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

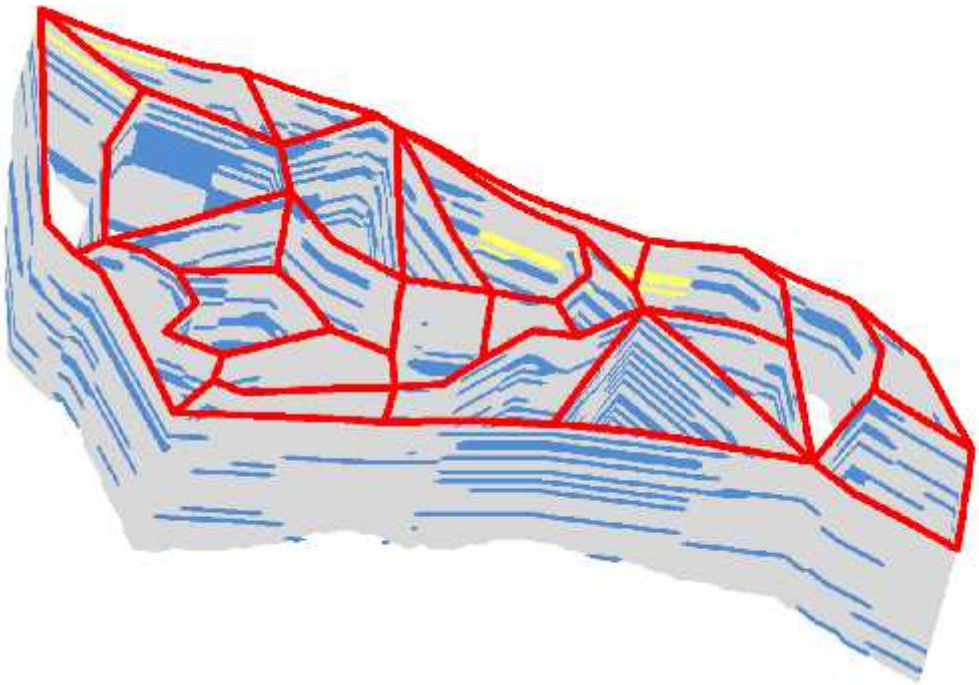
AQUIFER MAPPING AND MANAGEMENT PLAN

SAS Nagar District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING & MANAGEMENT PLAN OF SAS NAGAR DISTRICT, PUNJAB



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2017

AQUIFER MAPPING AND MANAGEMENT PLAN
SAS NAGAR (MOHALI) DISTRICT
(1189 Sq Km)

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1.0 INTRODUCTION

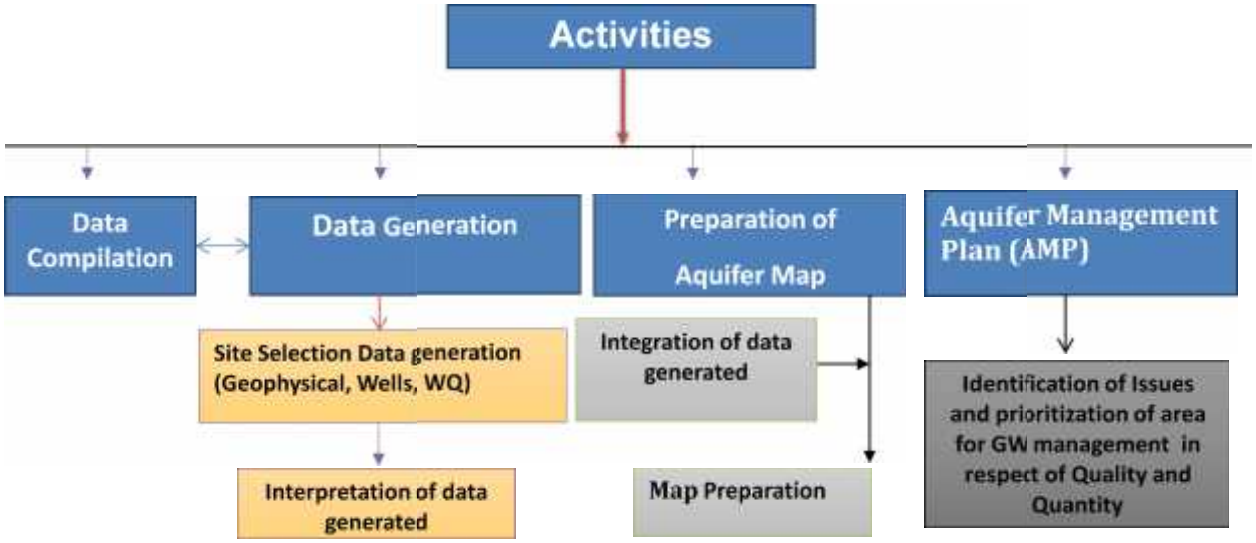
The primary objective of the Aquifer Mapping can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst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

The district SAS Nagar is named before its district headquarters, the town SAS Nagar, also known as Mohali. The town SAS Nagar has been named after the name of Sahibzada Ajit Singh elder son of Sh. Guru Gobind Singh Ji, 10th Guru of Sikh religion. The District came into existence on 13th April, 2006 (Baisakhi day). The SAS Nagar is a satellite city of Chandigarh. Mohali district lies in the eastern part of Punjab State. The area falls in the Survey of India Toposheet Nos. 53B/ 9,10,13 &14 lies between 30°21'00" to 30°56'00" North latitude and 760 30' to 760 55' East longitude covering an area of 1189 sq km (Fig.1). It is bounded by Patiala and Fatehgrah Sahib Districts in the south-west, Ropar district in the northwest, Chandigarh U.T. and Panchkula district in the east and Ambala district of Haryana state in the south.

The elevation of land surface ranges between 380m above m.s.l. at north east to 280 m a.msl towards south west. The district was created by carving out 2 blocks (Sialba Majri and Kharar) from Ropar district and one block (Derabassi) from Patiala district. Administratively, the district is divided into 3 tehsil viz.,Derabassi, Mohali & Kharar comprising of 3 development blocks and includes 433 villages. All the towns of the district fall on railway line. Most of the area of the district is plain having loam to silt clay & well drained soils except along the Ghaggar River and choes where some sandy patches are found. Some area comprises of Majri & Derabassi block falls in Kandi Area with slight to moderate soil erosion. The Ghaggar river passes close (3 to 6 km) to the towns of Derabassi & Zirakpur.

The total population of the district is 9,94,628 ,as per 2011 census. The total rural population is 544611 (59.74%) and the urban population is 450017 (40.26%) and the decennial growth rate is 30.02 % (2001-2011). Population density of district is 830 persons/sq. km. Mohali has a sex ratio of 879 females for every 1000 males and literacy rate of 83.80%.

1.5 Climatic Conditions: Rainfall and Climate

The climate of the district is classified as tropical steppe, semi-arid and hot which is mainly dry except in rainy months and characterized by intensely hot summer and cold winter. The temperature ranges from 40.40 C (May/June) to 7.10 C (December/January) and maximum temperature was observed is 470C.

The average annual rainfall is 617 mm, and Normal Annual rainfall is 1061 respectively, which is unevenly distributed over the area 49 days .Monsoon rainfall contributes 70% of annual rainfall in the district. The rainfall increases from southwest to northeast in the district. Monthly wise rainfall is given in below table.

Monthly wise Rainfall of Mohali District in mm (IMD, Chandigarh)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2010	0	0	0	0	3.2	137.5	507.6	162.4	195.3	21	0	59	1086
2011	13	20.6	1	2.5	33.8	62	89.3	59.7	84.5	0	0	4	370.4
2012	19.7	1.7	0	5.4	1	2	110.2	83.6	191.3	1	0	0	415.9
2013	3	16	15.3	0	3	241	103	188	58	14	2	3	646.3
2014	56.5	52	43	18	34	18.8	179.5	71.2	87	9.3	0	42.3	611.6

1.6 Geomorphology & Soil Type

The study area can be broadly grouped into two depending upon its geomorphic features as alluvial fan and alluvial plains. Alluvial fans are deposited by hill torrents with a wavy plain rather than a steep slope. Adjacent to the alluvial fan are the alluvial plains which forms a part of large Indo- Gangetic basin comprises of thick sand and silty sand layers interbedded with silt and clay beds of Quaternary Age. The alluvial plains are of vital economic value as it supports the dense population of the area.

The soils are mainly developed on alluvium under the dominant influence of climate followed by topography and time. The major soil type of the district is weakly solonized tropical arid brown soils.

1.7 Land Use/ Land Cover

The size of operational holdings in this area is generally very small. The main classes are Built Up land, Agricultural land, forestland, Land under non agriculture use, and water body. The land use pattern of the study area is given in below table

Land use pattern of SAS Nagar (Mohali) District, Punjab

Type of Land use	Area (hectares)
1. Total Geographical area	111000
2. Forest	16000
3. Current Fallows	1000
4. Land put to non-agricultural use	15000(14 %)
5. Net area sown	77000(86 %)
6. Gross cropped area	109000
7. Cropping intensity	142%

(Source: Statistical Abstract, Punjab, 2015)

1.8 River System and Water Resources

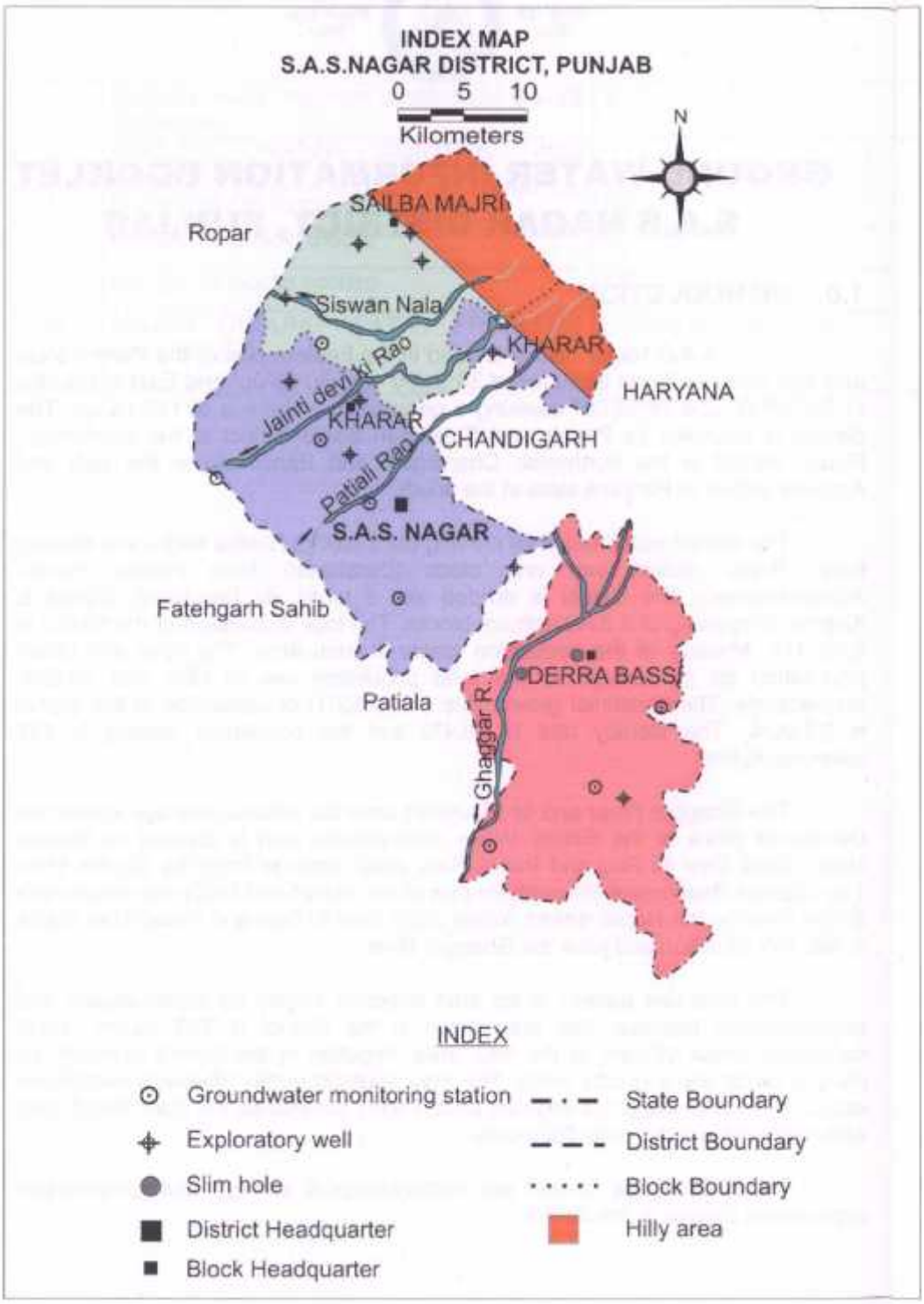
The study area has a well drainage system consisting of rivers and its tributaries. Ghaggar River and its major tributaries is the central part such as Siswan- nadi, Jainti devi ki Rao, Patiali Rao, Kansal nadi, Tangauri River, and Sirhind choa drain, all flow within the area (Fig.2). These channels exhibit fluvial deposits comprising of sand, silt and clay. Following the regional pattern of the slope of the area, all these streams are ephemeral in nature and flow in south –west direction except Sukhna choe (Seasonal). Sutlej Yamuna link (SYL) canal passes through the western part of the area.

1.9 Agriculture & Irrigation

Wheat, Paddy, cotton, potatoes and sugarcane are the principal major crops of the district. The maize & Sunflower crops are also cultivated in the district to some extent. The other crops grown in the area are oilseeds, gram, vegetables, etc. Main horticulture crops are viz., grapes, kinnow, ber, guava, peas, barley, garlic, bajra etc.

Irrigation in the district is carried out both by ground water. Tubewells are the main source of irrigation in the district. The total cropped area is 1, 09,000 hectares, which constitutes 100 % of the Net sown area. Net Irrigated area is 77,000 ha and Gross Irrigated Area 99,000 ha and Irrigation intensity is 129 %.

Fig.1: Index map of Mohali District



1.10 Industries

There are 212 Nos. small scale and 4 nos. large scale industries in the study area. The major industries are Paper mills, Food & beverages, Textiles, Machinery & Equipments etc.

1.11 Mineral Resources

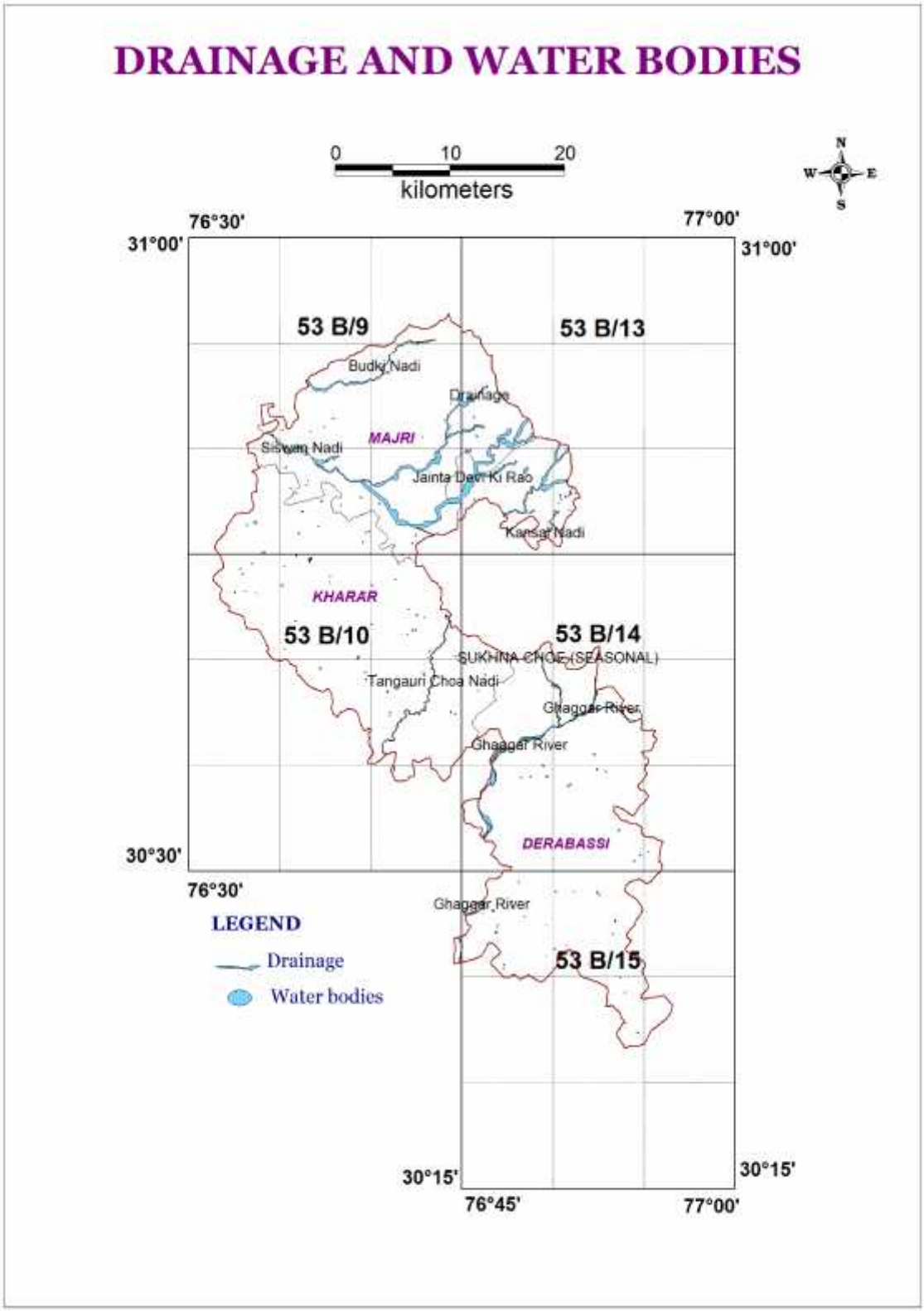
The district is poor as regards mineral wealth. A few minor minerals are, however, found are *Kankar*—It is massive, hard and com pact nodular calcareous material light grey to dark grey. Sand, silt and clay are found associated with kankar. It occurs mostly in the form of isolated beds and pockets. It can be used for white washing and road metalling. *Saltpetre* —Saltpetre is a general trade name for all the nitrates of sodium , potassiium and calcium. Nitrates of potassium are known as nitre of saltpetre whereas those of sodium are called sodanitre, caliche or chile salt petre. It is used in manufacture of gun powder, preparation of agricultural fertilizers, etc. *Alkaline Earth*—Some brick earth and foundary sands are reported from the district.

1.12 Water Conservation and Artificial recharge:

Artificial recharge structures may help in arrest decline in which Recharge Trench with injection well structure is the suitable for artificial recharge in all parts of the area due to water level decline trend. Central Ground Water Board (CGWB) has taken up rain water harvesting and artificial recharge studies in Sialba Majri Block, of the district.

Four pilot projects for artificial recharge to ground water were undertaken and same were completed successfully. The artificial structures proposed in these sites include lateral shaft and injection wells of 75 m deep. 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 Mohali District



2.0 DATA COLLECTION AND GENERATION

2.1 Geology and Hydrogeological data:

Geologically, the area is occupied by alluvial sediments of Quaternary age, consisting of Indo-Gangetic alluvium. Many of the streams draining the area originate from these Siwalik Hills and the lesser Himalayan range further north of it. The Quaternary sediments in the area, chiefly, comprises of clay, silt, sand and or the mixtures of the above with or without pebbles. The Quaternary alluvial sediments can be broadly classified under two distinct categories based on lithological characteristics viz. Older Alluvium and Younger Alluvium. Siwalik formations comprising sandstones, grits, clays, siltstones and conglomerates are exposed along the north eastern and eastern extremity of the district bordering HP State of Tertiary Period. The Older Alluvium occupy the major part of the area and form relatively higher ground where as the Younger Alluvium form narrow linear low lying tracts in between these Older alluviums. The generalized stratigraphic sequence of the area is given below,

Generalized Stratigraphy Sequence, Mohali District

Group	*Geological Age*	*Stratigraphic Units*	*Description*
Quaternary	Recent	Newer alluvium	Active flood plains and abandoned flood plain
	Pleistocene	Older alluvium	Bar uplands Sirowal deposit Piedmont deposit Alluvial fans and cones
Tertiary	Middle Miocene to Lower Miocene	Upper Siwalik Middle Siwalik Lower Siwalik	Hilly Terrain

Quaternary Alluvial deposits belonging to the vast Indo-Gangetic alluvial plains, which forms the main aquifer system. Groundwater occurs under phreatic conditions in the shallow aquifers while leaky confined to confined conditions occur along the deeper aquifers of Quaternary alluvial deposits.

Siwalik formations comprising sandstones, grits, clays, siltstones and conglomerates are exposed along the north eastern and eastern extremity of the district bordering HP State. The Kandi zone runs parallel to the Siwalik foothills comprising boulders, pebbles, gravel and clay. Silt and clay with sub-ordinate amount of sand, constitute the Sirowal zone. Kandi and Sirowal formations are contemporaneous. The alluvium is heterogeneous in character. Ground water in the area is fresh at all levels. The principal aquifer systems of the area are Alluvium and Sandstone and Major aquifer systems are older alluvium, pebbles/gravels and sandstones (Fig.4). The Principal and Major aquifer system are given in below table.

Principal and Major Aquifer Systems of SAS Nagar

S. No	Principal Aquifers Code	Principal Aquifers	Area	Major Aquifer Code	Major Aquifer	Area	% of Total Area	Age (As per Geological Time Scale)
1	**AL**	**Alluvium**	370.67	AL03	Older Alluvium	348.5	94	Quarternary
2								
3				AL06	Pebbles/ Gravels	22.17	53	Quarternary
4	**ST**	**Sandstone**	41.57	ST01	Sandstone/ Conglomerates	41.57	1	Upper Paleozoic to Cenozoic
Total			**412.24**				**148**	

* Area in Sq.Km.

2.1.1 Water Level Behavior

Fifteen monitoring stations of Central Ground Water Board (CGWB) (7 Piezometers and 8 Dug wells) and *sixteen* monitoring stations (16 Piezometers) of State government department represented shallow aquifer (Aquifer-I). Hydrograph of shallow observation wells are shown in Fig.3. *Two* monitoring stations (2 Piezometers) of State government departments represent Aquifer-II and there is no monitoring station for Aquifer-III. Depth to water level in the area ranges from 3.25 to 28.95 m bgl during pre-monsoon period (Fig.5) and 3.45 to 29.80 m bgl during post monsoon period (Fig.6). The major parts of the area having water levels 10 to 20 m. More than 20m water levels area observed in central and south western part. In the southern part water levels are <10 m bgl. Seasonal water level fluctuation shows a rise and fall in the range of 0.25 to (-) 4.88 meters respectively during the year 2015 (Annexure-I).

