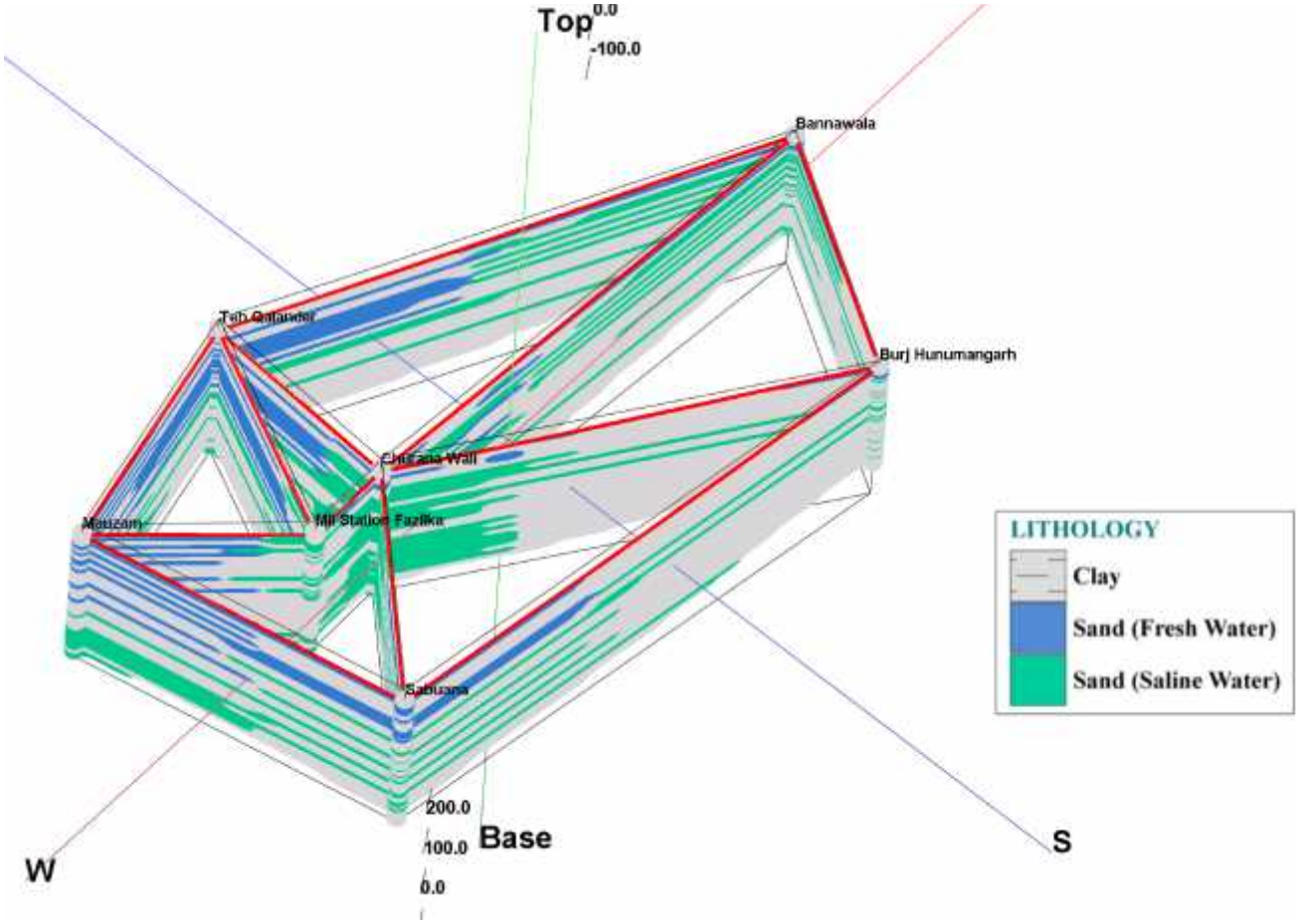
Lithological Cross section from Mauazam to Bannawala