Fig.3: Hydrograph of Different Observation Wells of CGWB

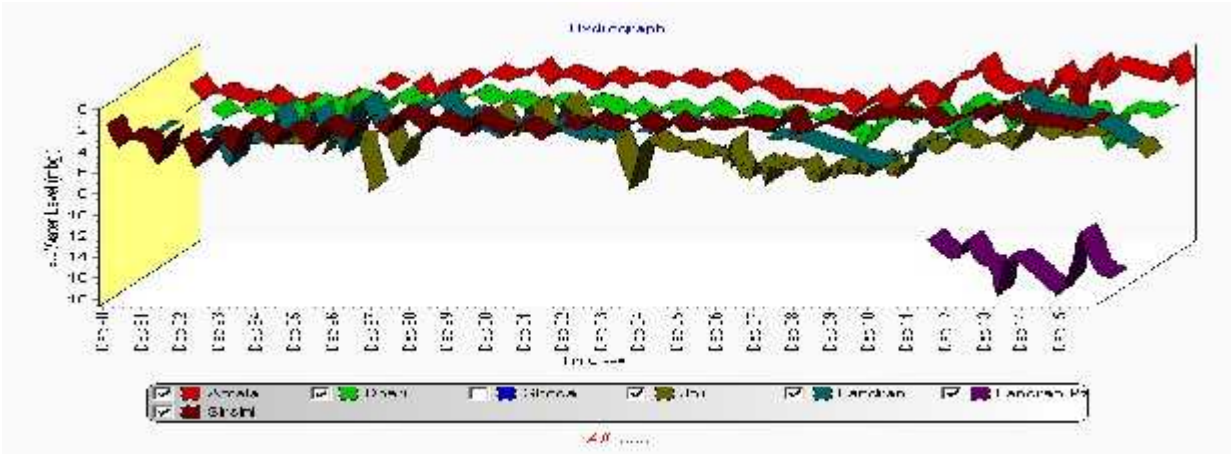


Fig.4: Major Aquifer

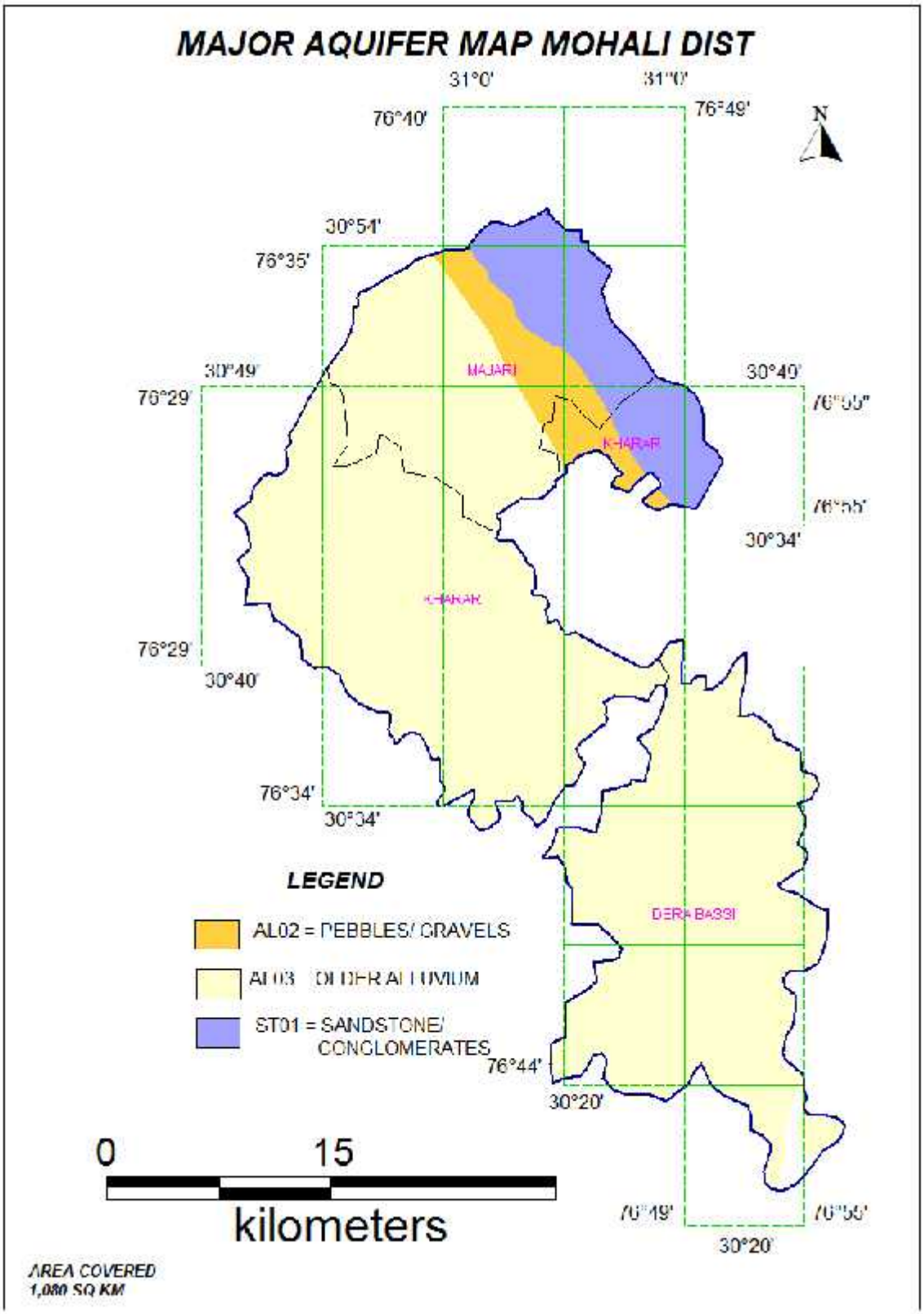


Fig.5: Depth to Water level Pre Monsoon, 2015

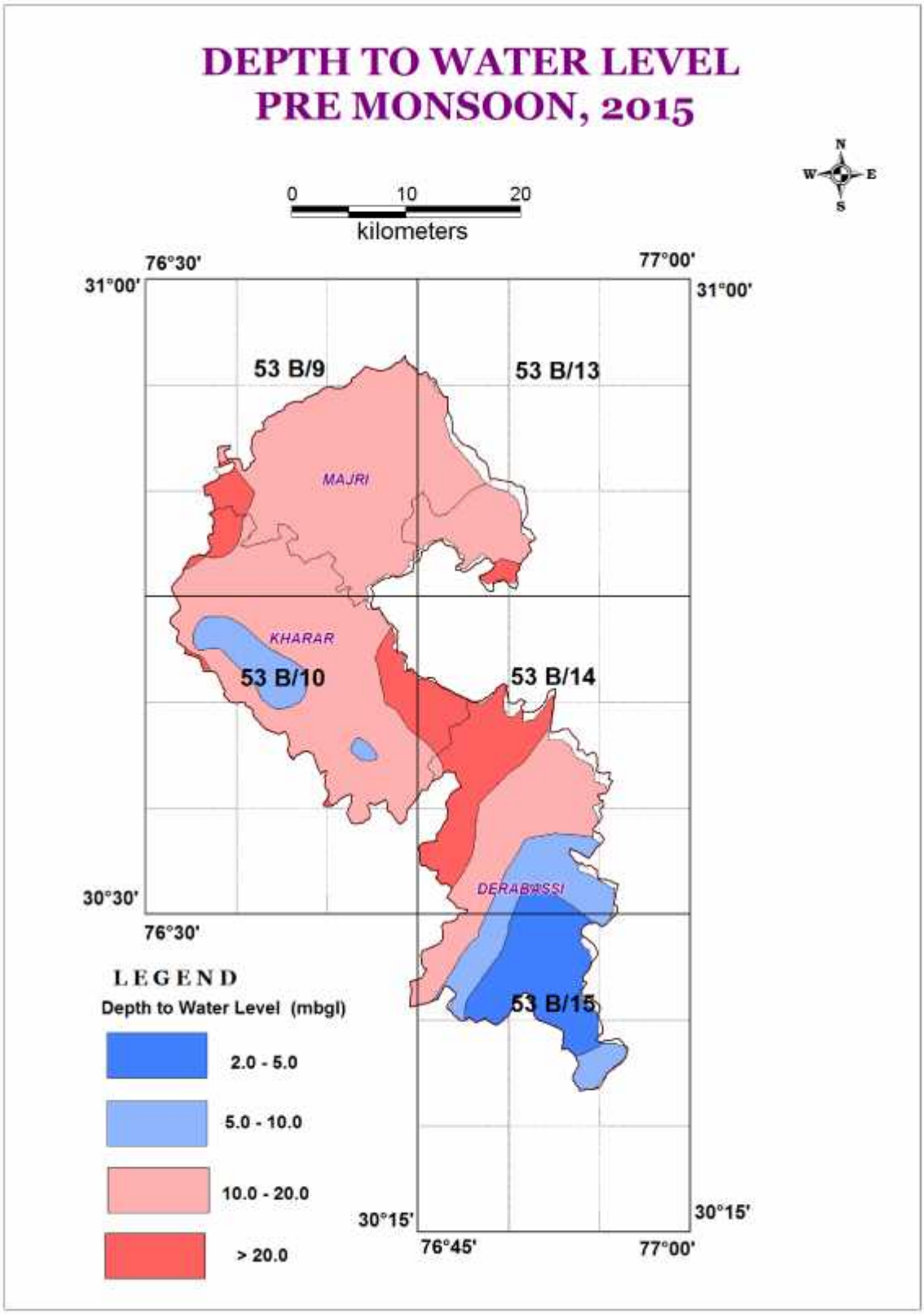
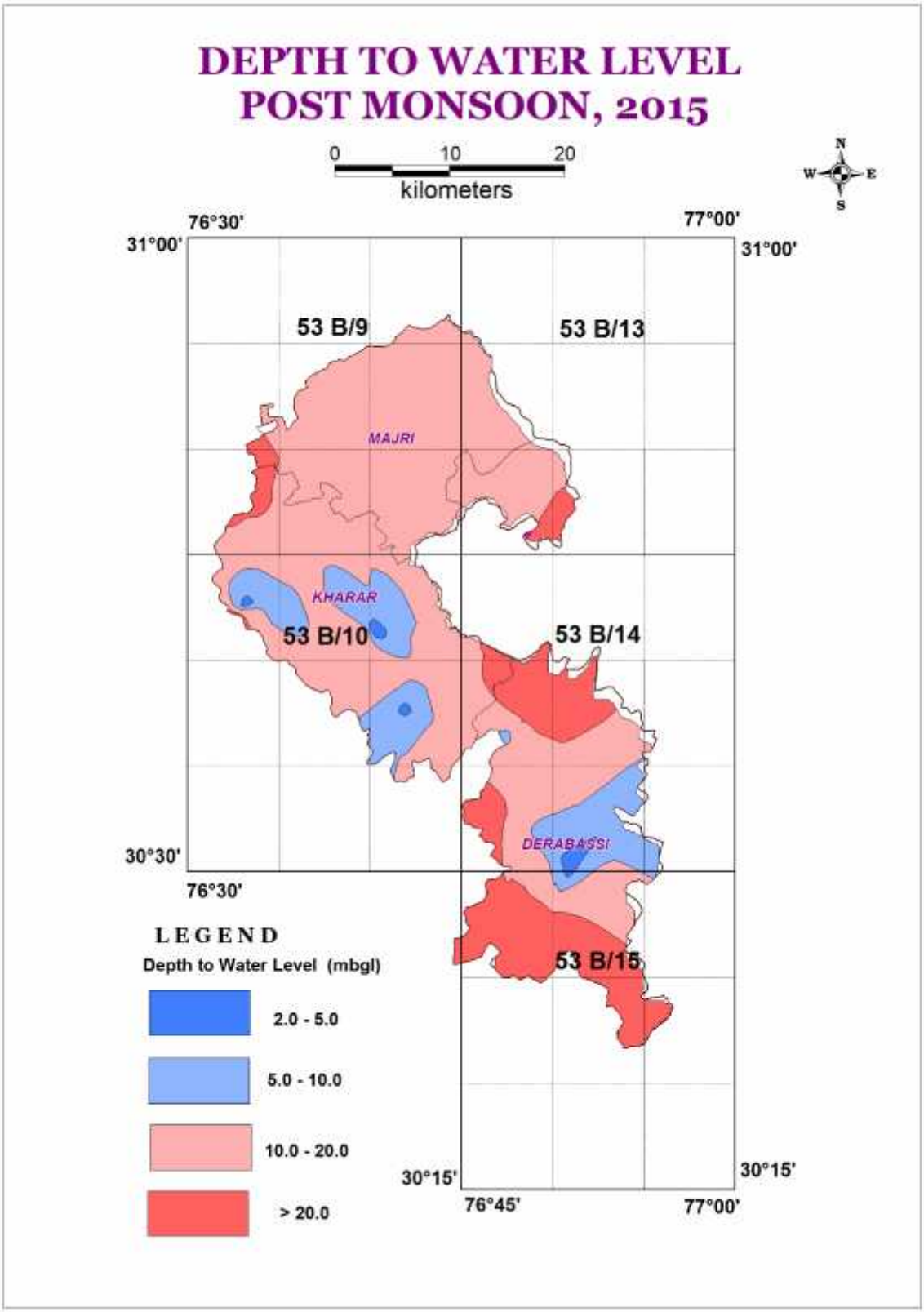


Fig.6: Depth to Water level Post Monsoon, 2015



2.2 Water Quality Data:

Ground water quality of shallow aquifer (Aquifer-I) is assessed based on chemical data of National Hydrograph Network stations i.e. NHNS monitored during Pre monsoon period. *Twelve* groundwater samples are collected and analyzed during NHNS, 2015, given in Annexure-II. The chemical quality of deeper aquifers has to be assessed during groundwater exploration programme under NAQUIM.

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline in nature where pH value in between 7.75 to 9.15. The Electrical Conductivity (EC) values ranges from 601 to 8970 µS/cm at 25^{o}C and seems to be fresh water. The EC values less than 1000 µS/cm have observed at five locations i.e. Ghoga (601), Handesaran (615), Dheri (765), Soara(875) and Joli (965) respectively. The EC values more than 1000 µS/cm have observed at six locations i.e. Antala (1240), Landran (1240), Gholu majra (1495), Sarsini (1545), Dera Bassi (2800) and Isarpur-II (8970) (Fig.7).

Salinity, chloride, fluoride and nitrate are the important parameters that are normally considered for evaluating the suitability of ground water for drinking uses. Generally it is suitable for drinking purposes as chemical parameters are within the permissible limits for safe drinking water set by Bureau of Indian Standard (BIS, 2012) except Fluoride and Nitrate at few places. The chloride concentration in ground water varies broadly between 13.9 mg/l at Ghoga and also 1549 mg/l at Isarpur-II.

Ground water with Fluoride concentration above permissible limit 1.5 mg/l is found mainly in Gholu majra (2.9), Nitrate concentration above permissible limit 45 mg/l is found in Isarpur (700), Derabassi (440), Antala (133) and Landran (118). Ground water with Iron concentration above permissible limit 1.5 mg/l are observed in Isarpur-I (12.53), Isarpur-II (25.83),Handesaran (6.28) and Sirsini (2.33).

Alkali hazards of irrigation ground waters are estimated through the computation of Residual Sodium Carbonate (RSC), also known as Eaton's Index. Classification based on RSC indicates that 1% of the waters are unsafe for irrigational use. Waters with RSC value <1.25 meq/L are safe for irrigational uses, RSC between 1.25 and 2.5 are marginal and waters with RSC value >2.5 meq/L are unsafe. RSC of ground waters are found to vary from (-28.40) to 9.50 meq/l. Classification based on RSC values indicates that Six Samples in Safe, Three Samples in Marginal and Two in Unsafe category for irrigational use. Analysing mechanism and equipments used for chemical analysis are given in table-1.

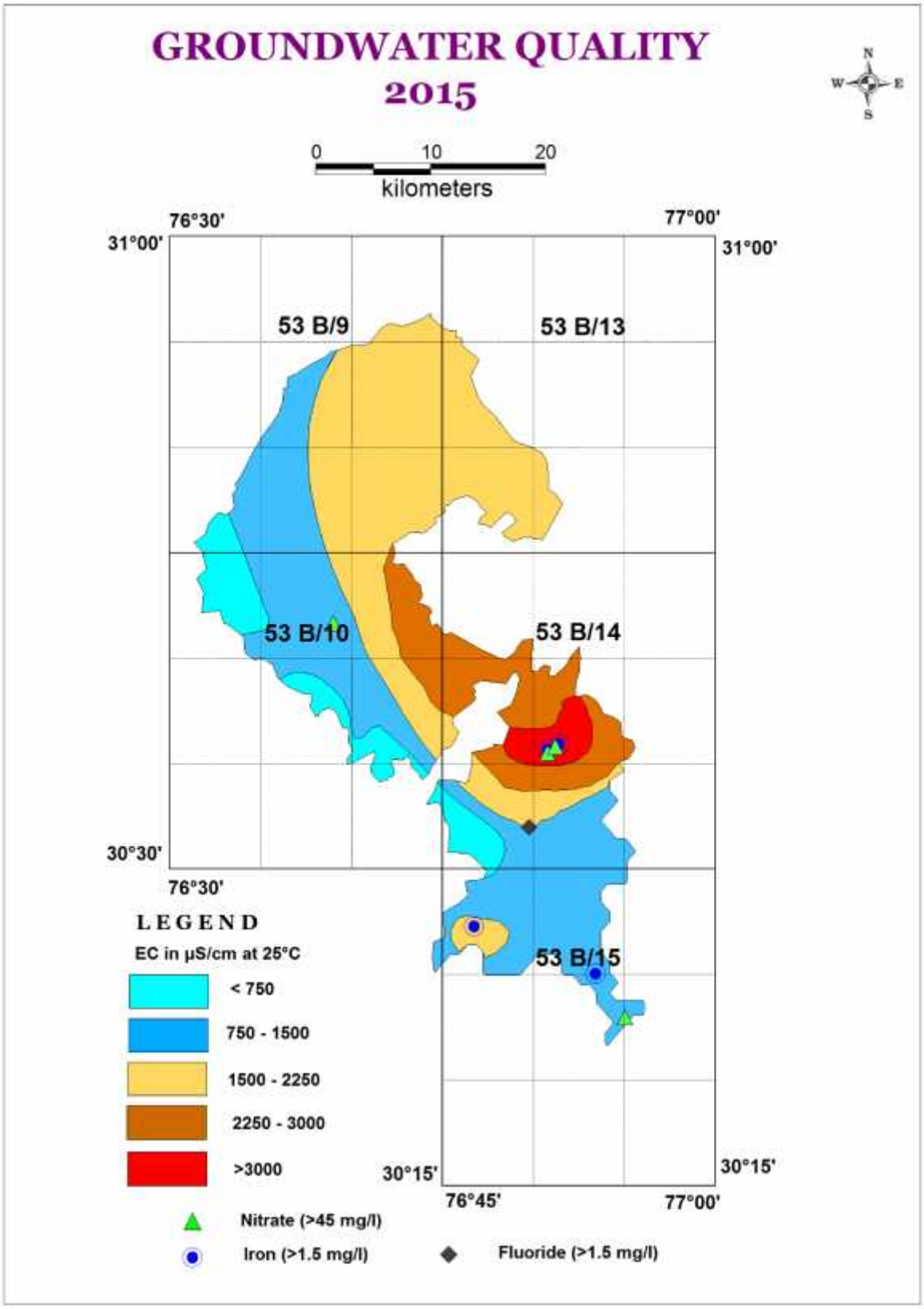
Irrigation Rating of Well Waters of Mohali District
(Based on Eaton's index)

IRRIGATION SUITABILITY		
EATON's INDEX (RSC in meq/L)		
Safe <1.25	Marginal 1.25-2.5	Unsafe >2.5
6	3	2

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

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

Fig.7: Groundwater Quality, 2015



2.3 Geophysical data:

The surface geophysical studies (using electrical method) are not conducted in the area. The aim of the survey was to delineate fresh water - saline water interface laterally as well as vertically. The study area is interpreted to be fresh up to 300m depth based on geophysical logging in the area.

2.4 Exploratory drilling State - Data Availability:

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB, WRED (Water Resources and Environment Directorate), Water Supply and Sanitation (WSS) and Private Wells have been collected and those supported electrical logs have been validated for aquifer map preparation. The details are given in below table.

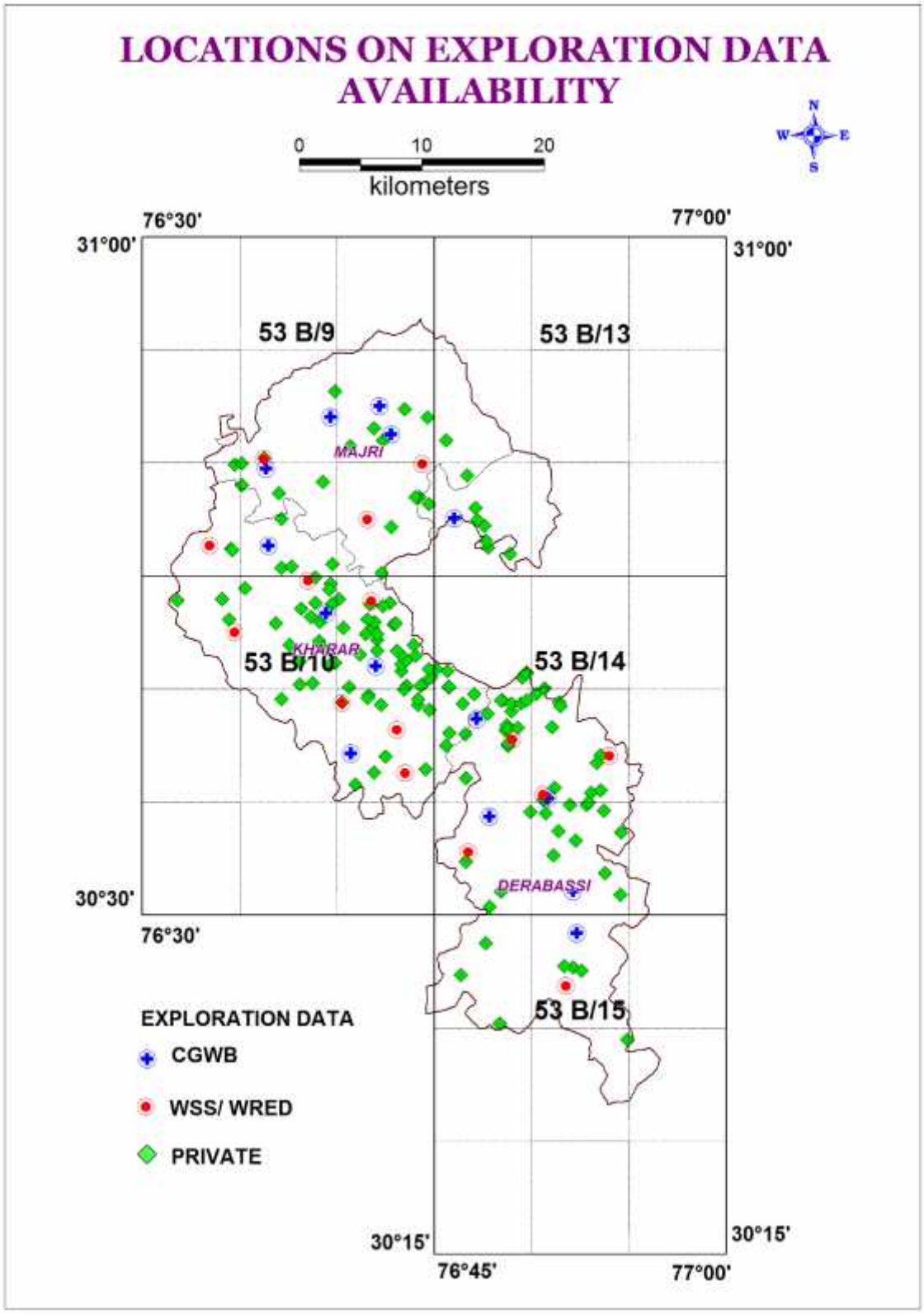
Data Availability of Exploration Wells of Mohali district

Sl.No	Source of data	Depth Range (m)				***Total***
		< 100	100-200	200-300	>300	
1	CGWB	5	0	1	14	**20**
2	WRED/WSS	16	0	0	0	**16**
3	PRIVATE WELLS	3	26	66	69	**164**
Total		**24**	**26**	**67**	**83**	**200**

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 (Fig. 8). Perusal of table shows that majority of tube wells falls in the in the depth range >300 m and 200 - 300 m. The grids/ formations devoid of groundwater exploration are identified as data gaps and these are to be filled by data generation. The physical record of availability of exploration data is given in Annexure-III.

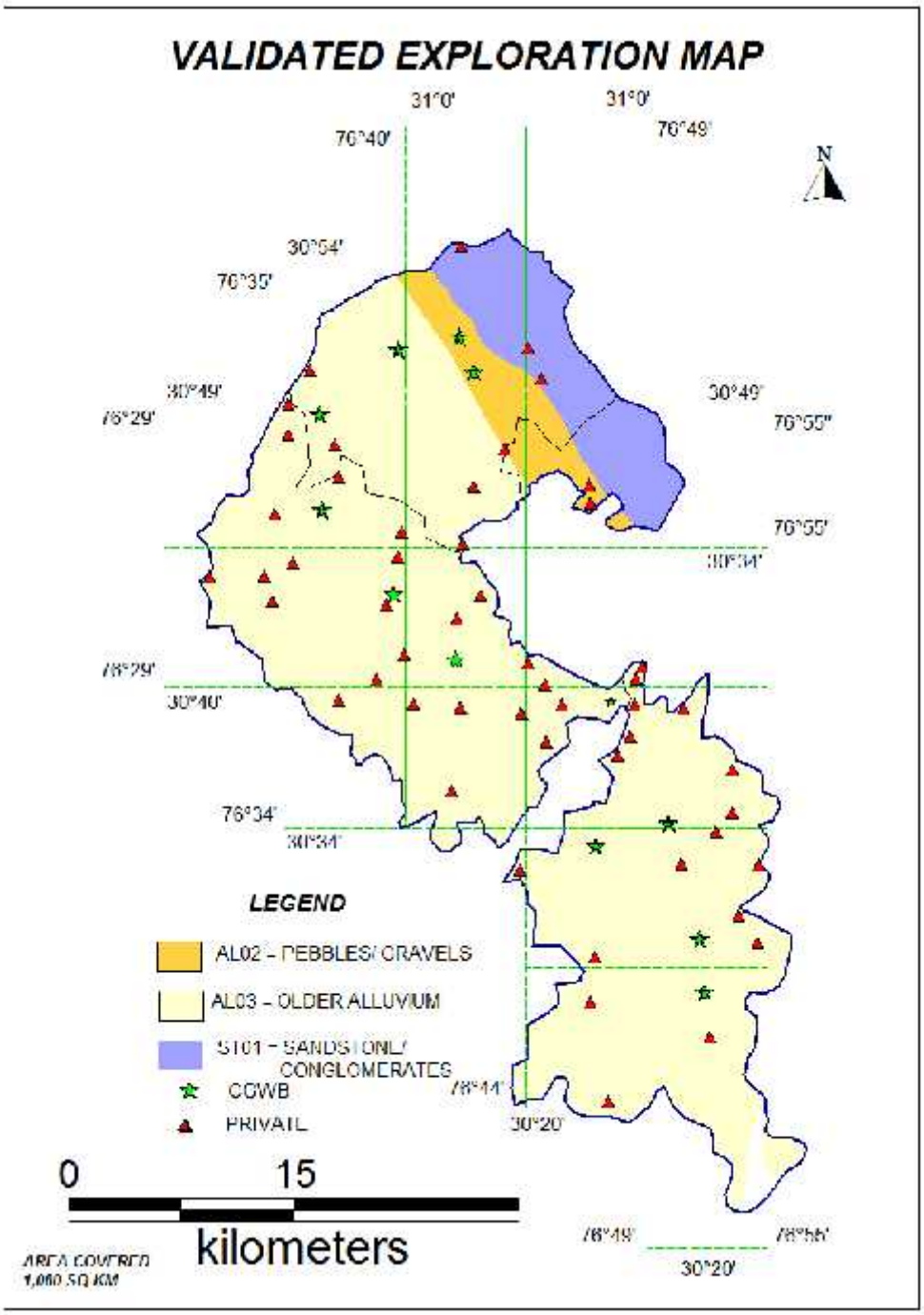
Fig.8: Locations of Exploration Data Availability



3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have considered and been validated 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.9.

Fig.9: Locations of Validated Exploration Data



The optimized wells of CGWB, 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.10. The locations of validated wells in quadrant and toposheet wise distributions in respective blocks are shown in Annexure-IV. Three dimensional locations of validated exploratory wells with litholog are given in Fig.11.

Fig.10: Elevation contour map

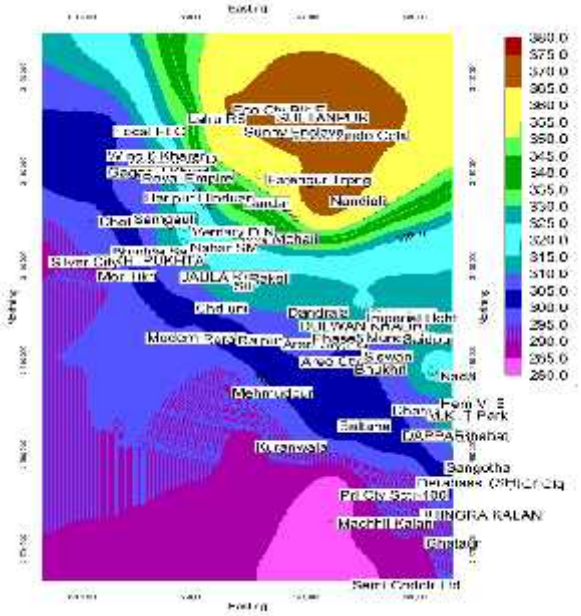
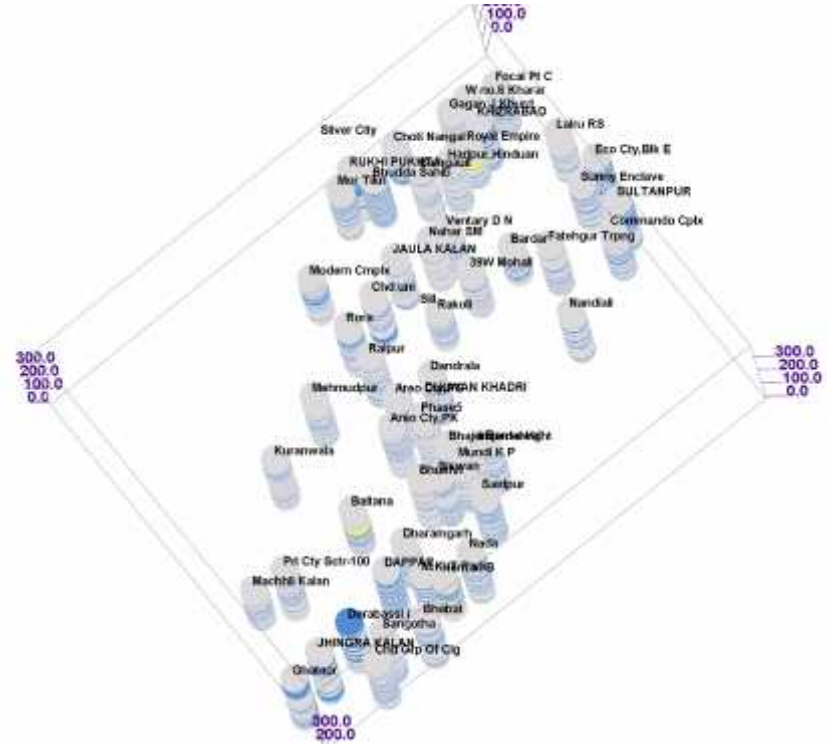


Fig.11: Three dimensional locations of validated exploratory wells with litholog



3.1 Sub Surface Disposition

3.1.1 Previous Work:

The area is underlain by formations of Quaternary age comprising of alluvium deposits belonging to vast Indus alluvial plains. Sub surface geological formations comprise of fine to coarse grained sand, silt, clay and kankar. Ground water at shallow depth occurs under unconfined to semi confined and confined conditions in deeper aquifers.

Exploratory drilling was carried out by CGWB at 14 locations in the district includes 12 Exploratory wells, 02 Slim holes through in-house activities and 03 piezometers through outsourced by M/s WAPCOS Ltd. to delineate and determine the potential aquifer zones, evaluation of aquifer characteristics etc. Maximum drilling of exploratory well was completed at Bhogla site down to a depth of 590.27m. The exploratory wells at Dera Bassi, Dulwam Khudri, Bagla, Jauli Kalan and Sat- Majra were abandoned due to fine sediments or insufficient thickness of aquifer zones and yielding low discharge. In the southern part of the district bore wells were drilled down to a depth between 276 m and 590m and wells were constructed in depth range of 106m and 352m bgl. The yield of the wells varies from 870lpm to 2680 lpm with drawdown of 4.8m to 21.65m. Transmissivity of the aquifers varies from 55 to 862m^2/day. Low values of transmissivity indicate the occurrence of finer sediments, which is revealed in several boreholes. The value of storage coefficient worked out to be 1.2 x 10^{-3} to 7.30 x 10^{-4}

The first aquifer group forms the shallow water table aquifer (Un confined) occurs maximum down to 111 m bgl and below that clay layer starts getting thickened about 10 -34 m depth and is considered as Unconfined Aquifer. The second and third aquifer behaves as semi-confined to confined aquifer and consisting of thin sand layers alternating with thicker clay layers. Overall flow of ground water is towards south to south-west direction.

Table- 2: The Aquifer Parameters of Mohali District

Aquifer Group	**Discharge 'Q' (lpm)**	**Transmissivity 'T' (m^2/day)**	**Storativity**
Aquifer-I	1253 - 2208	55 - 725	1.23x10^{-3}
Aquifer-II	1551 – 2074 (combined)	292 – 770 (combined)	1.69 x10^{-3} - 7.3 x10^{-4} (combined)
Aquifer-III	2857 – 3466 (combined)	687 – 1395 (combined)	

(Combined: Aquifer- II+III)

The details of validated data on exploration wells is given in below table

Data Validation of Exploration Wells of Mohali District

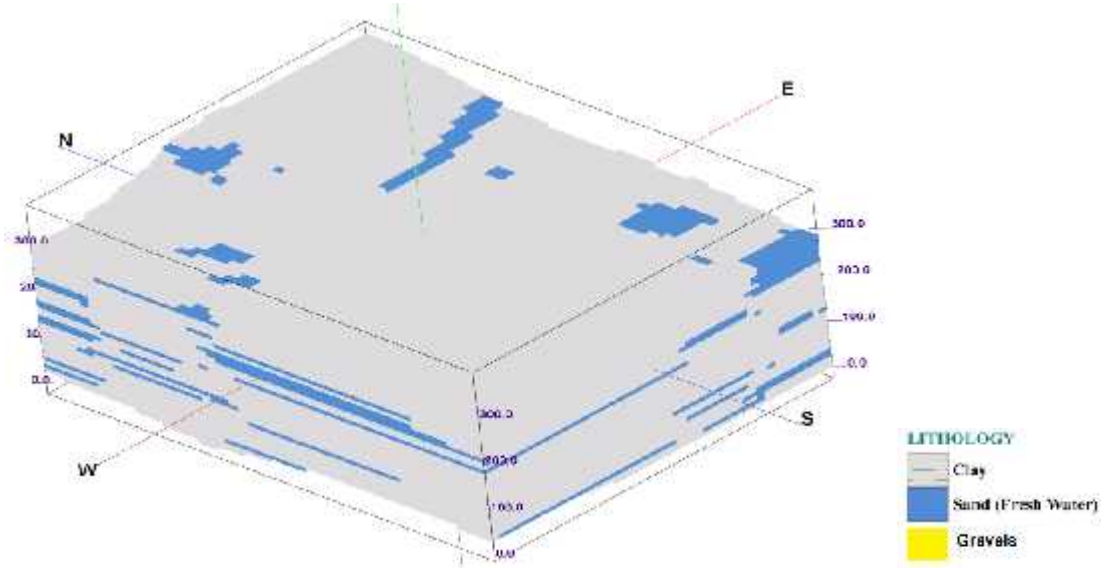
Sl.No	Source of data	Depth Range (m)				***Total***
		< 100	100-200	200-300	>300	
1	CGWB	0	0	2	8	**10**
2	WRED/WSS	0	0	0	0	**0**
3	PRIVATE WELLS	0	1	16	35	**52**
Total		**0**	**1**	**18**	**43**	**62**

3.1.2 Present NAQUIM Study:

To understand the sub surface disposition in the study area, geological sections and fence diagram have been prepared by synthesizing the various sub-surface sections on the basis of study of the lithological logs and electrical logs of boreholes drilled by CGWB, WRED and Private Agencies using the RockWorks15 software and a 3D lithological model has been prepared (Fig.12). The 2D lithology sections and 3D lithological fence diagram has been prepared using lithology model and are shown in Fig.13a, b & 14 respectively. The aquifers are composed of fine to medium sand with clay intercalations. The granular zones are extensive.

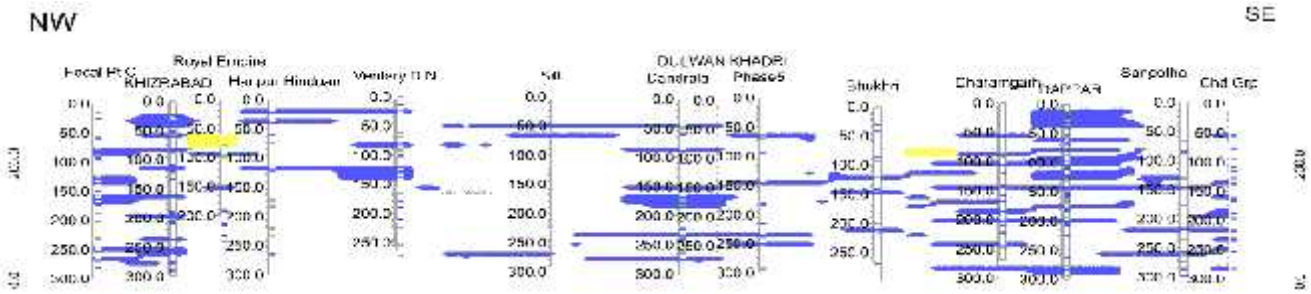
Based on geophysical borehole logging and use of resistivity profiling followed by the depth soundings at few selected places, for the present study and will be referred from time to time as it is obviously the higher resistivity beds represents freshwater zone in contrast in low resistive beds indicating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

Fig.12: 3-Dimension Lithological Model

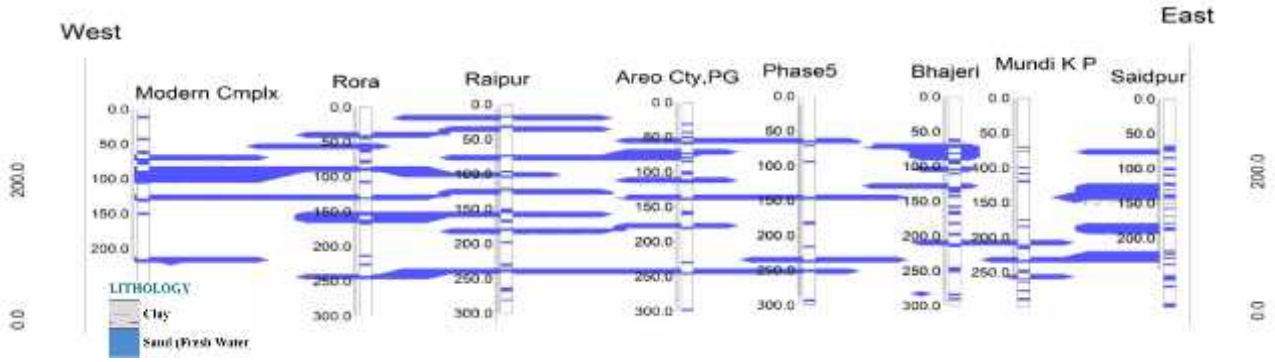


The major aquifer system of this area is quaternary alluvial deposits of Ghaggar basin, having older alluvium which mainly comprises of sand, silt and clay admixed with kankars. The top surface layer and soil is mainly clay. The lithology shows the variation in lithology thickness i.e. thick clay layers inter bedded with sand except at few locations. In northern parts of the district major lithological formations are characterized by layers of fine to coarse sands interbedded with thick layers of clay.

Fig.13a, b: 2-Dimension Lithological Sections



Study of the NW-SE lithological section indicates that surface soil of 6 to 20 m thickness is an admixture of clay with intercalation of sand lenses. There are 3 to 4 well defined granular zones up to 300 m depth separated by laterally extensive clay layers 10 – 30 m thick. The third clay bed occurring at 100 - 110 m is alternating with equally extensive thin sand layers shown in borehole Focal PT, Dappar, Khizrabad, Dharamgarh and Dhandrala. Below 200 m there are few granular zones and thick clay. Dulwan Khadri and Sill bore hole having inadequate granular zones. Clastic sedimentary like boulders and gravels are observed at the depth of 64 m in Royal Empire. The top sand beds are fine grained while the lower ones are fine to medium in texture. The overall lithological section shows the variation in lithology thickness i.e. thick clay layers inter bedded with sand except at location Dappar where thin clay layers interbedded with sand were identified. The sand percentage decreases towards north western direction. Granular zones are more thickened and potential in south eastern part.



Study of the W-E lithological section indicates that surface soil of 5 to 18 m thickness is an admixture of clay and kankar with intercalation of sand lenses. There are 3 to 4 well defined granular zones up to 250 m depth separated by laterally extensive clay layers 20-40 m thick in western part and eastern part depth up to 250m. The lithology shows the variation in thickness alternate sequence of sand and clay beds.

Study of the lithological cross sections shows that alluvium comprises of very fine to medium sand, gravel, silt and clay with kankar in varying proportions and shows heterogeneity of the formation (Fig.15). Zones of clay and silt occur intercalated with sand which either taper or disappear within short distance. Underlying the regional sand body clays layer occurs having large vertical thickness and lateral extent.

The geometry and nature of aquifers provide the basic parameters for determining occurrence and movement of ground water. The lithological disposition of the area is given in Annexure-V. The 3D lithological fence will represent the much more clear representation of sub-surface lithology in space.

Fig.14: 3-Dimension Lithological Fence

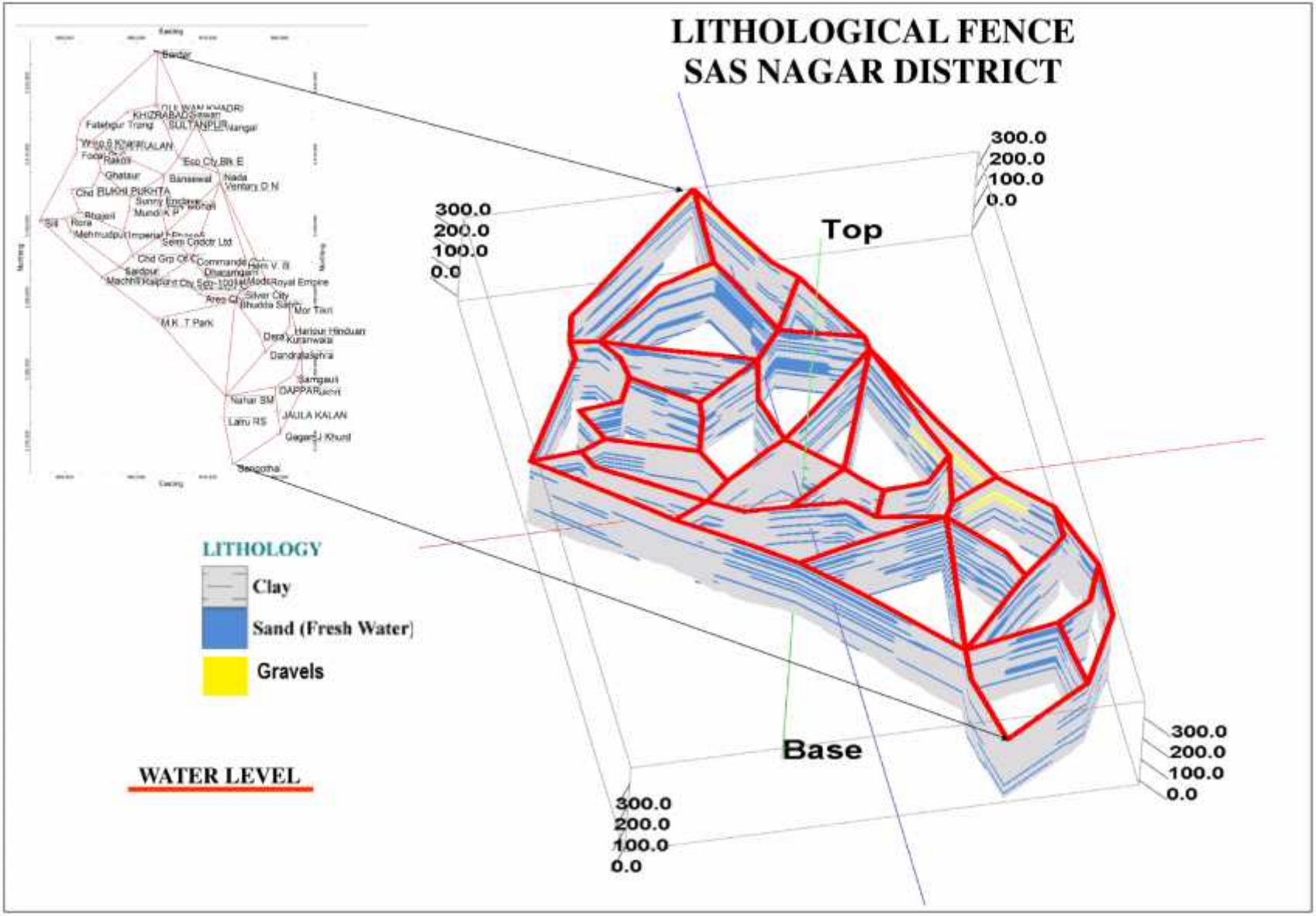
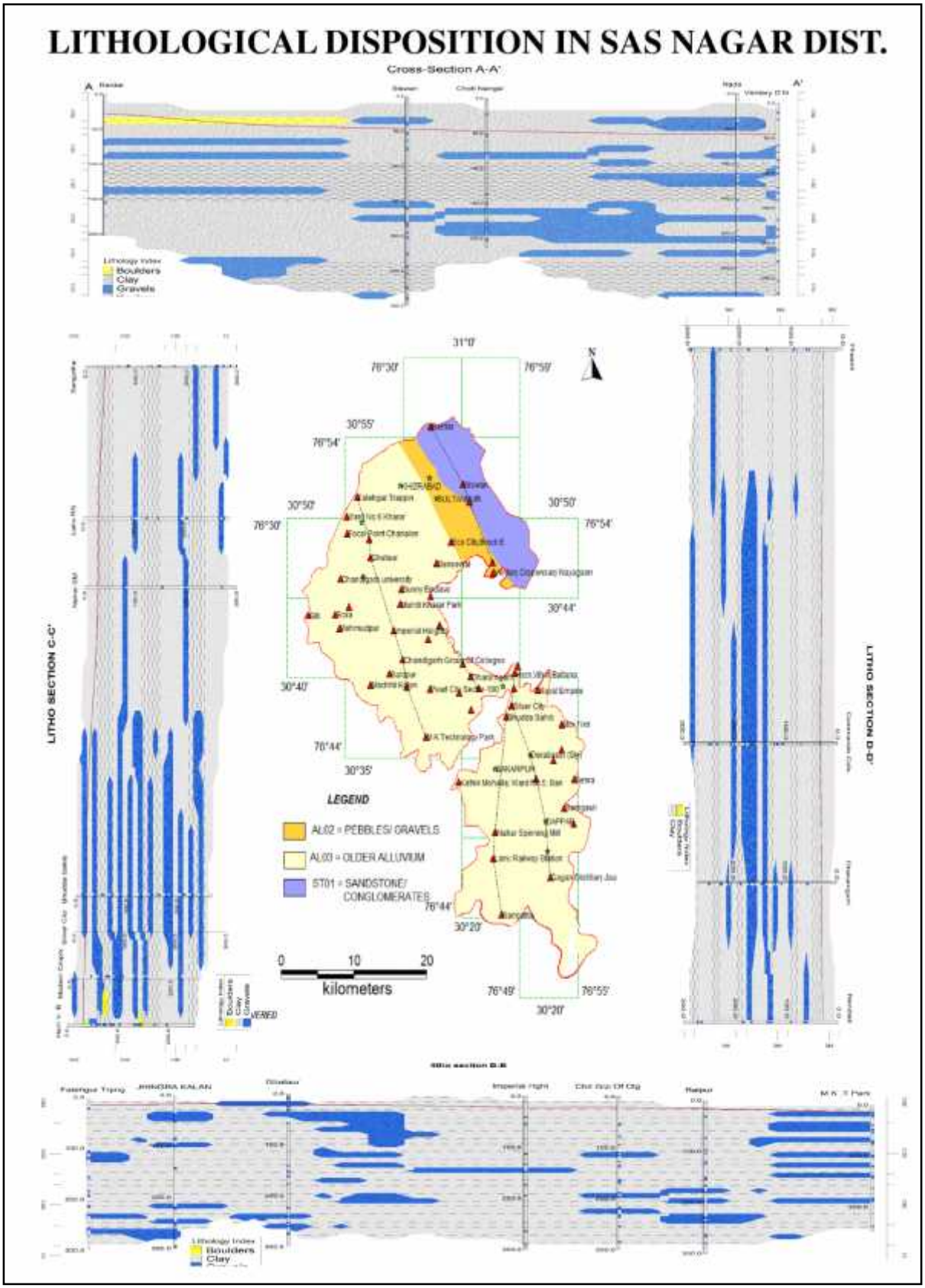


Fig.15: Lithological Cross sections in SAS Nagar district



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.