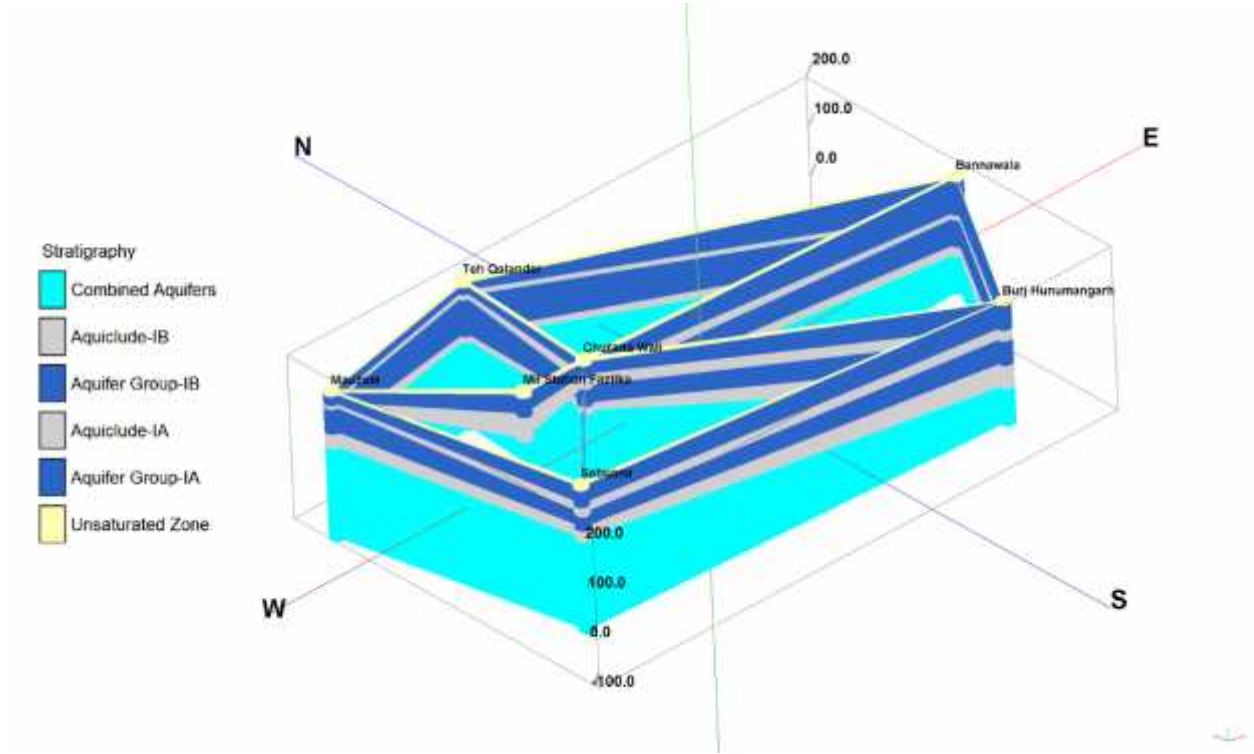
Lithological Cross section from Sabuana to Teh Qalander



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	267.11 mcm
	In-storage Fresh water resources	2731.56 mcm
	In-storage Saline water resources	213.41 mcm
	Total	3212 mcm
Ground Water Extraction (as per 2013)	Irrigation	378.59 mcm
	Domestic & Industrial	8.19 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		11.16 mcm
Stage of Groundwater Development		145 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.49 to 8.84. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges from 649 µS/cm to 787µS/cm at 25^0C.

Ground water Contamination Issues	NA
Other issues	Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 721.73 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 3.51*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: 859.20 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 68.04 mcm

Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean 7.3 % of the total rice area needs to change.*
Area coverage: 19.5 sq km
Anticipated volume of water to be saved: 19.5 mcm

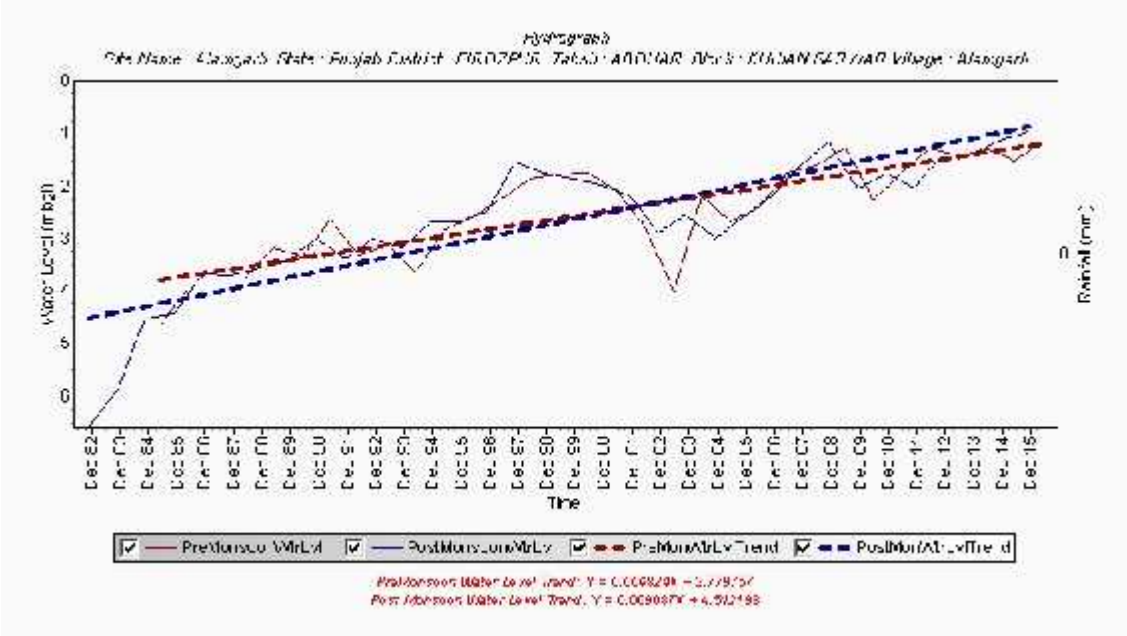
Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Change Paddy to Maize/ soya bean (Sq km)*	*Reduction in Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize (%)*	*Percentage of Crop Diversified area*
267.5	378.6	8.2	230	19.55	19.55	359.04	145	137	7.3