The first aquifer is water table aquifer and extends all over the area is composed mainly of less coarse sediments as compared to other groups. This aquifer is overlain by a clay layer of about 6 to 20 m and is also underlain by clayey group. Aquifer-I extends maximum upto 111 m of depth and below that clay layer starts getting thickened about 10 to 32 m separating Aquifer II and 12 to 29 m clay layer separated Aquifer-III upto 300m depth (Annexure VI).

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 Mohali district, the aquifer grouping has been done using the sub-surface lithology and a three-dimensional aquifer model has been prepared shown in Fig.16. An aquifer disposition 3D fence diagram and 2D Aquifer section are also prepared using the aquifer model and are shown in Fig.17 and Fig.18 a,b. The aquifer grouping, group thickness and granular zones encountered in the groups are given in table below,

Aquifer Grouping in Mohali District

Aquifer Group	Avg. Range		Thickness		Granular Zones	
	From	To	Min	Max	Min	Max
Aquifer I	8.24	111	52	103	13	44
Aquifer II	129	203	49	98	14	36
Aquifer III	228	300	27	85	8	40

Fig.16: 3D Aquifer disposition Model

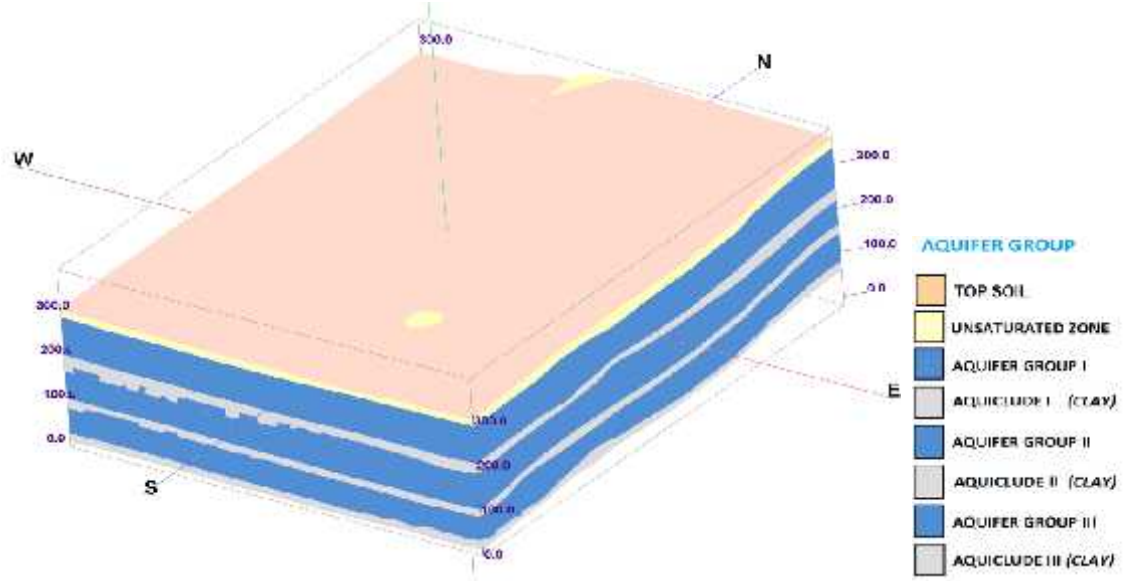


Fig.17: 3D Aquifer Disposition Fence

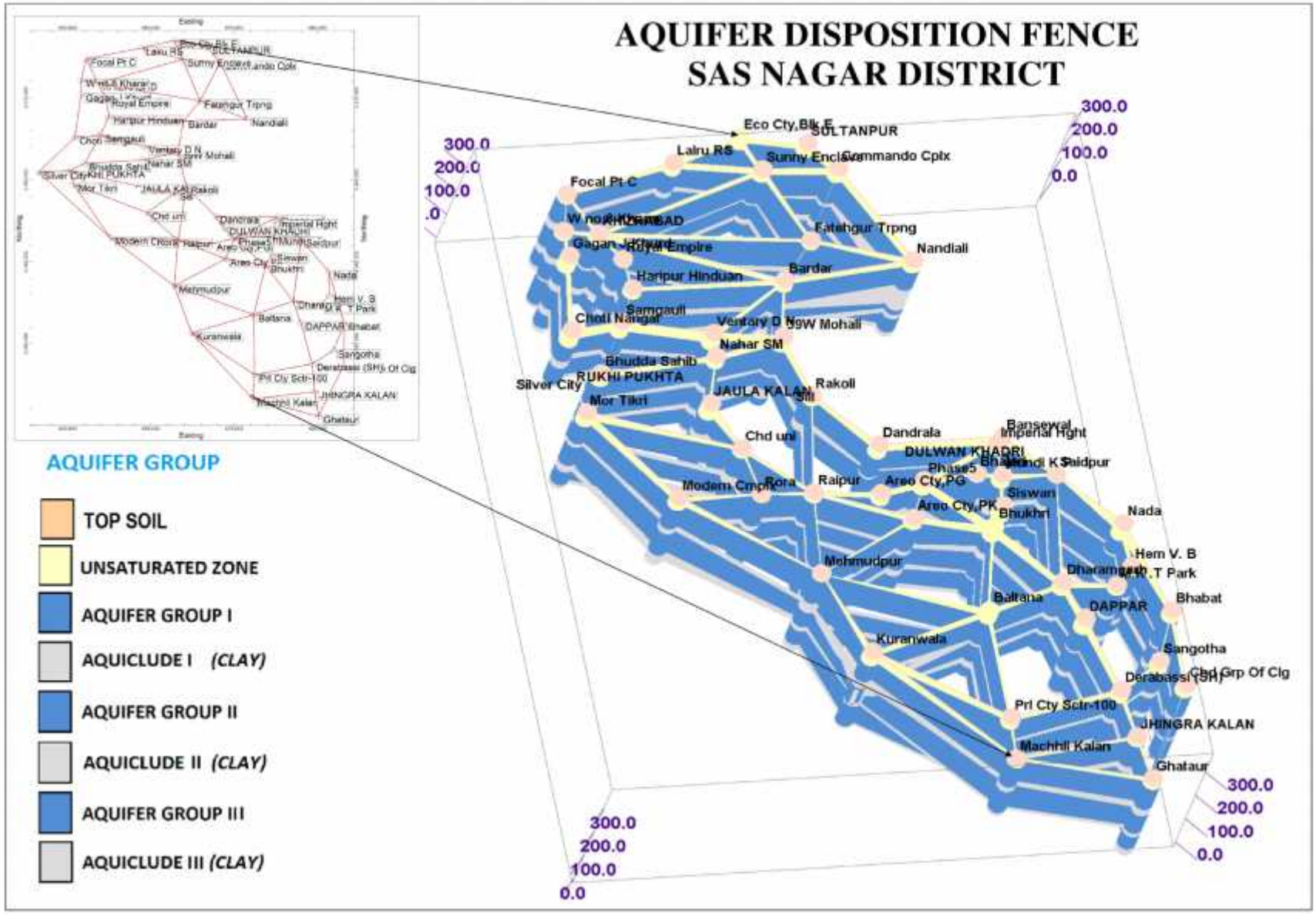


Fig.187a: 2-Dimension Aquifer Sections along Salwal to Chatbir

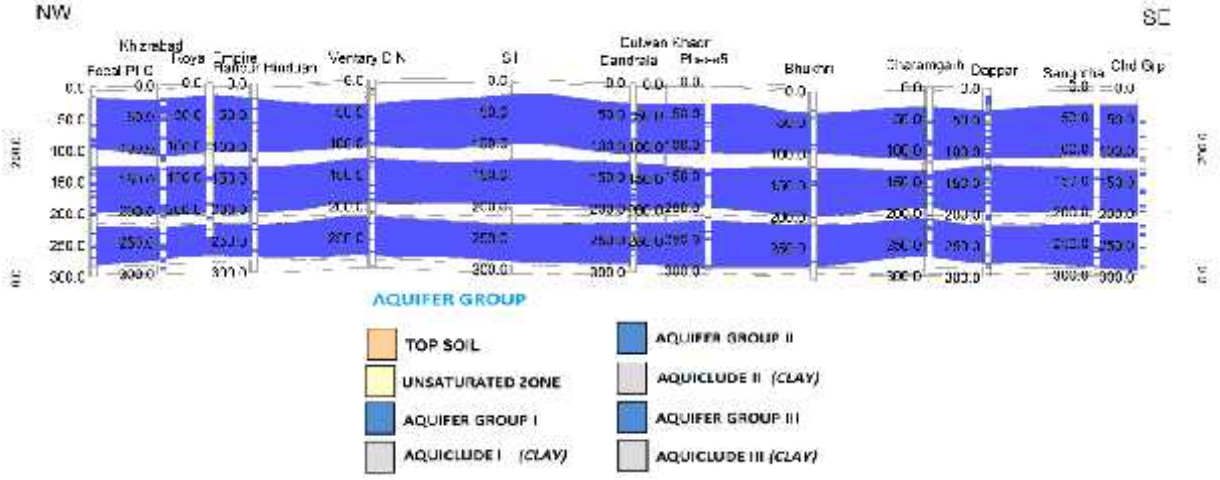


Fig.18b: 2-Dimension Aquifer Sections along Chaju Bhat to Loh Simbly

The borewell between Sultanpur and Jingran in Aquifer disposition Fence diagram reveals the occurrence of three major aquifers separated by clays beds. The first aquifer is very thick near Sultanpur and Jingran. At Jingran a thick clay lens occurs at the bottom of the third aquifer. The sand ratio is very high compared to clay in borehole Sultanpur and Jingran. The aquifers are constituted of fine to coarse sand with intercalations of clay.

In the above aquifer sections the Aquifer group -I disposition is most prominent in thickness and granular zones encountered than other Aquifer groups.

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 ground water resource of this zone has been calculated considering 12% specific yield of the formation. 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 Unconfined Aquifers

a. Dynamic Resources:

Block-wise ground water resource potential of the district has been assessed as per GEC-97 as on 31st March 2013. The primary source of recharge in the area is the rainfall. The ground water development in all the blocks has exceeded the available recharge, thus all the blocks have been categorized as over exploited. Stage of ground water development in the Mohali district has been assessed to be 189%. The details are explained in below Table-3.

Table-3: 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*
Dera Bassi	132.50	138.08	24.07	162.15	31.86	-37.43	122	Over Exploited
Kharar	93.12	68.71	24.50	93.22	32.04	-7.63	100	Over Exploited
Sialba Majri	64.00	26.44	1.94	28.38	3.45	34.12	44	Safe
TOTAL	**289.63**	**233.23**	**50.51**	**283.74**	**67.35**	**-10.95**	**98**	**Critical**

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

4.2 Confined Aquifer

The availability of ground water resources in confined aquifer have two components: Storage under pressure (using Storativity concept) and Storage under desaturated (gravity drainage) condition (using Specific Yield concept) (source: Assessment of Ground Water Resources; A Review of International Practices, 2014) and is shown in Fig 19. However, since ground water withdrawals from confined aquifer are known to have serious environmental degradation effects, the preliminary assessment of ground water resources in confined aquifer is restricted to the estimation of ground water storage under pressure conditions only but here the storage under de-saturation is also computed.

i) **Storativity Concept:**

In-storage Ground Water resources (within the Peizometer)	=	Thickness of the water column in Peizometer of particular confined aquifer up to the top layer of same confined aquifer	×	Storativity of the confined aquifer	×	Areal extent of the confined aquifer group

ii) **Specific Yield Concept:**

In-storage Ground Water resources (within the aquifer thickness)	=	Thickness of the confined aquifer (granular/ productive zone) down to the bottom layer of confined aquifer or exploitable depth of 300 m	×	Specific Yield of the aquifer	×	Areal extent of the confined aquifer group

Preliminary assessment of the ground water resources in confined aquifer does not imply that the assessed resource is available for exploitation. The objective of this exercise is to have an overview of the ground water regime in the particular confined aquifer. It should be kept in mind that any significant ground water withdrawal from confined aquifer may invoke serious environmental degradation problem. Therefore, in case the preliminary assessment reveals that ground water is being withdrawn in significant quantity for any confined aquifer, that particular aquifer should be identified for detailed assessment using numerical modeling approach. The Block Wise In storage Ground Water Resources in Unconfined Aquifer –I,

Confined Aquifer-II, III and total Groundwater resources (Alluvium) is given in Tables 4, 5, 6 & 7 respectively.

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

Fig 19: Concept for Resource Estimation in Unconfined and Confined Aquifer System

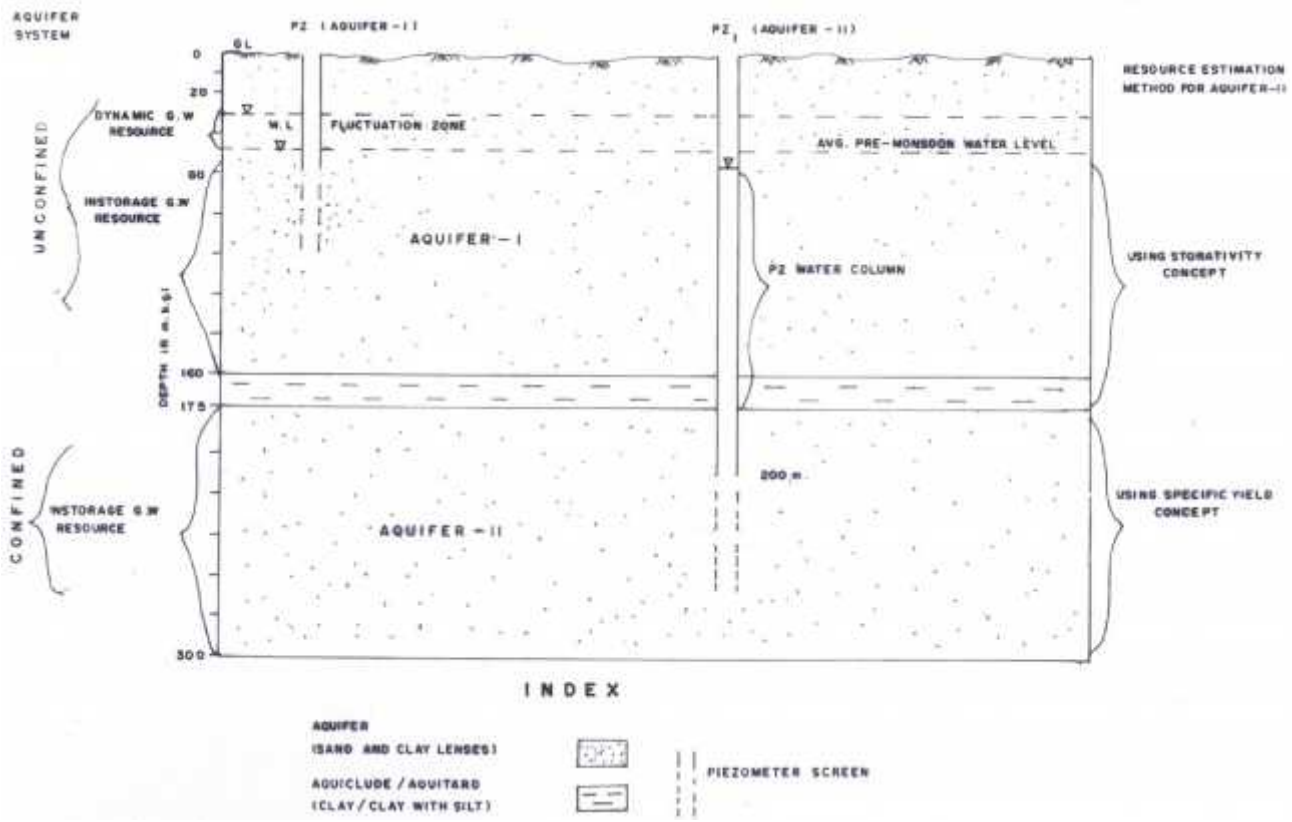


Table-4: Block Wise In storage Ground Water Resources in Unconfined Aquifer –I (Alluvium)

BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED AQUIFER –I (ALLUVIUM) OF SAS NAGAR (MOHALI) DISTRICT											
Sr. No.	Name of Assessment Unit	Areal extent (ha)				Average Pre-monsoon Water Level (m bgl)	Depth to bottom of Aquifer Group I (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) Col. (8-7)	Thickness of the Granular Zone in AQUIFER GROUP-I below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources (ham) Col. [(5)*(10)*(11)]
		Total Geographical Area (ha)	Assessment Area								
			Total	Fresh Water	Brackish/Saline Water						
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1	DeraBassi	47990	47990	47990	0	11.73	109	97.27	35	0.072	120935
2	Kharar	41620	41620	41620	0	9.89	108	98.11	34	0.072	101886
3	Sialba Majri	29290	29290	29290	0	8.24	117	108.76	35	0.072	73811
Dist. Total (ham)		**118900**	**118900**	**118900**							**296631**
Dist. Total (mcm)		**1189**	**1189**	**1189**							**2966**

ham: hectare metre

mcm: million cubic metre

Table-5: Block Wise In storage Ground Water Resources – Confined (Aquifer II)

BLOCK WISE INSTORAGE GROUND WATER RESOURCES – CONFINED (AQUIFER II) SAS NAGAR (MOHALI) DISTRICT															
Sr. No.	Name of Assessment Unit	Total Geogra-phical Area	Areal extent (ha)		Top Aqui-fer II (m bgl)	Depth to bottom of Aquifer II (m bgl)	Peizometer head value for Confined Aquifer-II (m bgl)	Thickness of piezometric level(m bgl) Col.(6-8)	Total Thickness of confined aquifer down to explored depth (m) Col.(7-6)	Thickness of the Granular Zone in confined aquifer down to explored depth (m)	Average Specific Yield	Average value of Storati-vity	In-Storage Ground Water Resources (ham) (Specific yield concept) Col.[(5)*(11)* (12)] FRESH	In-Storage Ground Water Resources (Storativity concept) Col.[(5)*(9)*(13)]	Total in-Storage Ground Water Resources (ham) Col. (14+15)
			Total	Fresh Water											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	DeraBassi	47990	47990	47990	129	199	12.7	116.3	70	28	0.072	0.00206	96748	11497	108245
2	Kharar	41620	41620	41620	130	201	22.95	107.05	71	24	0.072	0.00206	71919	9178	81098
3	Sialba Majri	29290	29290	29290	133	203	22.95	110.05	70	24	0.072	0.00206	50613	6640	57253
Dist. Total (ham)		**118900**	**118900**	**118900**									**219280**	**27316**	**246596**
Dist. Total (mcm)		**1189**	**1189**	**1189**									**2193**	**273**	**2466**

ham: hectare metre

mcm: million cubic metre

Table-6: Block Wise In storage Ground Water Resources – Confined (Aquifer III)

BLOCK WISE INSTORAGE GROUND WATER RESOURCES – CONFINED (AQUIFER III) SAS NAGAR (MOHALI) DISTRICT														
Sr. No	Name of Assess-ment Unit	Total Geographical Area	Areal extent (ha)		Top Aquifer III (m bgl)	Depth to bottom of Aquifer III (m bgl)	Thickness of piezo-metric level (m bgl) Col. (6-Avg. Piezo metrice Head)	Total Thicknes s of confined aquifer down to explored depth (m) Col. (7-6)	Thicknes s of the Granular Zone in confined aquifer down to explored depth (m)	Aver-age Specific Yield	Average value of Stora-tivity	In-Storage Ground Water Resources (ham) (Specific yield concept) Col. [(5)*(10)* (11)] FRESH	In-Storage Ground Water Resources (Storativity concept) Col. [(5)*(9)* (12)]	Total in-Storage Ground Water Resources (ham) Col. (13+14)
			Total	Fresh Water										
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	DeraBassi	47990	47990	47990	218	300	0	82	23	0.072	0.00073	79471	0	79471
2	Kharar	41620	41620	41620	220	300	0	80	19	0.072	0.00073	56936	0	56936
3	Sialba Majri	29290	29290	29290	228	300	0	72	18	0.072	0.00073	37960	0	37960
Dist. Total (ham)		**118900**	**118900**	**118900**								**174367**	**0**	**174367**
Dist. Total (mcm)		**1189**	**1189**	**1189**								**1744**	**0**	**1744**

The Average Peizometer head value for confined Aquifer - III is 34.40 m.bgl

ham: hectare metre

mcm: million cubic metre

Table-7: Block Wise Total Availability of Groundwater Resources upto 300 m Depth and Volume of Un-saturated granular zone after 3 mbgl upto Average Pre-Monsoon water level.

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN SAS NAGAR (MOHALI) DISTRICT									
Sl.No	Block	*Volume of Unsaturated Zone up to Pre-monsoon WL (ham)*	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources AQUIFER-I*	Fresh Groundwater Resources AQUIFER-I [(4)+(5)]	Fresh Groundwater Resources AQUIFER-II	Fresh Groundwater Resources AQUIFER-III	**Total Availabilty of Fresh Groundwater Resources [(6)+(7)+(8)]**	
								ham	mcm
1	2	*3*	*4*	5	6	7	8	9	10
1	DeraBassi	33171	13250	120935	134185	108245	79471	321902	3219
2	Kharar	21726	9312	101886	111198	81098	56936	249232	2492
3	Sialba Majri	9982	6400	73811	80211	57253	37960	175424	1754
Dist. Total (ham)		**64878**	**28963**	**296631**	**325594**	**246596**	**174367**	**746558**	**7466**
Dist. Total (mcm)		**649**	**290**	**2966**	**3256**	**2466**	**1744**		

ham: hectare metre

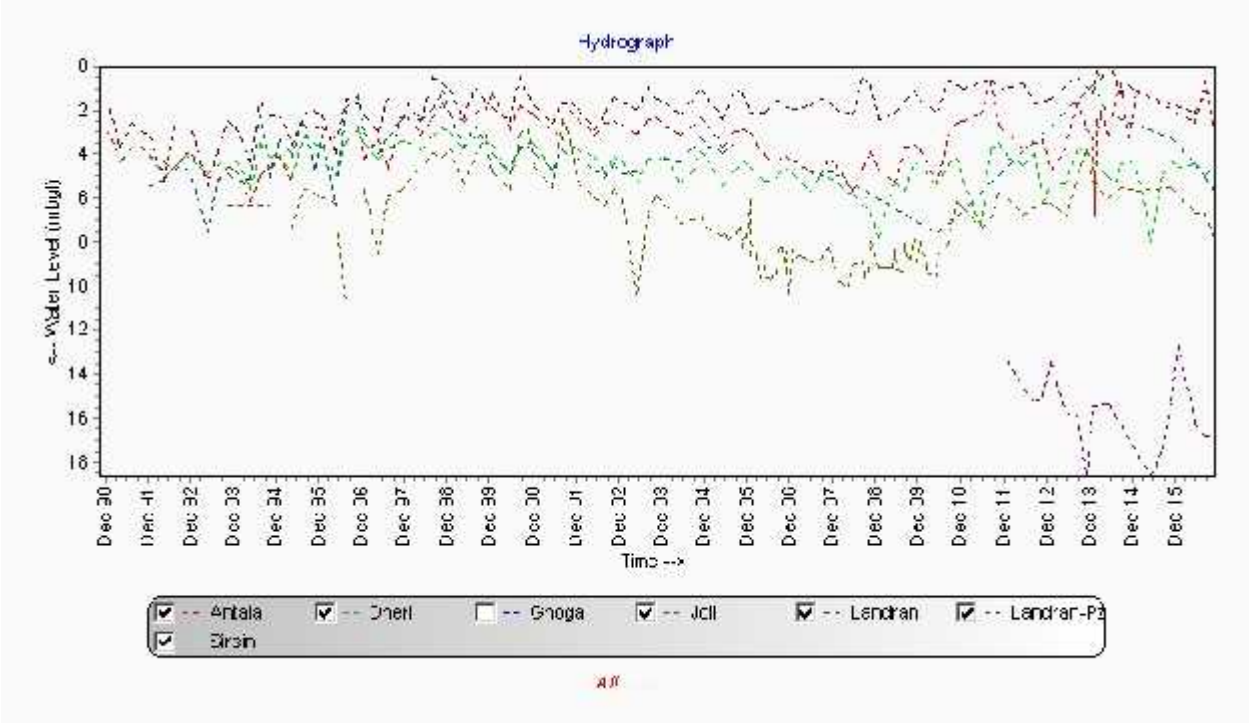
mcm: million cubic metre

5.0 GROUND WATER ISSUES

5.1 Ground Water Depletion

The study area is famous for its paddy and non paddy cultivation. The quality of ground water in the area is suitable for 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 SAS Nagar (Mohali) District as the recharge of the groundwater through rainfall and other sources are less than the overall extraction. The hydrographs (Shallow Observation Wells) also shows the declining water level trend over the years in the district (Fig.20) and is categorized as Over-Exploited, while Sialba majri block is in Safe category. This declining water table trend, if not checked, would assume an alarming situation in the near future affecting agricultural production and thus economy. Ground Water Recharge and Conservation may be carried out in these areas to overcome the depletion.

Fig.20: Long term ground water table variation (Shallow Observation Wells)



5.2 Ground Water Quality

The ground water of the study area is alkaline in nature and seems to be fresh. Ground water with Fluoride concentration above permissible limit 1.5 mg/l is found mainly in Gholu majra (2.9), Nitrate concentration above permissible limit 45 mg/l is found in Isarpur (700), Derabassi (440), Antala (133) and Landran (118). Ground water with Iron concentration above permissible limit 1.5 mg/l are observed in Isarpur-I (12.53), Isarpur-II (25.83),Handesaran (6.28) and Sirsini (2.33). The EC Value >3000 µS/cm at 25^0C are found in Isarpur(8970). There is

growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities.

5.3 Ground Water Irrigation Scenario

As per the data available from minor irrigation census 2006-07, the detailed number of shallow, deep, tube wells, lined, unlined water distribution system, land holdings of wells are given in Table-8,9 &10 .

Table-8: Distribution of Tube wells According to Well Owner's land holding Size

Type of Tube well (TW)	***Marginal (0-1 ha)***	***Small (1-2 ha)***	***Semi-Medium (2-4 ha)***	***Medium (4-10ha)***	***Big (>10ha)***	***Owned by other than individual farmers***	***Total***
Shallow TW	601	1850	3577	2484	538	0	**9050**
Deep TW	50	325	877	1067	267	0	**2586**
Total	**651**	**2175**	**4454**	**3551**	**805**	**0**	**11636**

Table-9: Distribution of Tube wells According to Depth

Depth of Tubewells in metres								**Total depth Range 0-150m**
Depth range	0-20 m	20-40 m	40-60 m	60-70 m	70-90m	90-150m	>150 m	
Tubewells	20	2570	2871	3589	877	1553	156	**11636**
Tubewells (%)	0.17	22.09	24.67	30.84	7.54	13.35	0	

Table-10: System of Ground water distribution device

	Open Water Channels			
Lined/pucca	*Unlined/kutcha*	*Underground Pipe*	*Others*	*Total*
1821	9815	0	0	**11636**

6.0 MANAGEMENT STRATEGIES AND AQUIFER MANAGEMENT PLAN

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

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

Artificial recharge plan is less feasible in the Fatehgarh Sahib District due to very low availability of volume of surplus water (9.95 mcm) (Table-11a). Another focus has been given to minimize the gross draft by enhancing ground water use efficiency in irrigation system after replacing the water distribution system from unlined/kutcha channel to Under Ground Pipeline System (UGPS) in over exploited blocks of the district.

6.1 Scope of Implementation

This plan is focusing on the technical aspects of the ground water recharge through various means so that various implementing agencies may get the appropriate technical guidelines. The existing/ongoing schemes of the central or state govt. like MANERGA, IWSP, PMKSY (Prime Minister 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 1821 (out of 89815) tube wells (84.35 %) operated by farmers for irrigation through unlined/Kutcha open channel system in study area (Table-10) where water from the tube well is discharge to the agricultural field. In this process, huge (around 25 %) (RKVY, 2015) quantity of ground water is wasted in soil moisture and evaporation losses.

Around 77.77 % of the tube wells are of shallow depth (20 to 70m) and remaining wells are deeper depth (70 to >150 m) existed in the area (Table-9). Thus, majority of wells are tapping shallow aquifer which is under stress.

Dynamic ground water resources (2013) indicate that Gross ground water draft for irrigation in the district is estimated at 233.23 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 184.05 mcm (Table-11a) assuming that there is no need of crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks. The measure if implemented will bring down the ground water overdraft from 98 % to 81%. The category of the blocks will also improve resulting in boosting of agriculture and industrial development otherwise not sustainable in over-exploited blocks (Table-11b).

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

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

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

The block wise saving of water in mcm by applying various management strategies such as crop diversification, Under Ground Pipe lines (UGPL) in individual land and artificial recharge methods are given in tables 11.a, b.

Table-13a: 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*	*Total Draft (mcm)*	*Present Stage of draft (SOD) (%) (As per 2013)*	*Reduction in draft by different water saving method*				*SOD afterwards (%)*
					Replace water courses by UG Pipes (mcm)	*Adopt Artificial recharge (mcm)*	*Change Paddy to Maize/ Soyabean (mcm)*	*Total (mcm) (2+3+4)*	
				1	2	3	4	5	
Dera Bassi	132.50	138.08	162.15	122	29.12	4.84	NR	33.96	97
Kharar	93.12	68.71	93.22	100	14.49	5.11	NR	19.60	79
Sialba Majri	64.00	26.44	28.38	44	5.57	0.00	NR	5.57	36
Total	**289.63**	**233.23**	**283.74**	**98**	**49.18**	**9.95**	**NR**	**59.13**	**78**

Table-13b: Impact on Stage of Development (SOD) after applying various management strategies in Mohali District

Block	*Present SOD (%) as on 2013*	*Reduction in SOD (%) after unlined channel (%)*	*Resultant SOD (%) Col.(2 - 3)*	*Reduction in Stage of development after Artificial recharge (%)*	*Resultant SOD (%) Col.(2 - 5)*	*Total Reduction in Stage of development (%) (3 +5)*	*Stage of development afterwards (%) (2-7)*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Dera Bassi	122	21.97	100.40	3.65	118.72	25.63	97
Kharar	100	15.56	84.54	5.48	94.62	21.04	79
Sialba Majri	44	8.71	35.62	0.00	44.33	8.71	36
Total	**98**	**16.98**	**80.99**	**3.43**	**94.53**	**20.42**	**78**

By adopting all the management strategies resulting in total reduction in stage of groundwater development is 20.42 %. Hence overall stage of development afterwards is 100 % and is given in Table.11.

BLOCK WISE

AQUIFER MAPS

AND

MANAGEMENT PLAN

(PART-II)

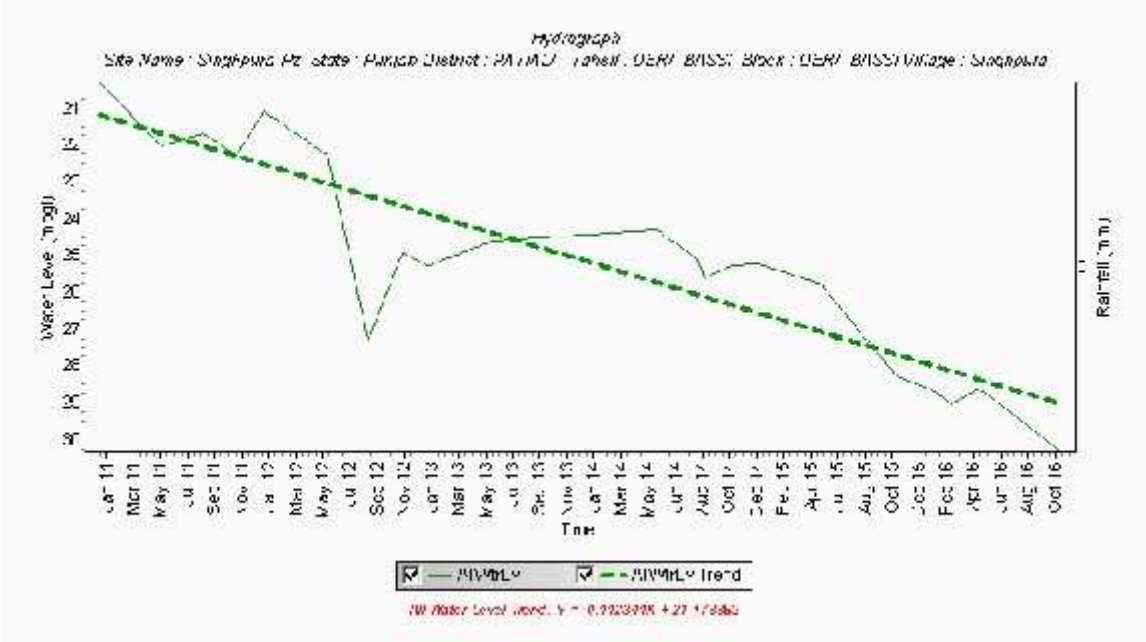
I. Salient Information of Dera Bassi Block

<table>
<tr><td>Block Area
(in Km^2)</td><td>479.90 sq km</td></tr>
<tr><td>District/ State</td><td>Mohali, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 49282
Rural Population: 184794
Total population: 234076</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 619 mm
Non-monsoon Rainfall : 152 mm
Annual Average Rainfall: 771 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Wheat, Rice, Maize and Sugar cane
Other crops: Vegetables and Fodder
Gross cropped area: 458.62 sq km
Net sown area: 240.92 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 190%
<u>Area under</u>
Ground water Irrigation: 230.87 sq km
Surface water irrigation: Nil
Gross Irrigated area: 377.63 sq km
Net Irrigated area: 197.19 sq km
Intensity of Irrigation: 192%
Number and types of abstraction structures: 4651, Tubewells</td></tr>
<tr><td>Ground Water Resource Availability and Extraction</td><td><u>Ground water Resources Availability</u>
Ground Water Resources are available in the different group of aquifers. The fresh water resources are estimated up to the depth of 300 m on the basis of geophysical interpretations.
<table>
<tr><th>Aquifer Group</th><th>Aquifer Depth range (m)</th><th>Aquifer Thickness (m)</th><th>Granular Zones (m)</th><th>Resources (mcm)</th></tr>
<tr><td>Aquifer-I</td><td>11.73 – 109.0</td><td>97</td><td>35</td><td>1341.85</td></tr>
<tr><td>Aquifer-II</td><td>129.0 – 199.0</td><td>70</td><td>28</td><td>1082.45</td></tr>
<tr><td>Aquifer-III</td><td>218.0 – 300.0</td><td>82</td><td>23</td><td>794.71</td></tr>
</table>
Total Ground Water Resources available is 3219.02 mcm and total potential granular zones available are 86 m up to depth of 300 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment.
<u>Ground water Resources Extraction</u>
Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply wells of State Government tapping combined aquifers. Therefore, the ground water draft could not be assessed for Aquifer-II and III separately.</td></tr>
</table>

Existing and future water demands	Water Scarcity Villages: 145 Small Scale Industries : 169 Large Scale Industries : 0 Total Villages : 159 *Existing Gross Ground water Draft as on 2013* Irrigation: 138.08 mcm Domestic and industrial water supply: 24.07 mcm *Future water demands* Irrigation development potential : (-)37.43 mcm Domestic and industrial water supply up to 2025 years : 31.86 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 3.25 - 25.80 m bgl Post Monsoon: 3.45 - 28.30 m bgl Seasonal Fluctuation: 0.25 - (-)4.88 m/yr Mean (10 yrs) : 1.76 - (-)7.32 m/yr *Trends* Pre Monsoon: 0.51 - (-)2.46 m/yr Post Monsoon: 0.26 - (-)0.01 m/yr **Aquifer-II** Pre Monsoon: 11.60 m bgl Post Monsoon: 12.70 m bgl Seasonal Fluctuation: (-)1.10 m/yr **Aquifer-III** No Monitoring Station

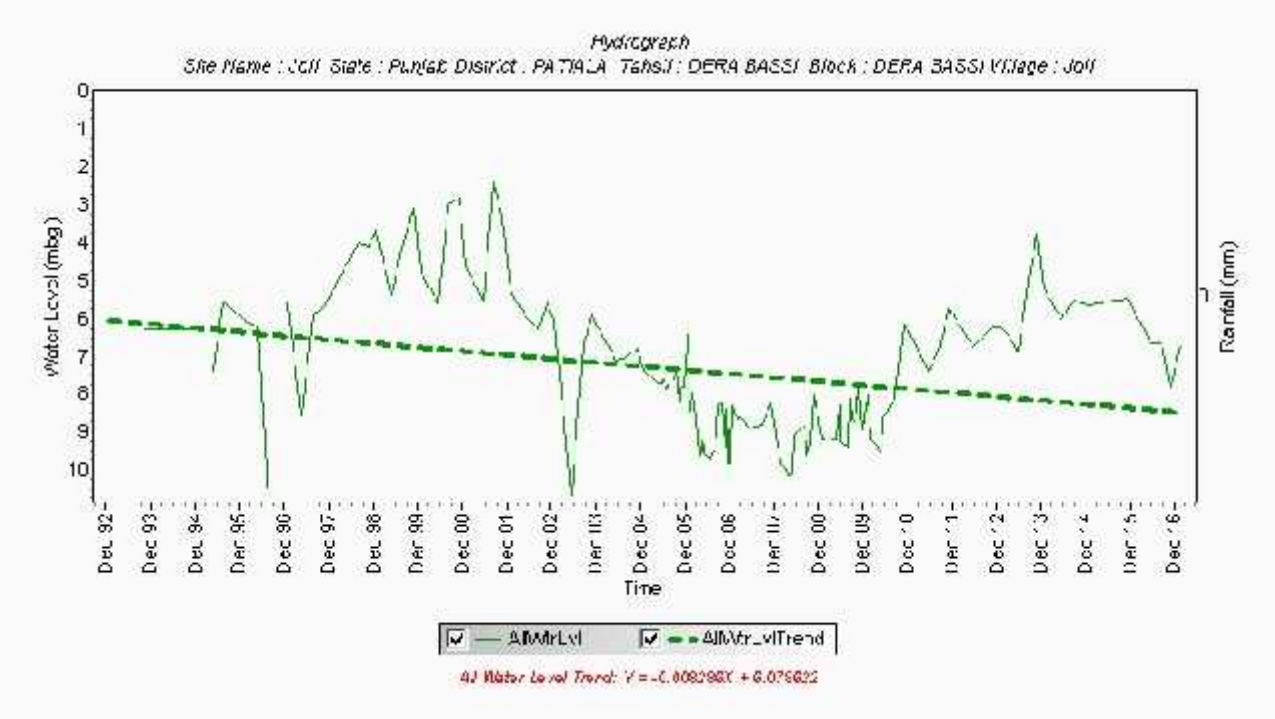
HYDROGRAPH SHOWING DECLINING WATER TABLE

(Location: Singhpura)



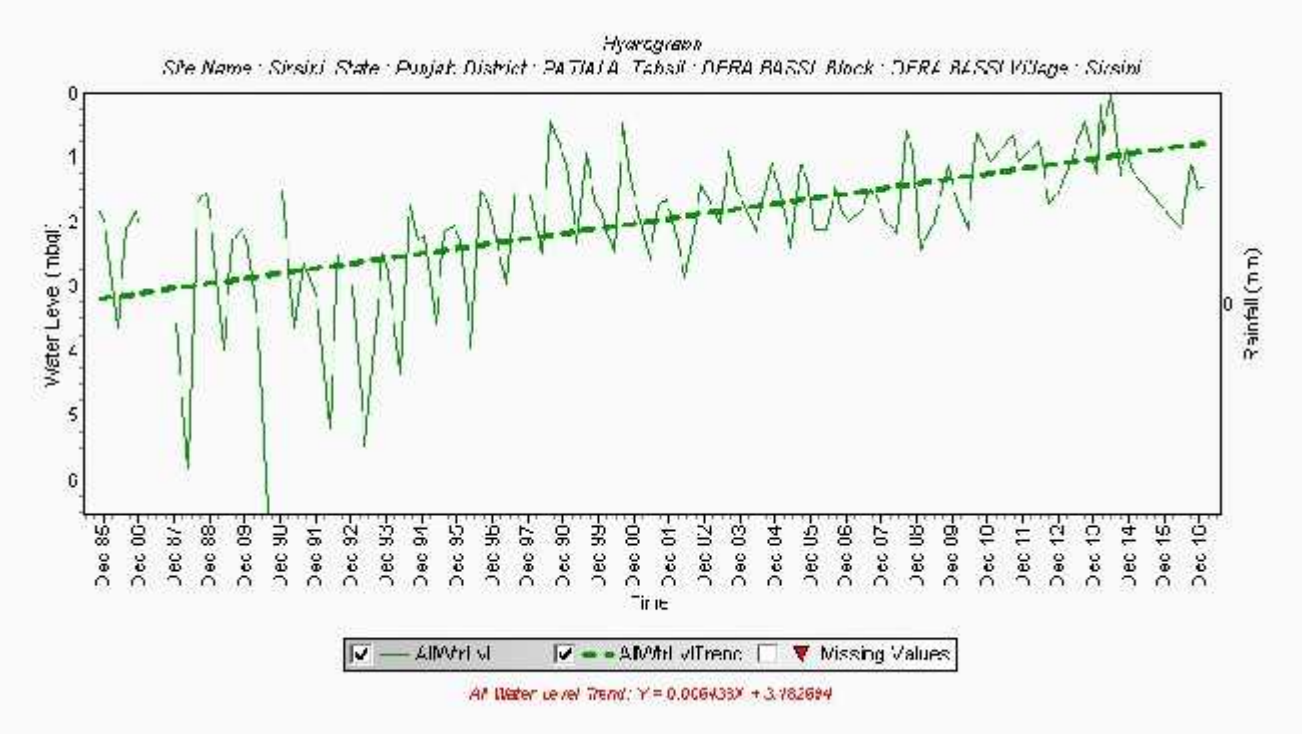
HYDROGRAPH SHOWING DECLINING WATER TABLE

(Location: Joli)



HYDROGRAPH SHOWING RISING WATER TABLE

(Location: Sirsini)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Younger Alluvium
Aquifer Disposition	Multiple Aquifer System (Three Aquifer Groups)

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	1	0	0	6	**7**
WRED/WSS	4	0	0	0	**4**
PRIVATE	0	1	7	12	**20**
TOTAL	**5**	**1**	**7**	**18**	**31**

Aquifer wise Characteristics

Aquifer Group	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)	Discharge (m^3/day)	Specific Yield	Storativity
Aquifer –I (11.73 -109 m)	Quarter-nary Alluvial deposits	Unconfined to confined	35	154	3859	12 % *(0.072)*	2.85×10^{-4}
Aquifer-II (129 - 199 m)		Semi confined to Confined	28				NA
Aquifer-III (218 - 300 m)		Semi confined to Confined	23	NA	NA		NA

NA: Not Available

Source: Ground Water Exploration Report, CGWB, 2015

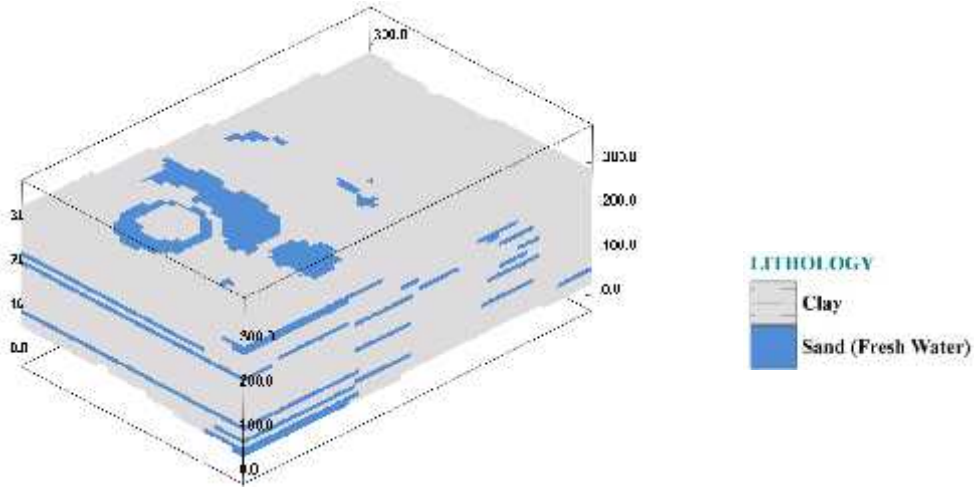
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

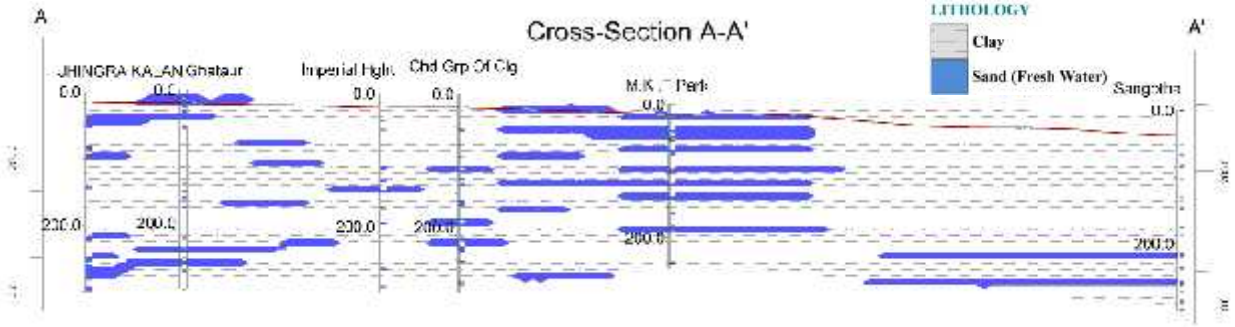
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	5	**5**
WRED/WSS	0	0	0	0	**0**
PRIVATE	0	0	7	2	**9**
TOTAL	**0**	**0**	**7**	**7**	**14**

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.