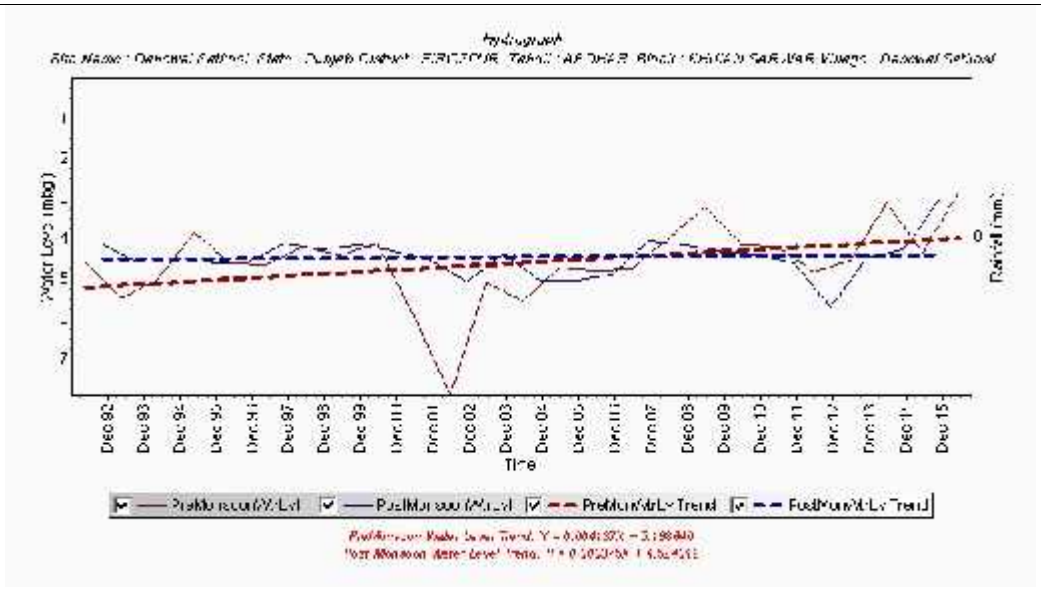
9.0 Salient Information

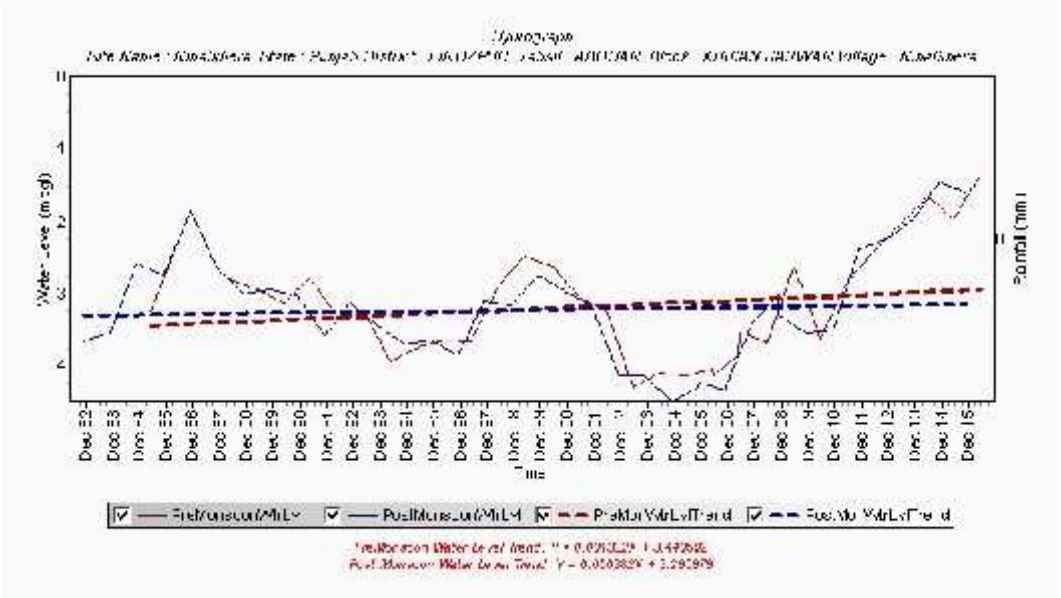
Name of the Block and Area (in Km^2)	**KHUIAN SARWAR** **845.4 sq km**
District/ State	Fazilka, Punjab
Population	Urban Population: 0 Rural Population: **183688** Total population: **183688**
Rainfall	Normal Monsoon: 249 mm Non-monsoon Rainfall : 49 mm Annual Average Rainfall: 326 mm
Agriculture and Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 100% Number and types of abstraction structures: 3327 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 5560 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 155 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 93 m. Saline water resources are estimated based on the available depth of wells existed up to 300 m and the granular zones are counted after the depth of 155 m and available zones are 73 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.

Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 75.97 mcm Domestic and industrial water supply: 3.44 mcm *Future water demands* Irrigation development potential : -6.735mcm Domestic and industrial water supply up to 2025 years : 4.79mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr

HYDROGRAPHS




Hydrograph
Water Level (mbgl)
Rainfall (mm)
Time
Dec 92
Dec 93
Dec 94
Dec 95
Dec 96
Dec 97
Dec 98
Dec 99
Dec 00
Dec 01
Dec 02
Dec 03
Dec 04
Dec 05
Dec 06
Dec 07
Dec 08
Dec 09
Dec 10
Dec 11
Dec 12
Dec 13
Dec 14
Dec 15
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend


Hydrograph
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend

Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Aeolian Alluvium

Aquifer wise Characteristics

*Aquifer Group **	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	166	NA	NA	NA	NA

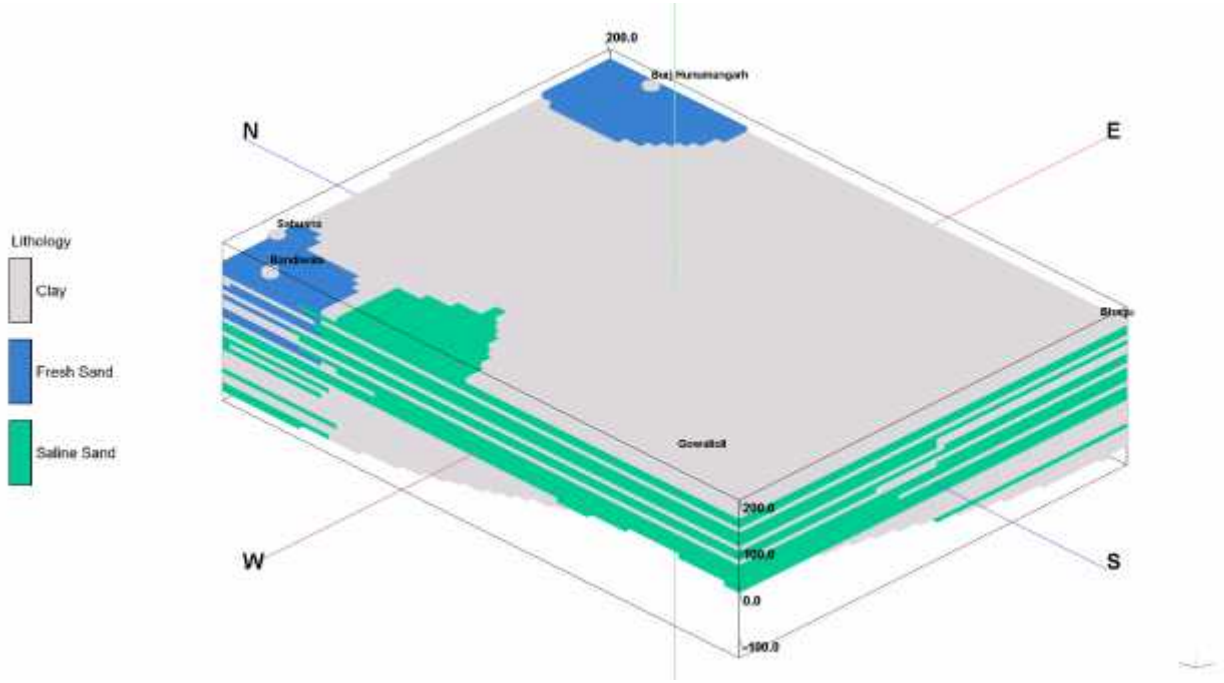
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB		1		2	**3**
TOTAL		**1**		**2**	**3**