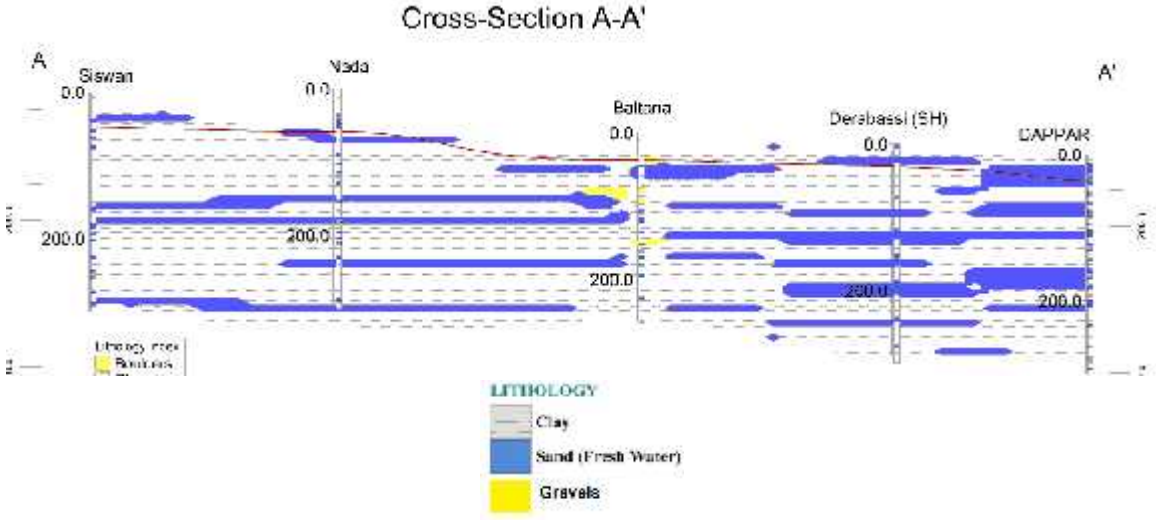
3-D Lithological model of Dera Bassi Block



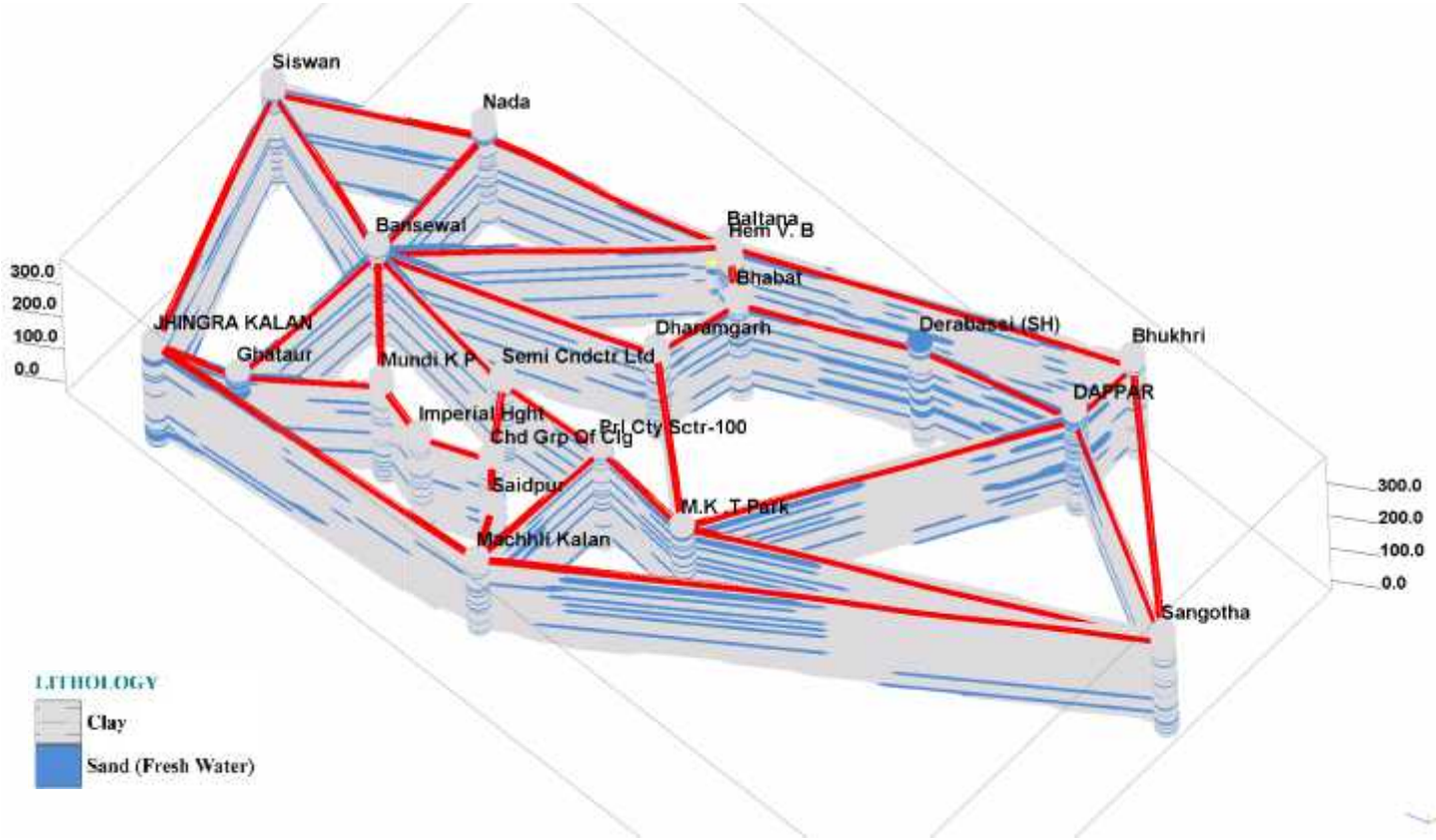
Lithological Cross section from Jingra to Sangotha



Lithological Cross section from Siswan to Dappar

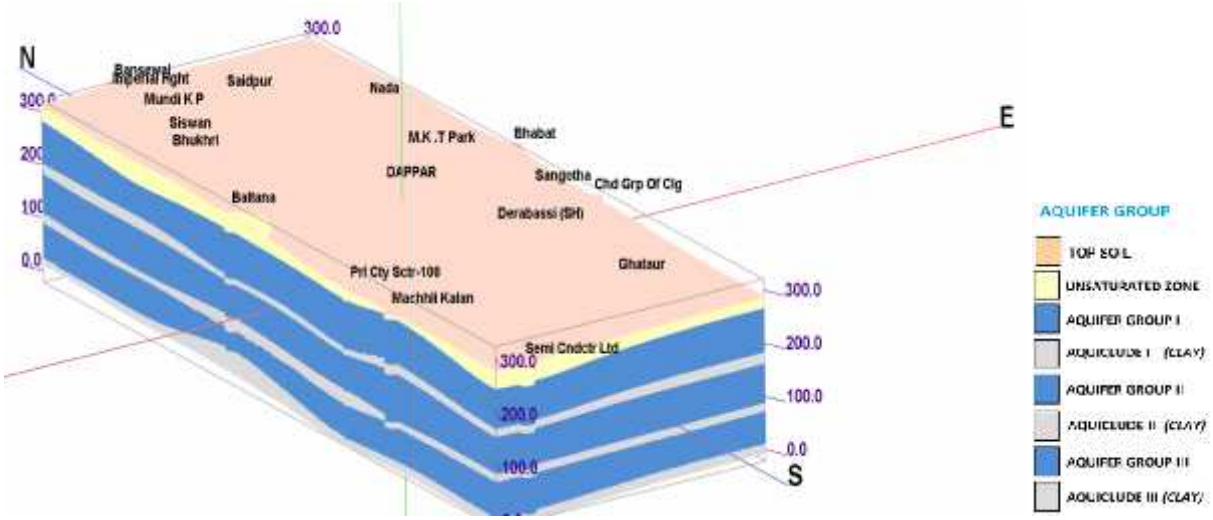


3-D Lithological Fence Diagram

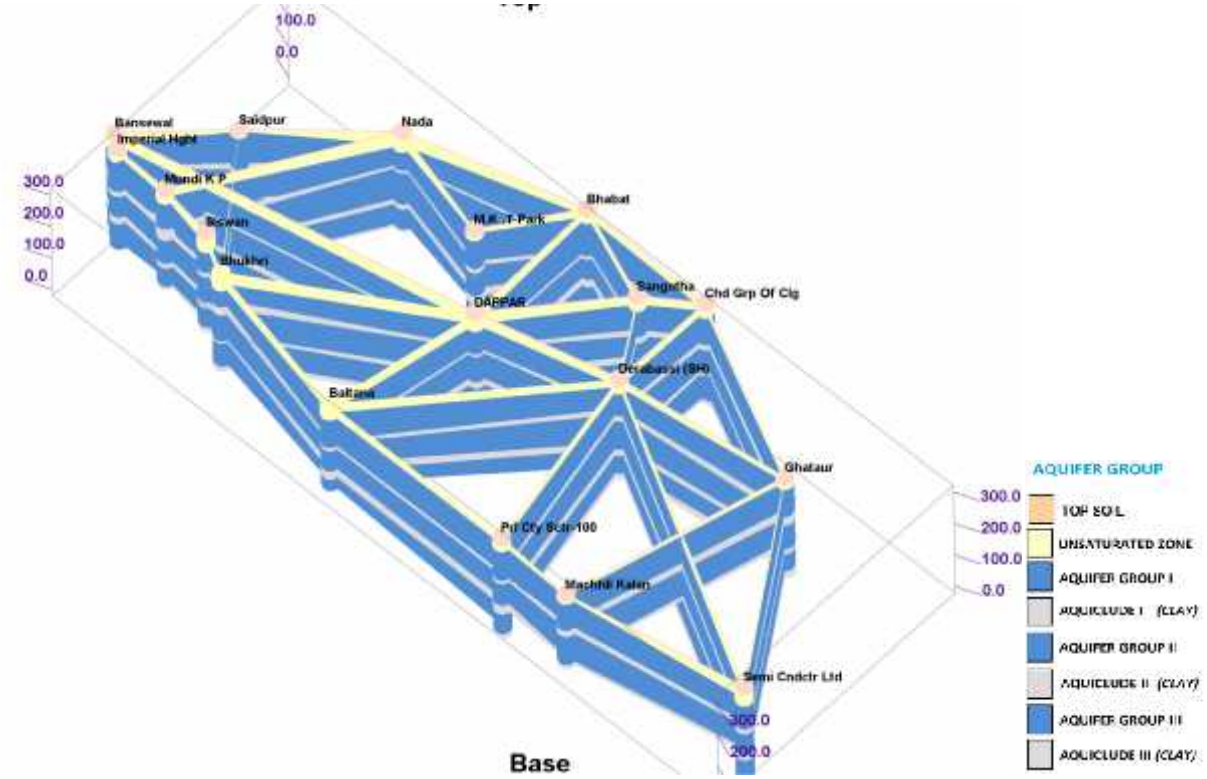


WATER LEVEL

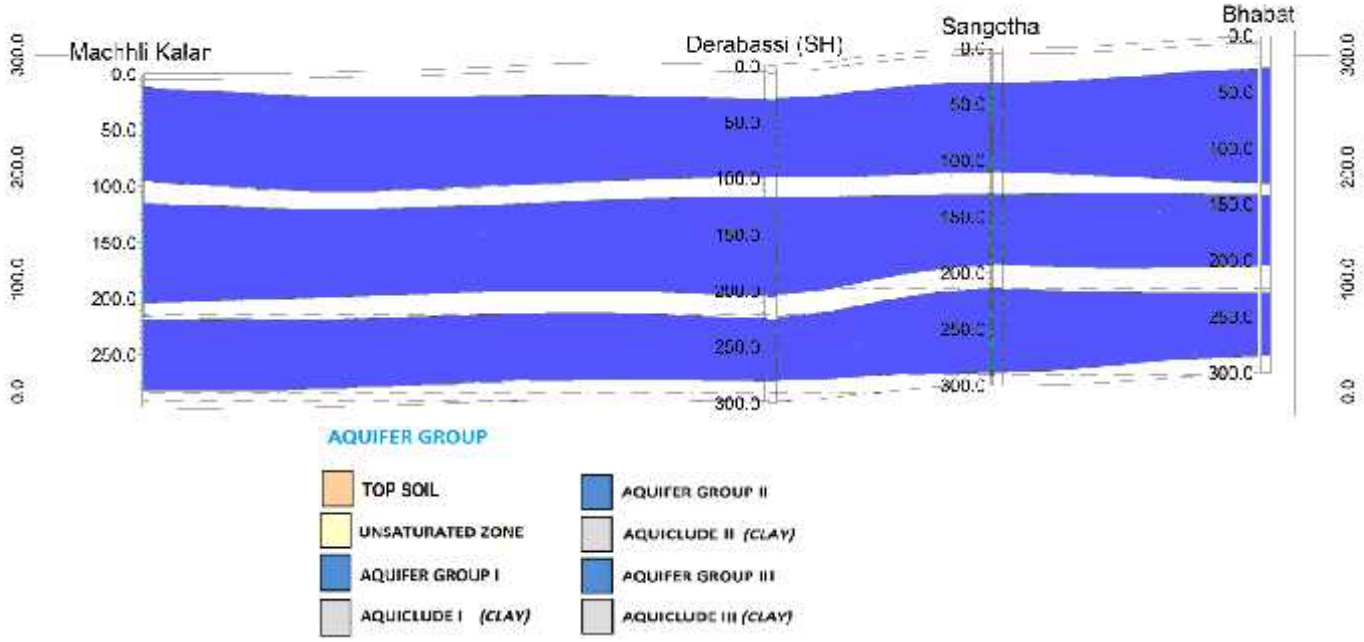
3-D Aquifer Disposition Model of Dera Bassi Block



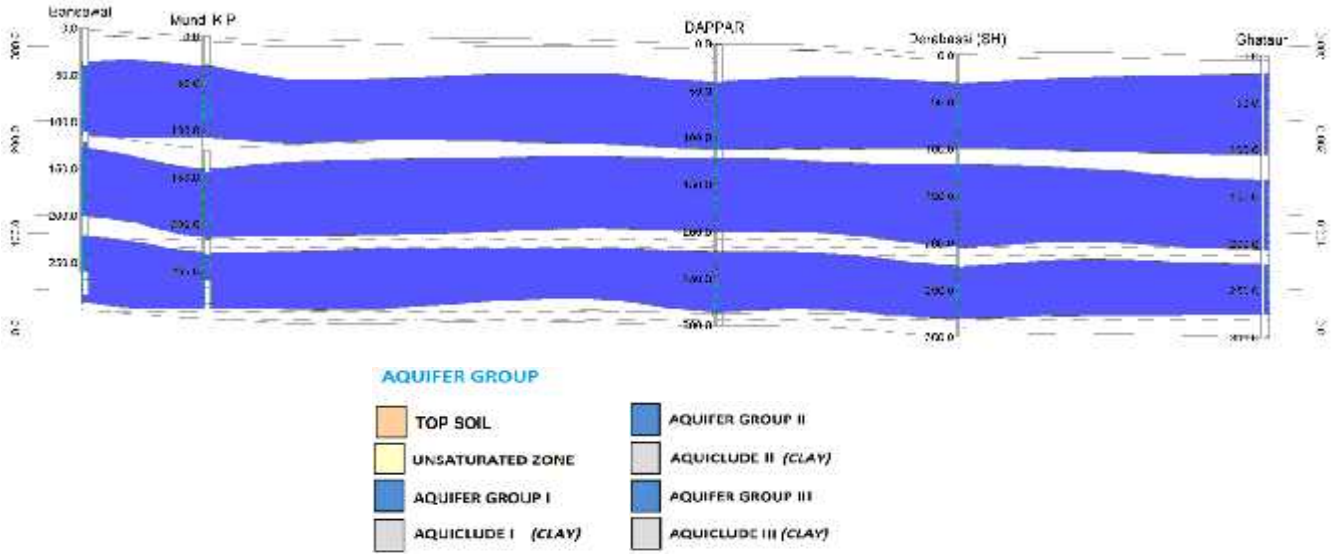
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Machhli kalan to Bhabat



Aquifer Cross section along Bansewal to Ghataur



Ground water Resource, Extraction, Contamination and other issues in Dera Bassi Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	132.50 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1209.35 mcm
	In-storage Aquifer-II (Specific Yield Concept)	967.48 mcm
	In-storage Aquifer-II (Storativity Concept)	114.97 mcm
	In-storage Aquifer-III (Specific Yield Concept)	794.71 mcm
	In-storage Aquifer-II (Storativity Concept)	NA
	Total Resources	3219.02 mcm
Ground Water Extraction (as per 2013)	Irrigation	138.08 mcm
	Domestic & Industrial	24.07 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		31.86 mcm
Stage of Groundwater Development		122 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature and pH ranges between 7.75 to 9.15. EC value of the ground water show wide variations and ranges from 615 µS/cm to 8970 µS/cm at 25^0C. RSC values are varies from -28.42 to 9.47

	meq/L and the area is fit for irrigation.
Ground water Contamination Issues	***Iron (>1.5 mg/l):*** Isarpur-I (12.53), Isarpur-II (25.83), Sarsini (4.23), Handesaran (6.28) ***Nitrate (>45mg/l):*** Isarpur (700), Derabassi (440), Antala (133) ***Fluoride (>1.5 mg/l):*** Gholu majra (2.9) ***EC* «S/cm at 25^{0}C:** Isarpur (8970)
Other issues	Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources.