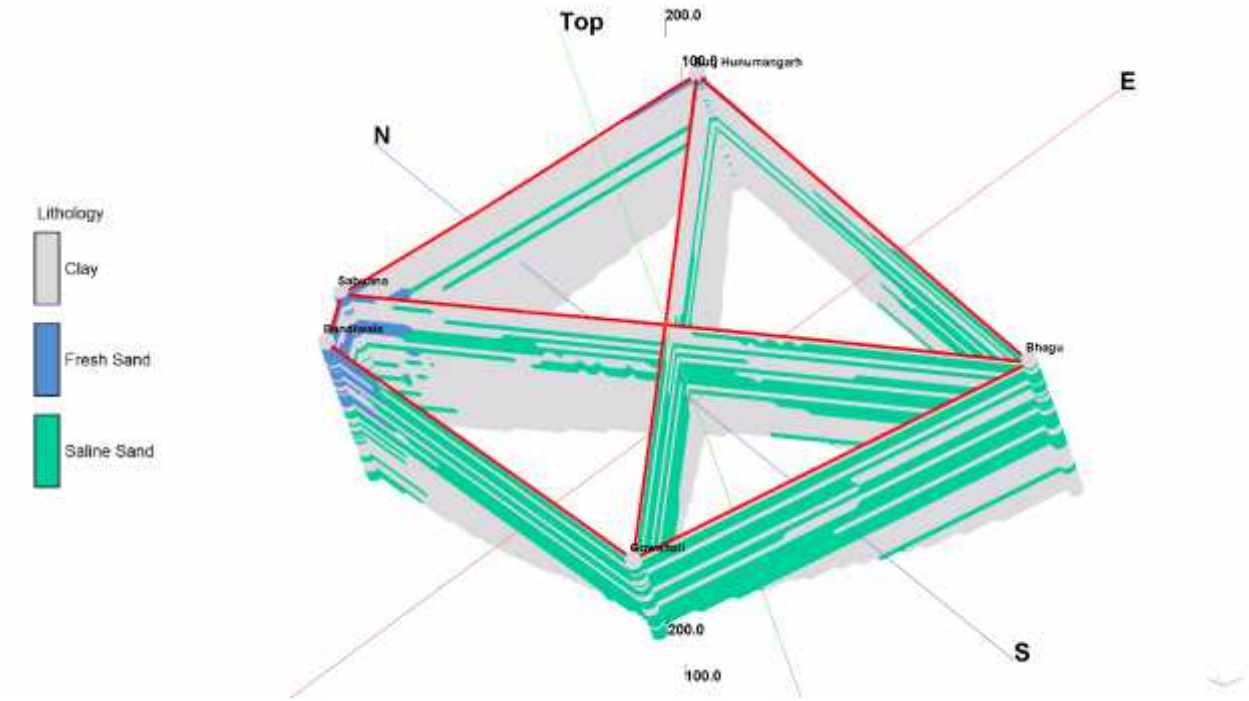
The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

3-D Lithological model of Khuian Sarwar Block

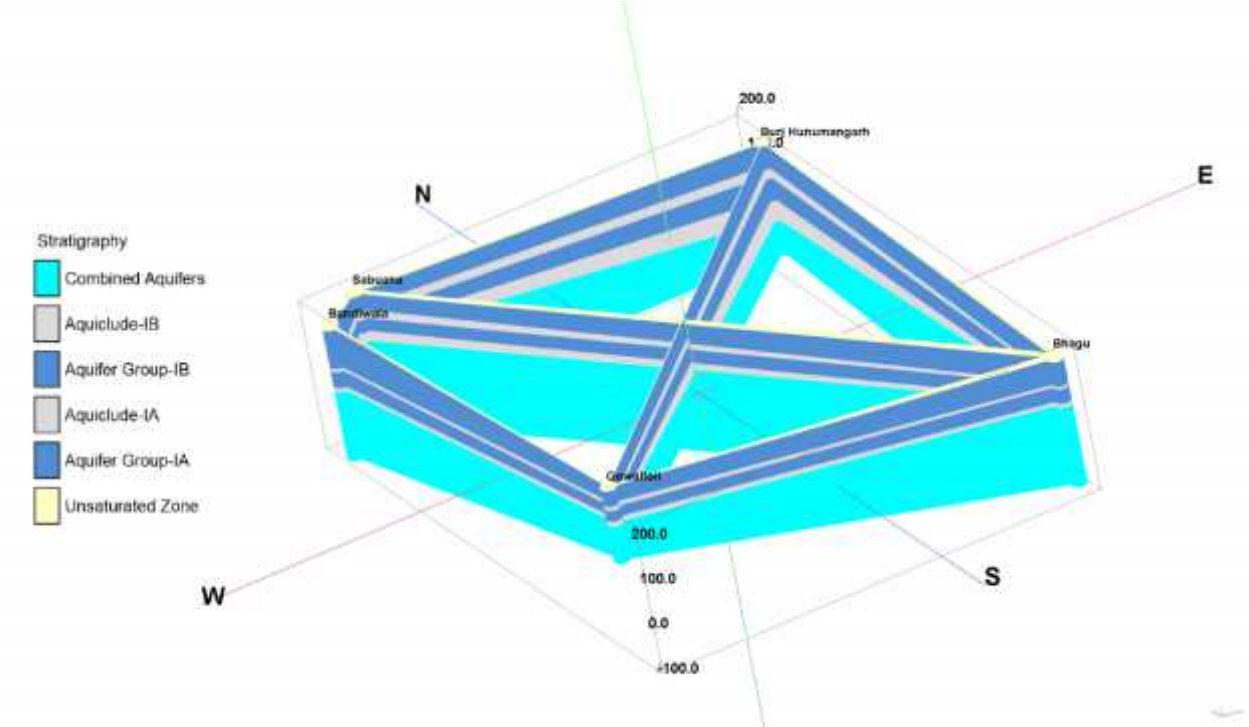


Lithological Cross section from Sabuana to Gowaltoli

3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	148.11 mcm
	In-storage Fresh water resources	4502.3 mcm
	In-storage Saline water resources	909.29 mcm
	Total	5560 mcm
Ground Water Extraction (as per 2013)	Irrigation	75.97 mcm
	Domestic & Industrial	3.44 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		4.79 mcm
Stage of Groundwater Development		95 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 8.0 to 8.83 Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges from 1274 μS/cm to 5812 μS/cm at 25^0C.
Ground water Contamination Issues		*Fluoride (mg/l):* Khuain Sarwar (3.39),: *Nitrate (mg/l):* Almargarh (146), Danewal (240)
Other issues		Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources. In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 608.69 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 0.0 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices
Area proposed to be covered: 845.4sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 13.65 mcm

Change in cropping pattern : Not Required

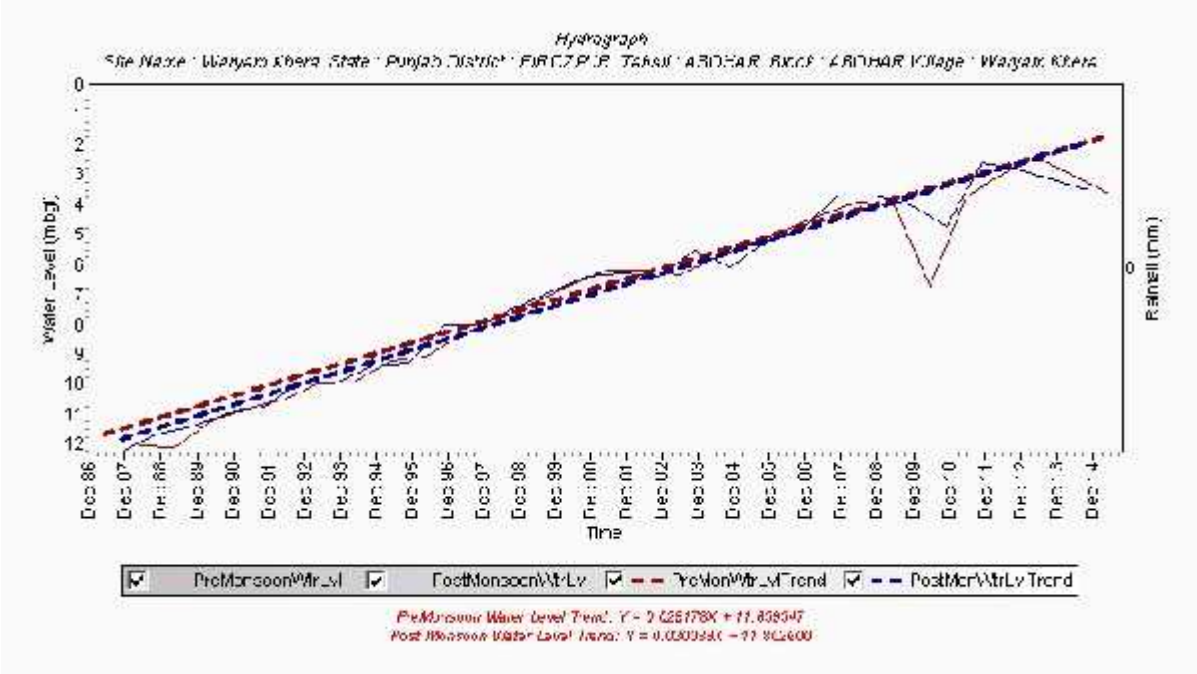
Proposed change in cropping pattern: Not Required
Area coverage: Not Required
Anticipated volume of water to be saved : Not Required

10.0 Salient Information

Name of the Block and Area (in Km^2)	**ABOHAR** **672.9 sq km**
District/ State	Fazilka, Punjab
Population	Urban Population: Rural Population: 221202 Total population: 221202
Rainfall	Normal Monsoon: 195 mm Non-monsoon Rainfall : 15 mm Annual Average Rainfall: 340 mm
Irrigation	Irrigation practices: Canal and Tube well Irrigation Cropping intensity: 100% Number and types of abstraction structures: 4732 nos., Tubewells
Ground Water Resource Availability and Extraction	**Ground water Resources Availability** Ground Water Resources are available in 1535 mcm (fresh and saline water resources) up to the depth of 300 m. The fresh water resources are estimated up to the depth of 18 m based on geophysical interpretations interface. The potential granular zones are available for fresh water is 3 m. Saline water resources are estimated based on the available depth of wells existed up to 300 m and the granular zones are counted after the depth of 18 m and available zones are 135 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment. **Ground water Resources Extraction** Deeper aquifers are marginal to highly saline and it is not suitable for irrigation purpose so that all users are tapping at shallow aquifers only. State government drinking water supply wells tapped at shallow aquifers and canal supply water are used for domestic and Irrigation purpose. So that the ground water draft could not be addressed for deeper aquifer.
Existing and future water demands	*Existing Gross Ground water Draft as on 2013* Irrigation: 98.61 mcm Domestic and industrial water supply: 9.54 mcm *Future water demands* Irrigation development potential : 185.41 mcm Domestic and industrial water supply up to 2025 years : 13.31 mcm

Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 2.35 – 16.00 m bgl Post Monsoon: 1.55 – 18.20 m bgl Mean (10 yrs) : 1.58 – (-)0.86 m/yr *Trends* Pre Monsoon: 0.16 – (-)0.26 m/yr Post Monsoon: 0.15 – (-)0.29 m/yr

HYDROGRAPHS



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Aeolian Alluvium

Aquifer wise Characteristics

*Aquifer Group **	*Geology*	*Type of Aquifer*	*Thickness of Granular zones (m)*	*Transmissivity (m^2/day)*	*Yield (m^3/day)*	*Specific Yield %*	*Storativity*
Aquifer -I	Quaternary Alluvial deposits	Unconfined to confined	138	NA	NA	0.72	NA

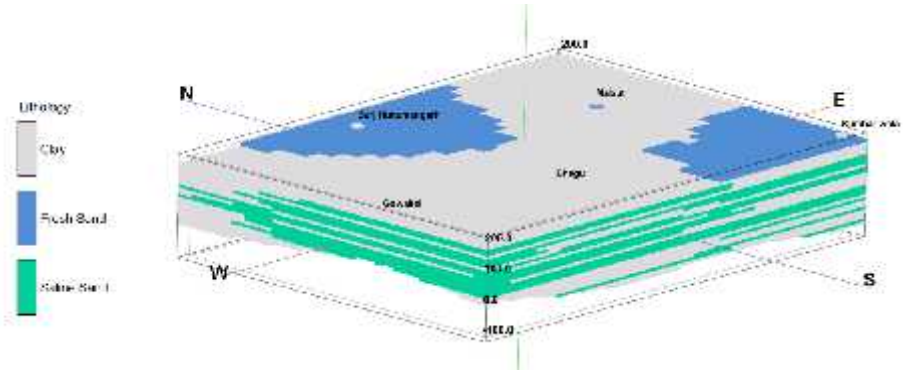
The Aquifer comprises of both fresh and saline water and the main aquifer material is sand. The non-aquifer material comprise of clay, clay with silt.

Exploratory Data Validated

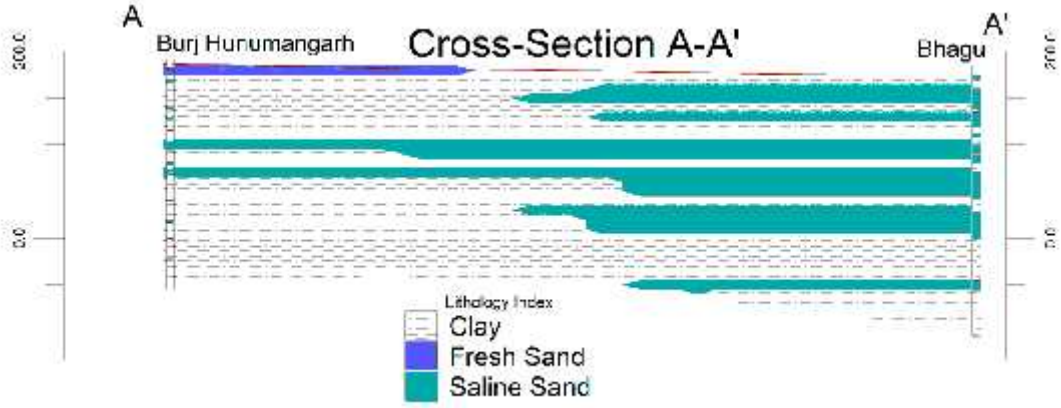
Source of Data	*No. of exploration wells as per depth range (m)*				*Total*
	<100	*100-200*	*200-300*	*>300*	
CGWB			1		**1**
TOTAL			**1**		**1**

The data is validated by selecting the deepest well in each quadrant and used for preparation of 3-D Litho models, 2-D geological cross sections, Fence diagrams and aquifer maps.