Ground water Resource Enhancement Potential

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

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 331.71 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 conserve 4.84 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Dera bassi Block (479.90 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 29.12 mcm

Required Change in cropping pattern

Not Required

Alternate Water sources

Surface water sources: *Tanks, Ponds*
No.of Water tanks: 65
Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Sunflower, Maize

Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

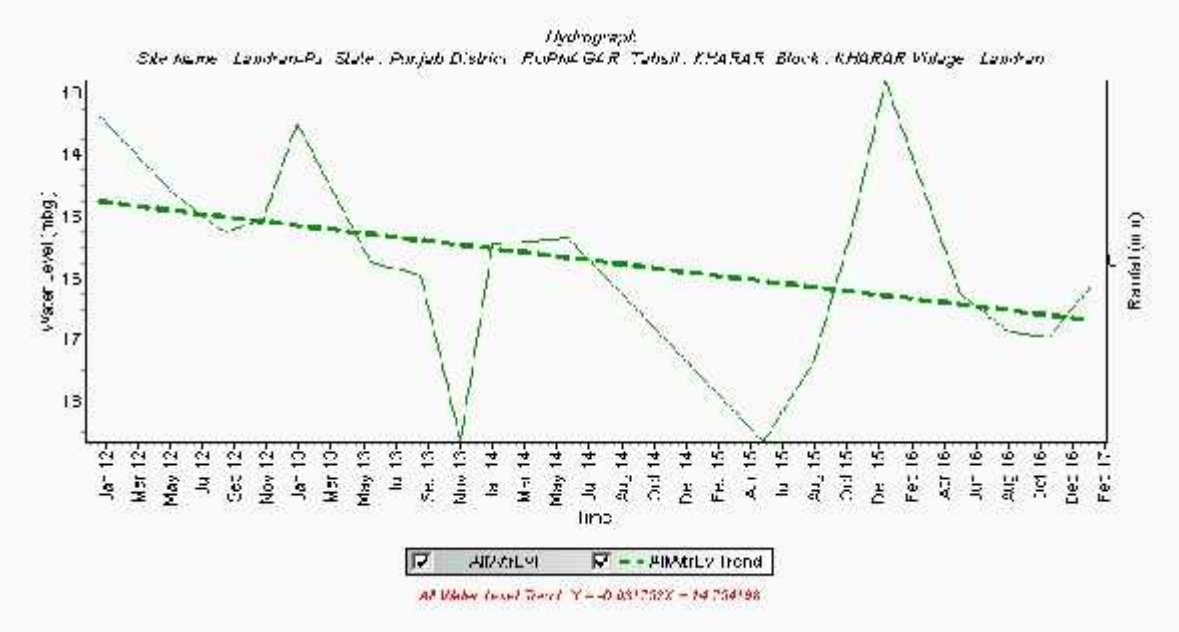
II. Salient Information of Kharar Block

<table>
<tr><td>Block Area
(in Km^2)</td><td>479.90 sq km</td></tr>
<tr><td>District/ State</td><td>Mohali, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 52104
Rural Population: 169219
Total population: 221323</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 611mm
Non-monsoon Rainfall : 158 mm
Annual Average Rainfall: 769 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Wheat, Rice, Maize and Sugar cane
Other crops: Vegetables and Fodder
Gross cropped area: 405.59 sq km
Net sown area: 226.10 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 179%
<u>Area under</u>
Ground water Irrigation: 218.73 sq km
Surface water irrigation: NIL
Gross Irrigated area: 390 sq km
Net Irrigated area: 207.81 sq km
Intensity of Irrigation: 188%
Number and types of abstraction structures: 6691, Tubewells</td></tr>
<tr><td>Ground Water Resource Availability and Extraction</td><td><u>Ground water Resources Availability</u>
Ground Water Resources are available in the different group of aquifers. The fresh water resources are estimated up to the depth of 300 m on the basis of geophysical interpretations.
<table>
<tr><th>Aquifer Group</th><th>Aquifer Depth range (m)</th><th>Aquifer Thickness (m)</th><th>Granular Zones (m)</th><th>Resources (mcm)</th></tr>
<tr><td>Aquifer-I</td><td>9.89 – 108.0</td><td>98</td><td>34</td><td>1111.98</td></tr>
<tr><td>Aquifer-II</td><td>130.0 – 201.0</td><td>71</td><td>24</td><td>810.98</td></tr>
<tr><td>Aquifer-III</td><td>220.0 – 300.0</td><td>80</td><td>19</td><td>569.36</td></tr>
</table>
Total Ground Water Resources available is 2492.32 mcm and total potential granular zones available are 77 m up to depth of 300 m. Block is categorized as Over-Exploited as per Dynamic Groundwater Resources, 2013 assessment.
<u>Ground water Resources Extraction</u>
Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply wells of State Government tapping combined aquifers. Therefore, the ground water draft could not be assessed for Aquifer-II and III separately.</td></tr>
</table>

Existing and future water demands	Water Scarcity Villages: 141 Small Scale Industries : 16 Large Scale Industries : 1 Total Villages : 143 *Existing Gross Ground water Draft as on 2013* Irrigation: 68.71 mcm Domestic and industrial water supply: 24.50 mcm *Future water demands* Irrigation development potential : (-)7.63 mcm Domestic and industrial water supply up to 2025 years : 32.04 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 6.58 - 18.65 m bgl Post Monsoon: 3.78 - 19.50 m bgl Seasonal Fluctuation: 3.76 - (-)1.90 m/yr Mean (10 yrs) : 1.37 - (-)2.63 m/yr *Trends* Pre Monsoon: 0.43 - (-)0.13 m/yr Post Monsoon: 0.11 - (-)0.04 m/yr **Aquifer-II** Pre Monsoon: 22.00 m bgl Post Monsoon: 22.95 m bgl Seasonal Fluctuation: (-)0.95m/yr **Aquifer-III** No Monitoring Station

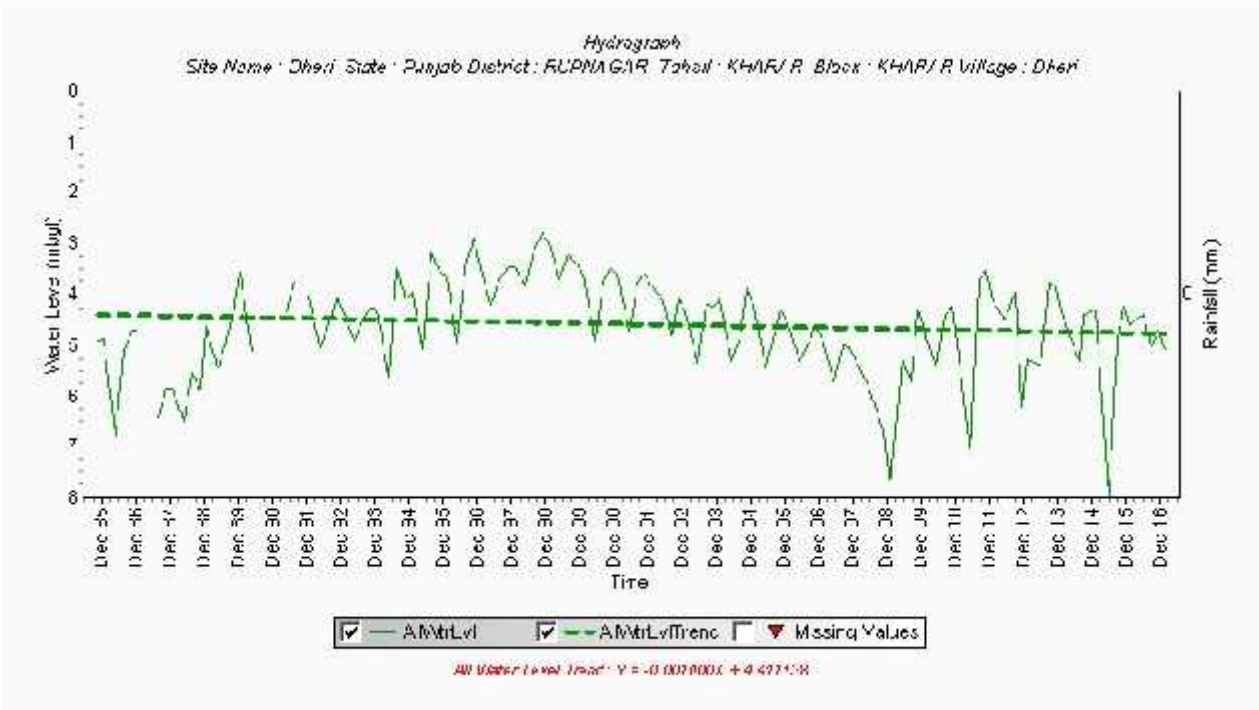
HYDROGRAPH SHOWING DECLINING WATER TABLE

(Location: Landran)



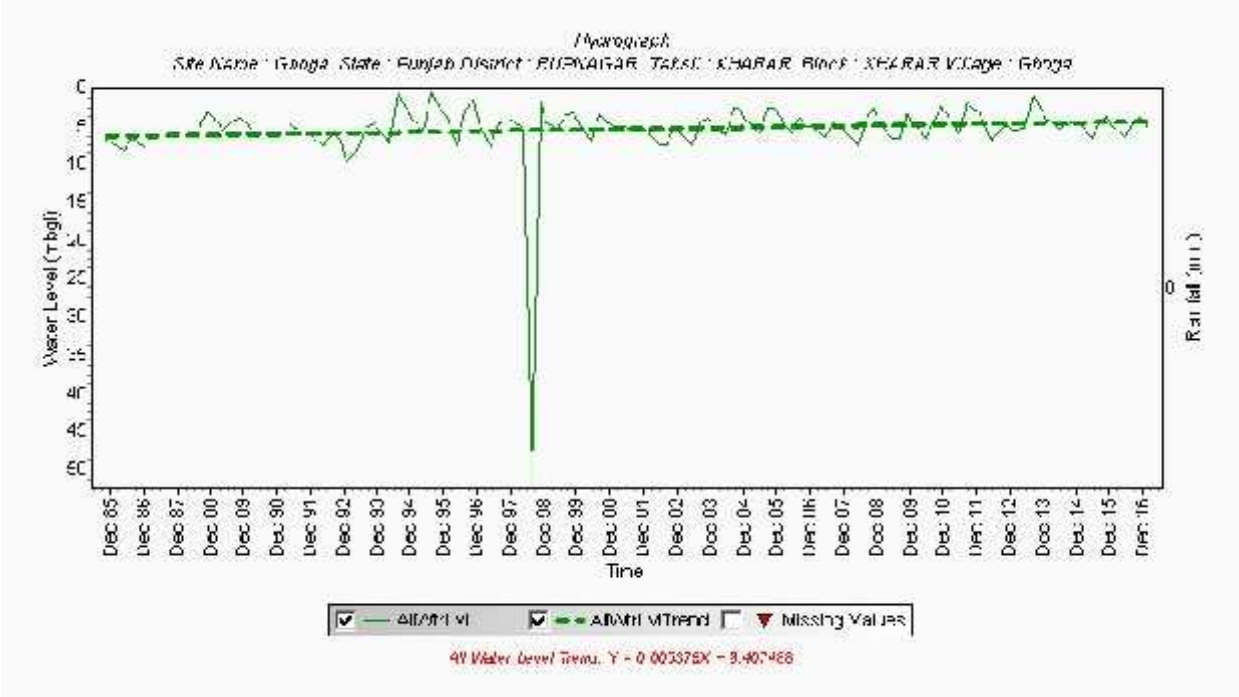
HYDROGRAPH SHOWING DECLINING WATER TABLE

(Location: Dheri)



HYDROGRAPH SHOWING RISING WATER TABLE

(Location: Ghoga)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Younger Alluvium
Aquifer Disposition	Multiple Aquifer System (Three Aquifer Groups)

Exploratory Data Availability

Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	2	0	0	4	**6**
WRED/WSS	7	0	0	0	**7**
PRIVATE	0	3	19	41	**53**
TOTAL	**9**	**3**	**19**	**45**	**76**

Aquifer wise Characteristics

Aquifer Group	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)	Discharge (m^3/day)	Specific Yield	Storativity
Aquifer –I (9.89 -108 m)	Quarter-nary Alluvial deposits	Unconfined to confined	34	687 - 1395	2857 - 3466	12 % *(0.072)*	1.69×10^{-3} - 7.30×10^{-4}
Aquifer-II (130 - 201 m)		Semi confined to Confined	24				
Aquifer-III (220 - 300 m)		Semi confined to Confined	19				

Aquifer group wise Parameters are not available

Source: Ground Water Exploration Report, CGWB, 2015

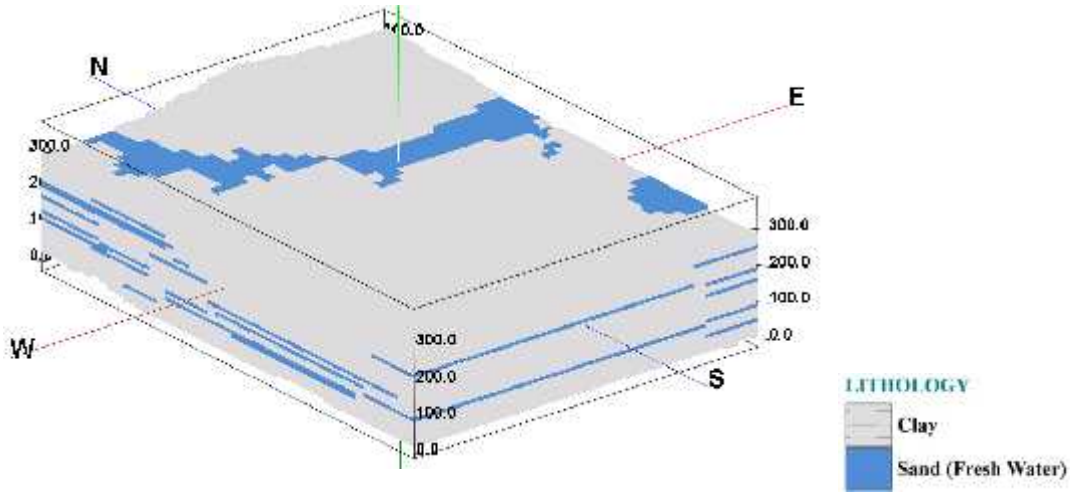
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

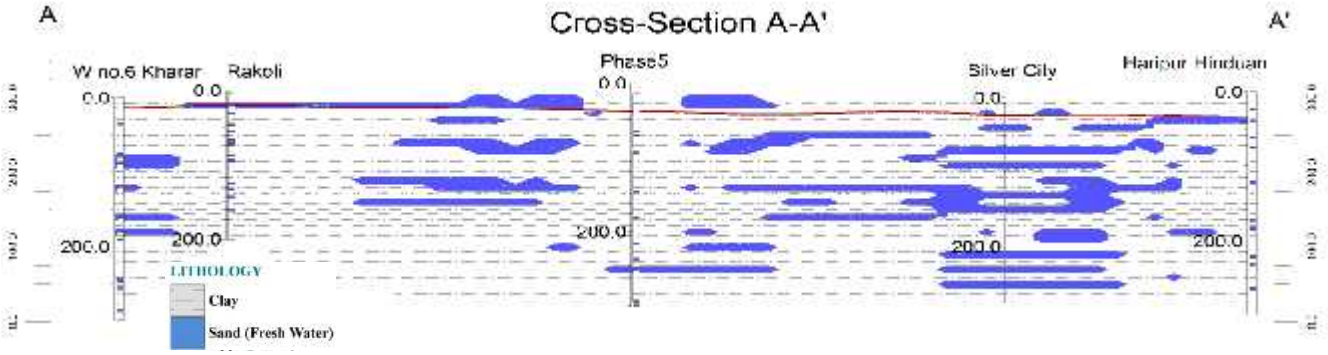
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	2	**2**
WRED/WSS	0	0	0	0	**0**
PRIVATE	0	0	5	25	**30**
TOTAL	**0**	**0**	**5**	**27**	**32**

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.

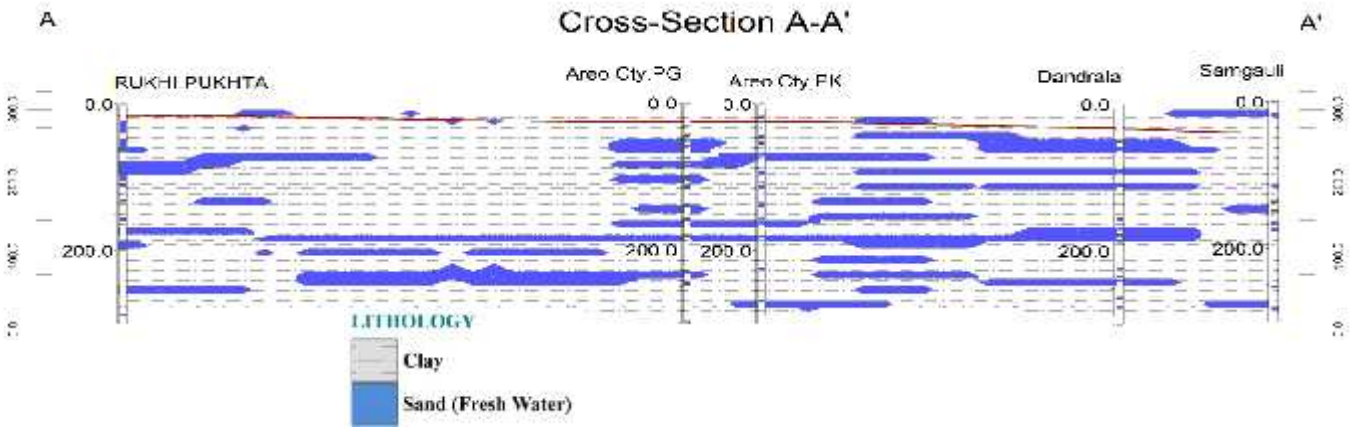
3-D Lithological model of Kharar Block



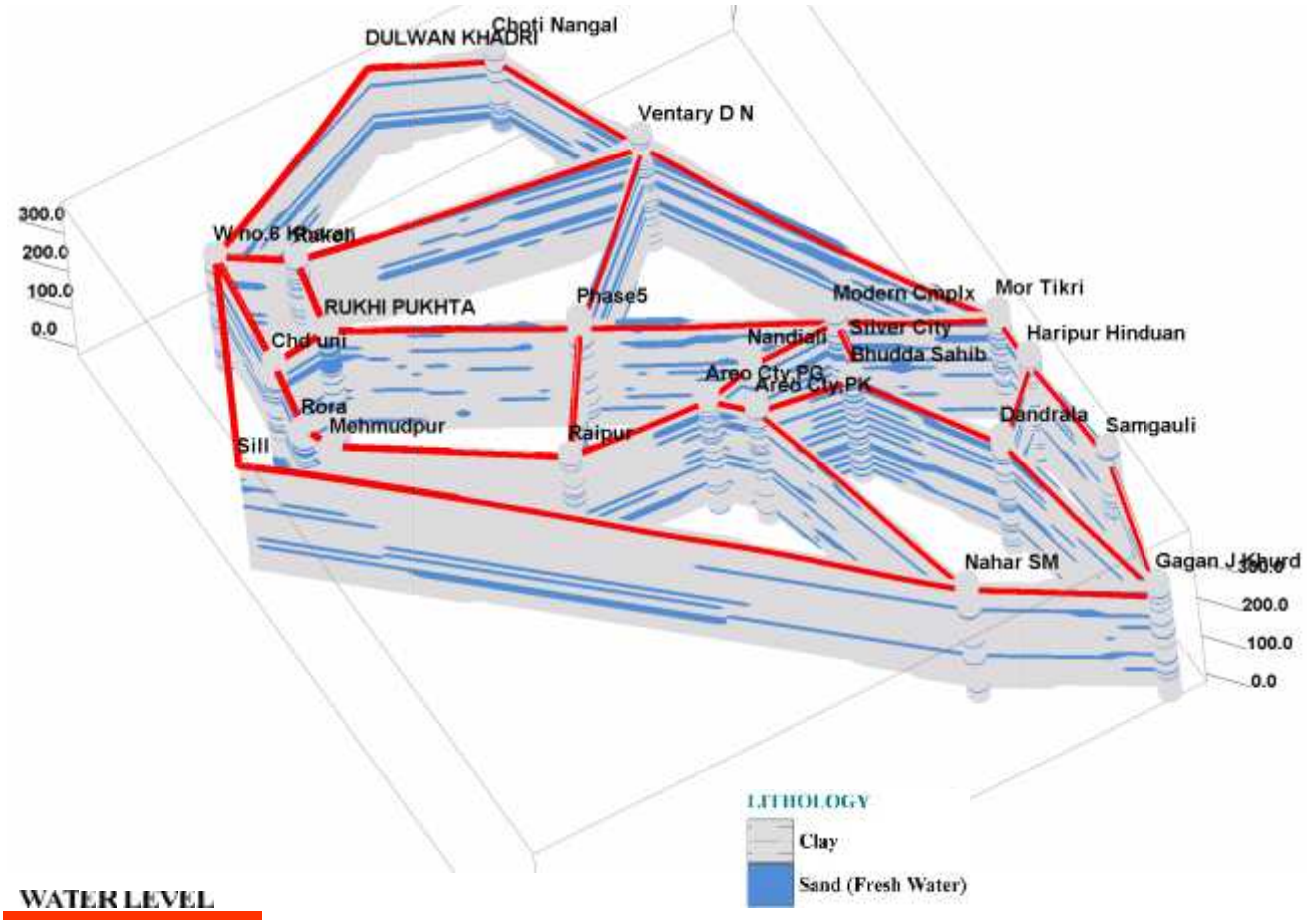
Lithological Cross section from Kharar to Haripur Hinduan



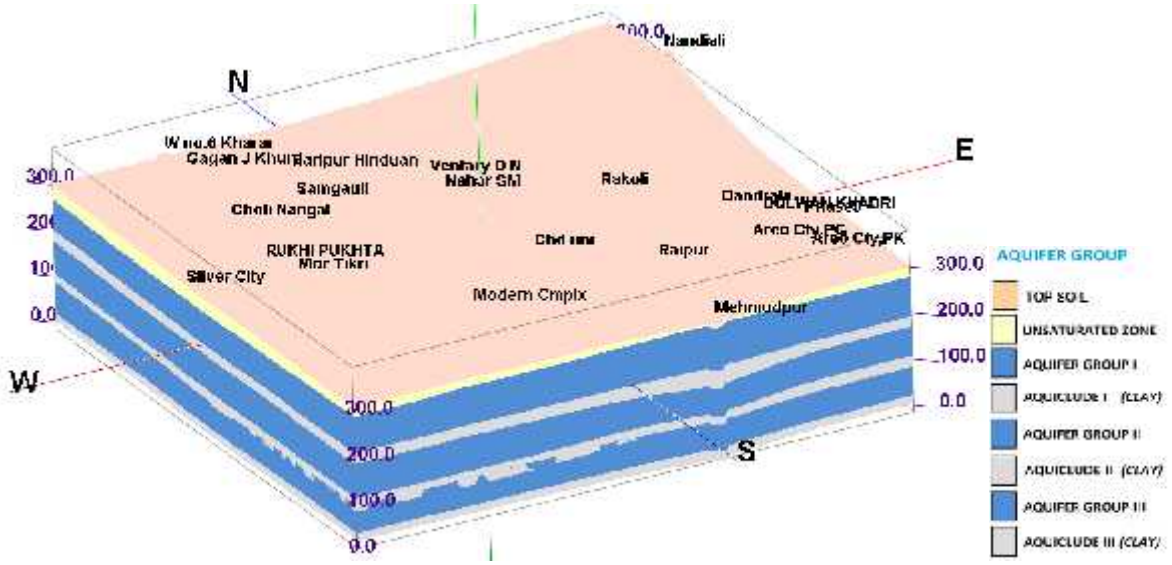
Lithological Cross section from Rukhi pukta to Samgauli