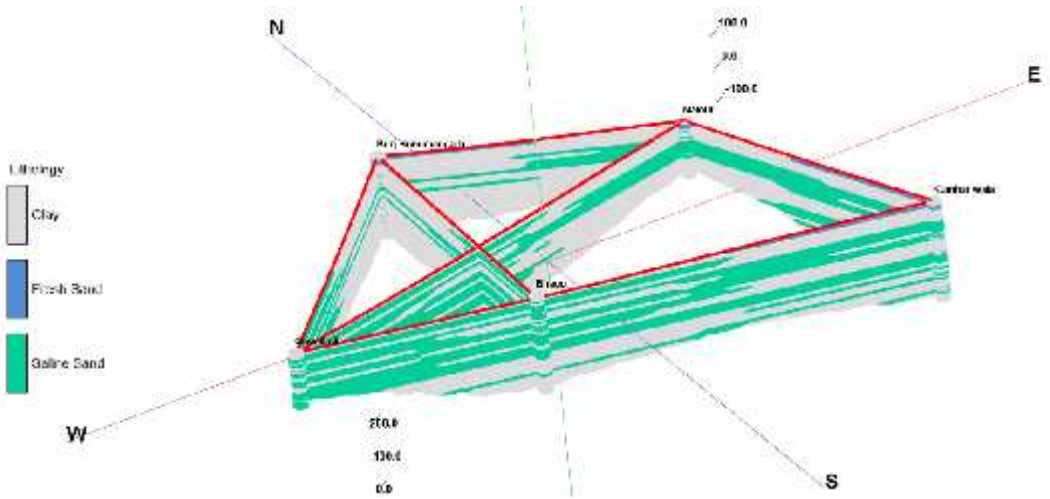
3-D Lithological model of Abhor Block



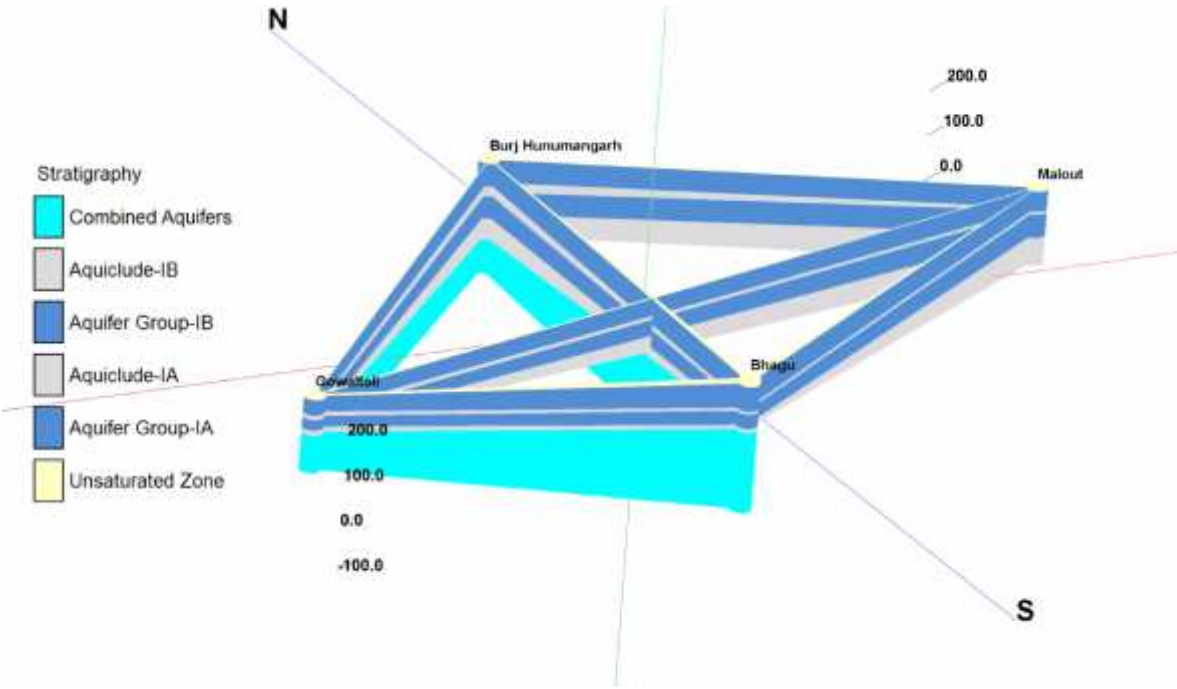
Lithological Cross section from Burj Hanumangarh to Bhagu



3-D Lithological Fence Diagram



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources	297.3 mcm
	In-storage Fresh water resources	246.63 mcm
	In-storage Saline water resources	991.44 mcm
	Total	1535 mcm
Ground Water Extraction (as per 2013)	Irrigation	98.61 mcm
	Domestic & Industrial	9.54 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		13.33 mcm
Stage of Groundwater Development		36 %
Chemical Quality of ground water		Ground water in the area is alkaline and pH ranges between 7.74 to 9.13. Ground water in the area is fresh to marginal saline. EC value of the ground water show wide variations and ranges from 618 µS/cm to 3906 µS/cm at 25^0C.
Ground water Contamination Issues		*Fluoride (mg/l):* Bazidapurabl (9.11), Dhilwan Kalan (3.10), Matta (2.75):

	Nitrate (mg/l): Abohar (472), Kundal (221)
Other issues	In shallow water level area, less development of ground water resource couple with recharge from canal irrigation is causing water logging and inland salinity problems.

Ground water Resource enhancement

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)

Aquifer-I:

Volumes of unsaturated zone after 3m upto a desirable depth: 242.24 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: --
Other interventions proposed*: Artificial Recharge, Roof top Rainwater harvesting will save 0.0 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices
Area proposed to be covered: 672.9 sq km
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 17.72 mcm

Change in cropping pattern Not Required

Proposed change in cropping pattern: Not Required
Area coverage: Not Required
Anticipated volume of water to be saved: Not Required

Alternate Water sources
Surface water sources: *Tanks, Ponds*

Regulation and Control: Punjab Subsoil Act, 2009 for delay in paddy plantation should continue in this area.