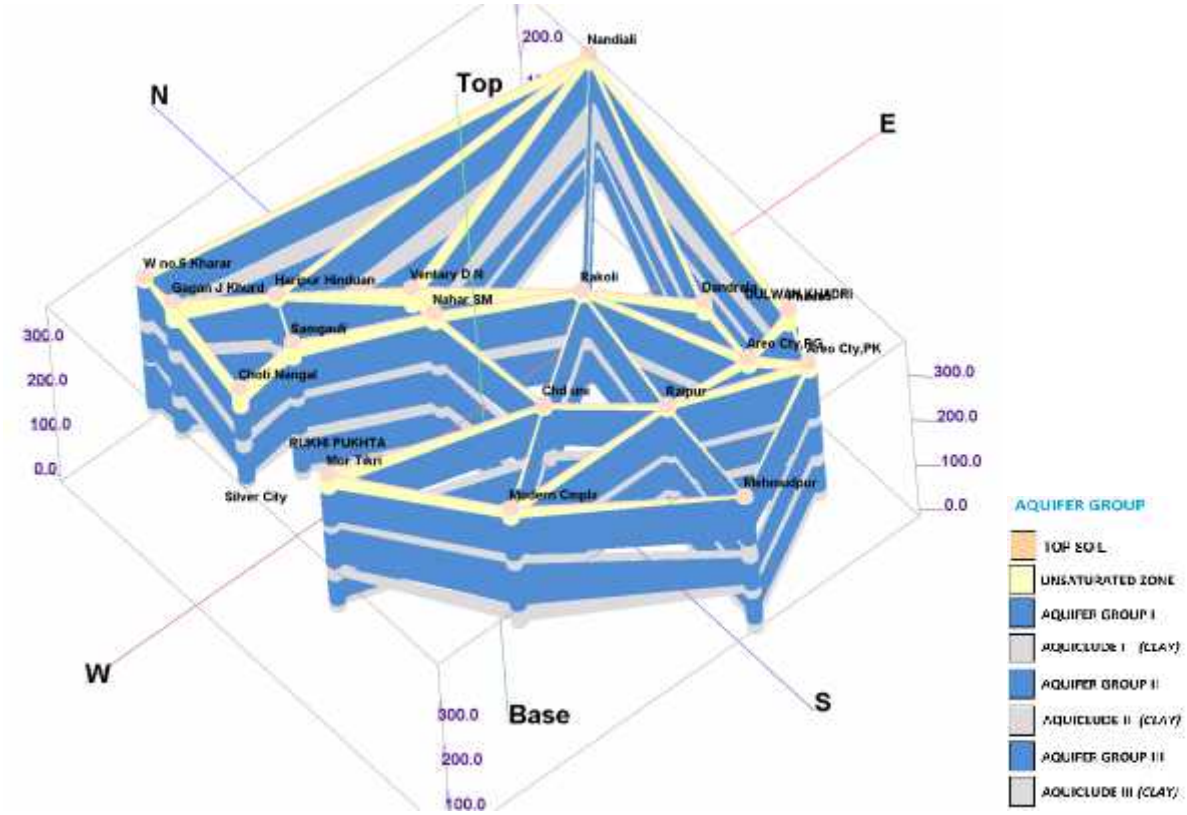
3-D Lithological Fence Diagram



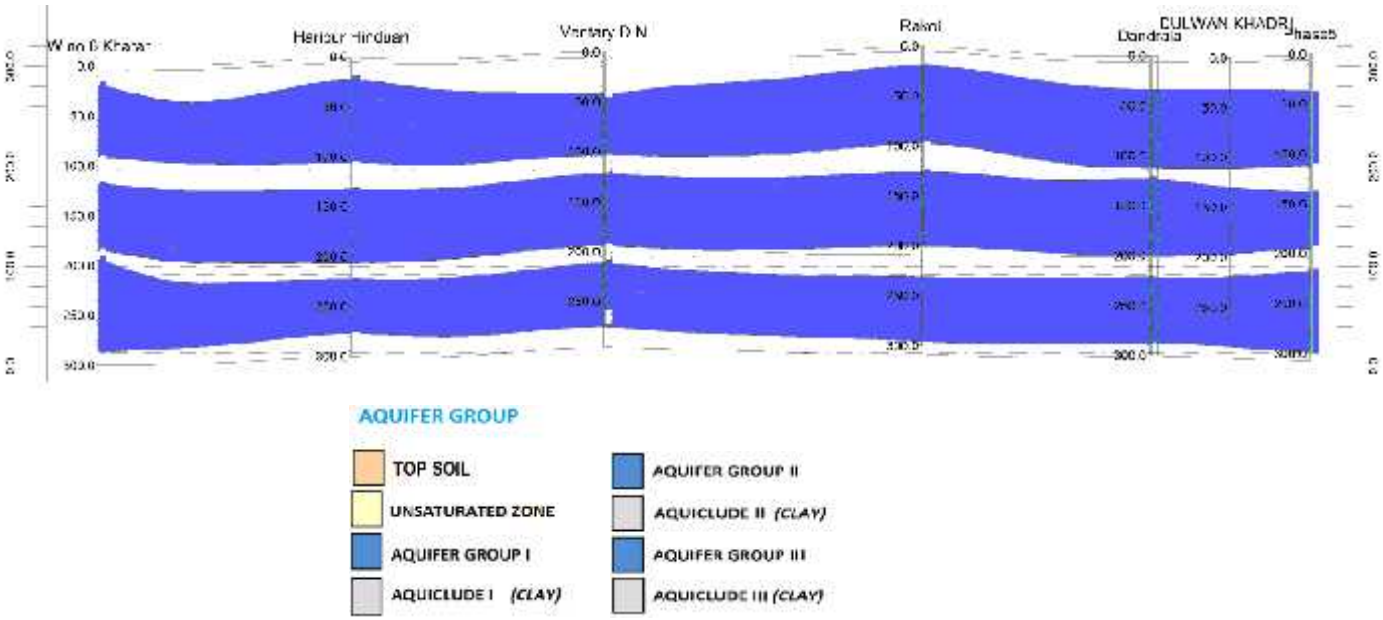
3-D Aquifer Disposition Model of Kharar Block



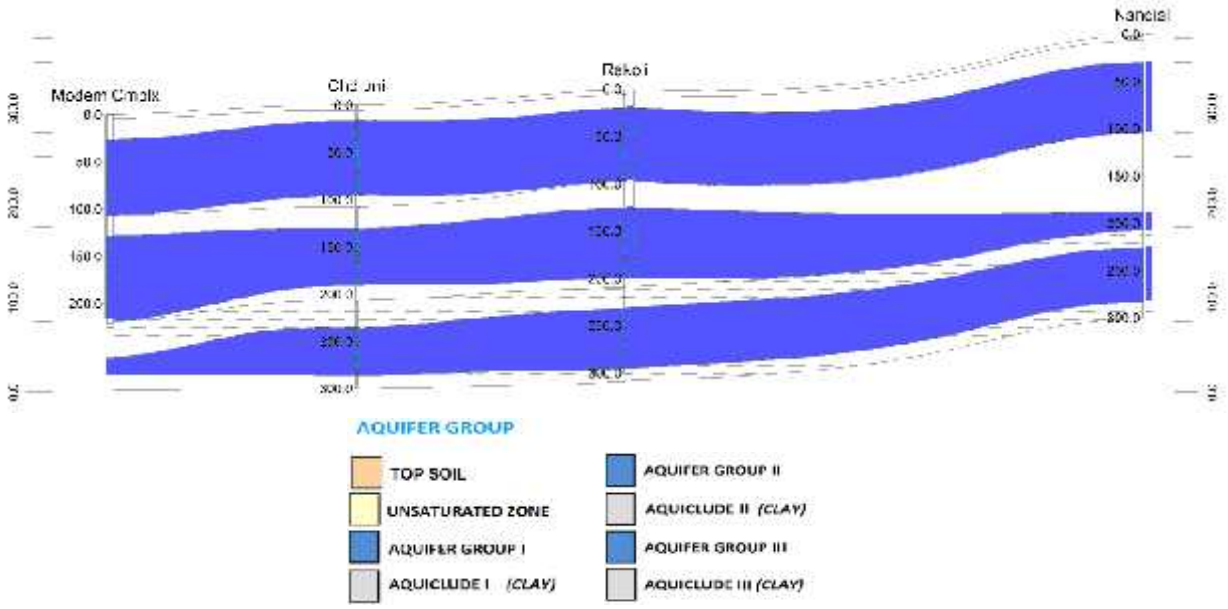
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along W No. 6 Kharar to Phase-5



Aquifer Cross section along Modern complx to Nandiali



Ground water Resource, Extraction, Contamination and other issues in Kharar Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	93.12 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1018.86 mcm
	In-storage Aquifer-II (Specific Yield Concept)	719.19 mcm
	In-storage Aquifer-II (Storativity Concept)	91.78 mcm
	In-storage Aquifer-III (Specific Yield Concept)	569.36 mcm
	In-storage Aquifer-II (Storativity Concept)	NA
	Total Resources	2492.32 mcm
Ground Water Extraction (as per 2013)	Irrigation	68.71 mcm
	Domestic & Industrial	24.50 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		32.04 mcm
Stage of Groundwater Development		100 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature and pH ranges between 8.07 to 8.85. EC value of the ground water show wide variations and ranges from 601 µS/cm to 1240 µS/cm at 25^0C.

	RSC values are varies from -3.18 to 3.72 meq/L and the area is fit for irrigation.
Ground water Contamination Issues	***Nitrate (>45mg/l):*** Landran (118)
Other issues	Water level decline has been observed in major parts of the block due to in discriminate development of ground water resources.

Ground water Resource Enhancement Potential

Aquifer wise space available for recharge and proposed interventions (Supply Side Measures)
Aquifer-I:
Volume of unsaturated zone after 3m upto a desirable depth: 217.26 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 conserve 5.11 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Kharar Block (416.20 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 14.49 mcm
Required Change in cropping pattern
Not Required
Alternate Water sources
Surface water sources: *Tanks, Ponds*
No.of Water tanks: 101
Location, details and availability from such sources outside the area: Not Available
Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Sunflower, Maize

Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

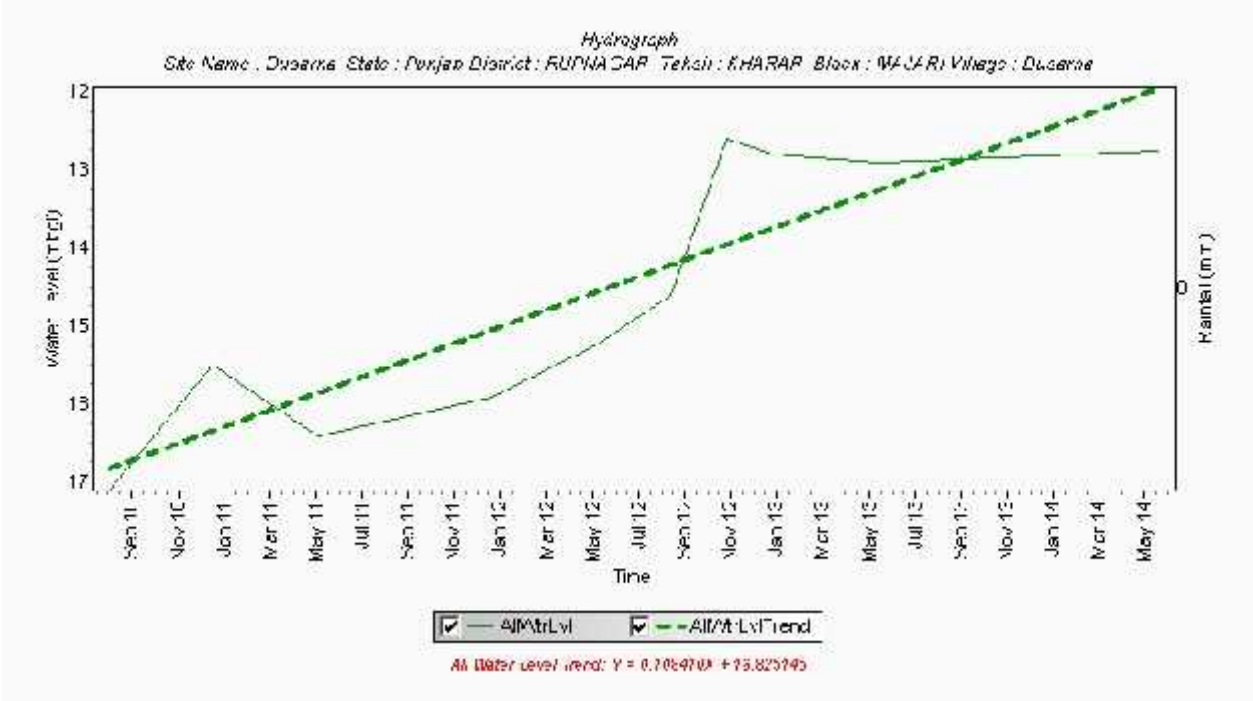
III. Salient Information of Sialba Majri Block

<table>
<tr><td>Block Area
(in Km^2)</td><td>292.30 sq km</td></tr>
<tr><td>District/ State</td><td>Mohali, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 0
Rural Population: 96004
Total population: 96004</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 623 mm
Non-monsoon Rainfall : 183 mm
Annual Average Rainfall: 806 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Wheat, Rice, Maize and Sugar cane
Other crops: Vegetables and Fodder
Gross cropped area: 250.45 sq km
Net sown area: 130.90 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 191%
<u>Area under</u>
Ground water Irrigation: 114.64 sq km
Surface water irrigation: NIL
Gross Irrigated area: 185.72 sq km
Net Irrigated area: 109.25 sq km
Intensity of Irrigation: 170%
Number and types of abstraction structures: 3616, Tubewells</td></tr>
<tr><td>Ground Water Resource Availability and Extraction</td><td><u>Ground water Resources Availability</u>
Ground Water Resources are available in the different group of aquifers. The fresh water resources are estimated up to the depth of 300 m on the basis of geophysical interpretations.
<table>
<tr><th>Aquifer Group</th><th>Aquifer Depth range (m)</th><th>Aquifer Thickness (m)</th><th>Granular Zones (m)</th><th>Resources (mcm)</th></tr>
<tr><td>Aquifer-I</td><td>8.24 – 117.0</td><td>109</td><td>35</td><td>802.11</td></tr>
<tr><td>Aquifer-II</td><td>133.0 – 203.0</td><td>70</td><td>24</td><td>572.53</td></tr>
<tr><td>Aquifer-III</td><td>228.0 – 300.0</td><td>72</td><td>18</td><td>379.60</td></tr>
</table>
Total Ground Water Resources available is 1754.24 mcm and total potential granular zones available are 77 m up to depth of 300 m. Block is categorized as Safe as per Dynamic Groundwater Resources, 2013 assessment.
<u>Ground water Resources Extraction</u>
Information regarding the abstraction from Aquifer II is not available, but there are drinking water supply wells of State Government tapping combined aquifers. Therefore, the ground water draft could not be assessed for Aquifer-II and III separately.</td></tr>
</table>

Existing and future water demands	Water Scarcity Villages: 114 Small Scale Industries : 27 Large Scale Industries : 3 Total Villages : 117 *Existing Gross Ground water Draft as on 2013* Irrigation: 26.44 mcm Domestic and industrial water supply: 1.94 mcm *Future water demands* Irrigation development potential : 34.12 mcm Domestic and industrial water supply up to 2025 years : 3.45 mcm
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 5.40 - 28.95 m bgl Post Monsoon: 5.25 - 29.80 m bgl Seasonal Fluctuation: 0.15 - (-)0.95 m/yr Mean (10 yrs) : Not Available (NA) *Trends* Pre Monsoon: NA Post Monsoon: NA **Aquifer-II & III** No Monitoring Stations

HYDROGRAPH SHOWING RISINGWATER TABLE

(Location: Dusrana)



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium, Pebbles/Gravels, Sandstone/ Conglomerates
Aquifer Disposition	Multiple Aquifer System (Three Aquifer Groups)

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	1	4	**5**
WRED/WSS	4	0	0	0	**4**
PRIVATE	0	8	23	12	**43**
TOTAL	**4**	**8**	**24**	**16**	**52**

Aquifer wise Characteristics

Aquifer Group	Geology	Type of Aquifer	Thickness of Granular zones (m)	Transmiss-ivity (m^2/day)	Discharge (m^3/day)	Specific Yield	Storativity
Aquifer –I (8.24 -117 m)	Quarter-nary Alluvial deposits	Unconfined to confined	35	55 - 725	1253 - 2208	12 % *(0.072)*	1.2×10^{-3}
Aquifer-II (133 - 203 m)		Semi confined to Confined	24	292 - 770	1551 - 2074		NA
Aquifer-III (228 - 300 m)		Semi confined to Confined	18				NA

NA: Not Available

Source: Ground Water Exploration Report, CGWB, 2015

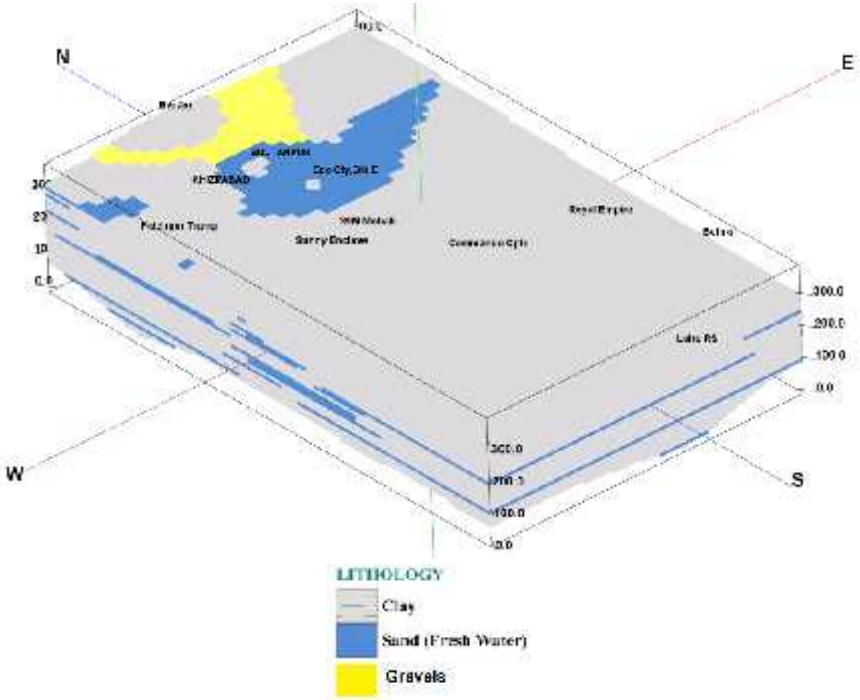
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

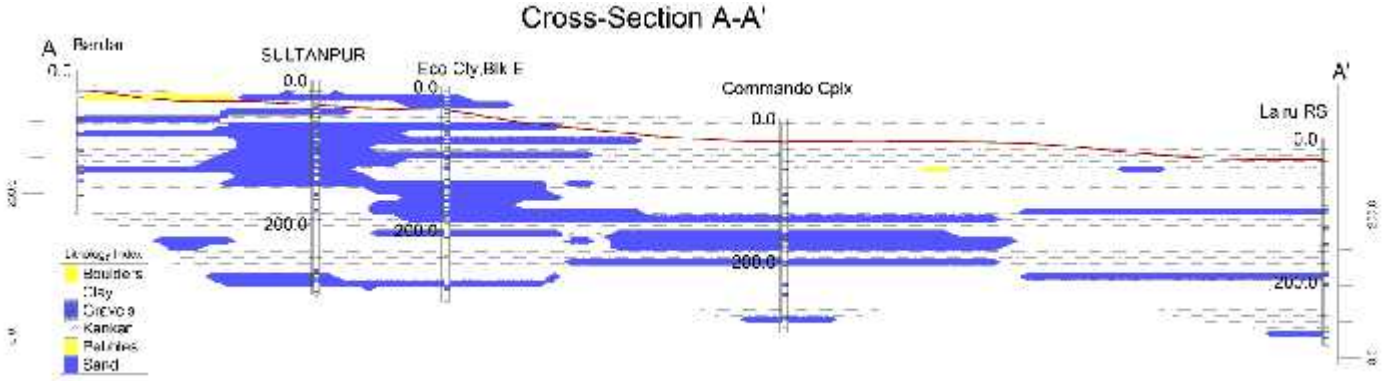
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	3	**3**
WRED/WSS	0	0	0	0	**0**
PRIVATE	0	0	4	4	**8**
TOTAL	**0**	**0**	**4**	**7**	**11**

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.

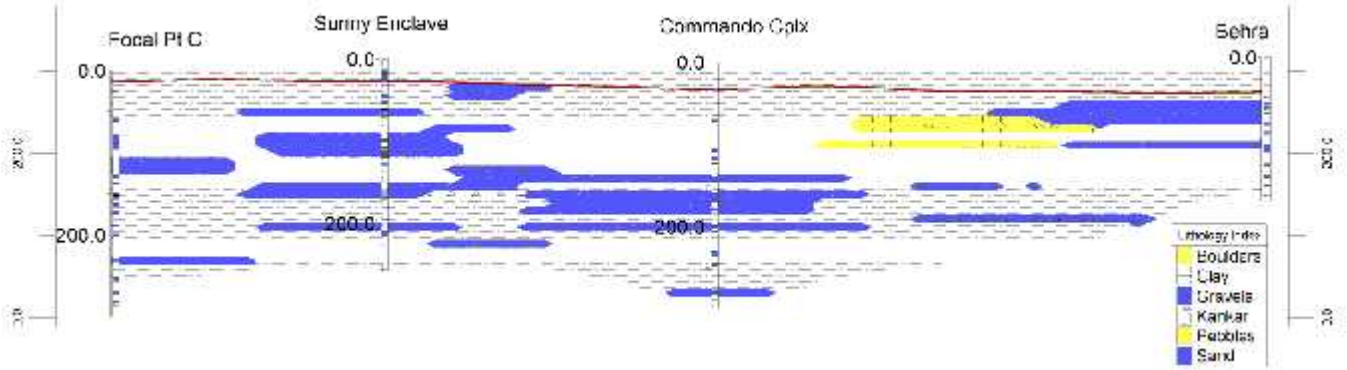
3-D Lithological model of Sialba Majri Block



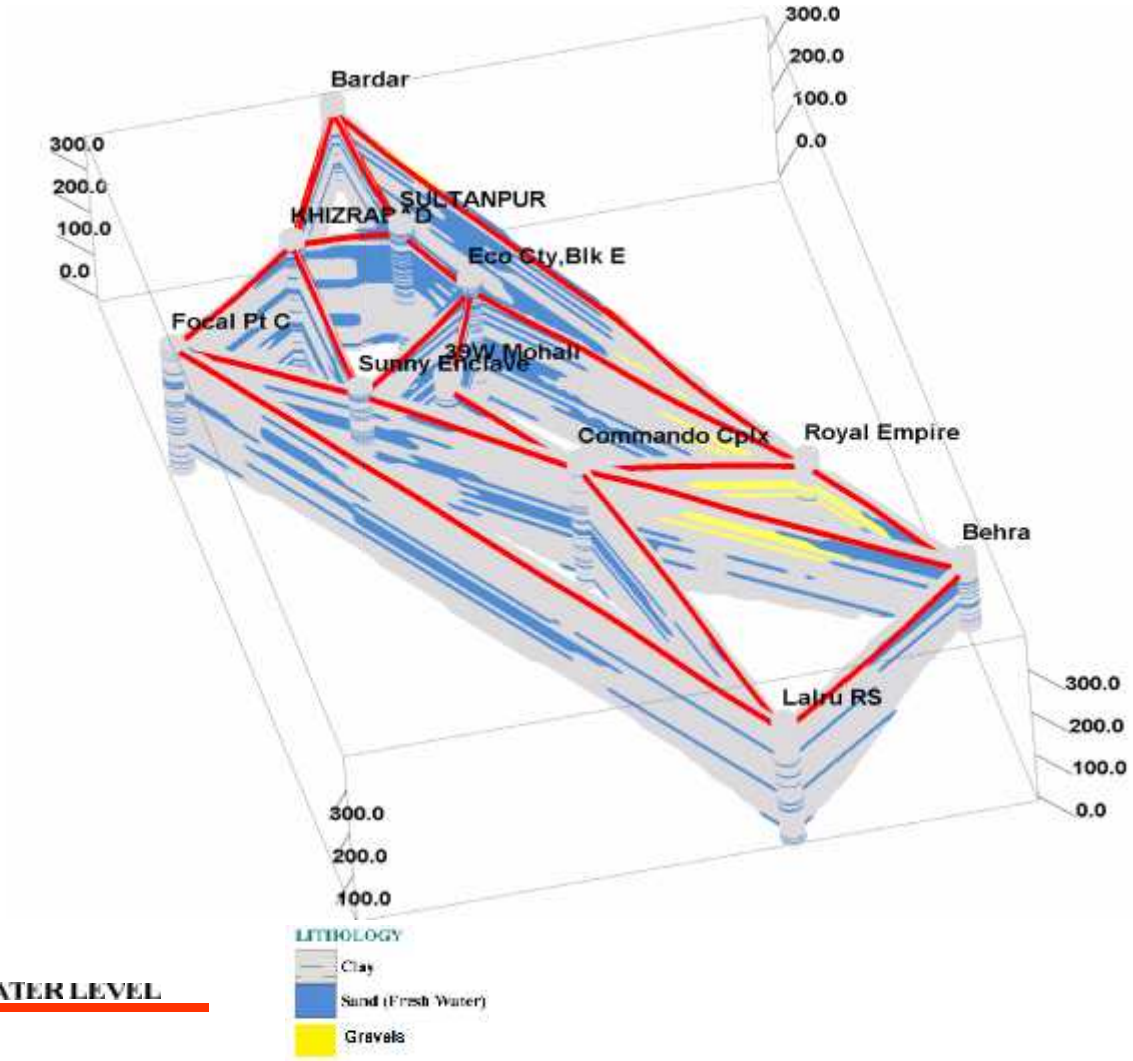
Lithological Cross section from Bardar to Lalru



Lithological Cross section from Focal Pt C to Behra

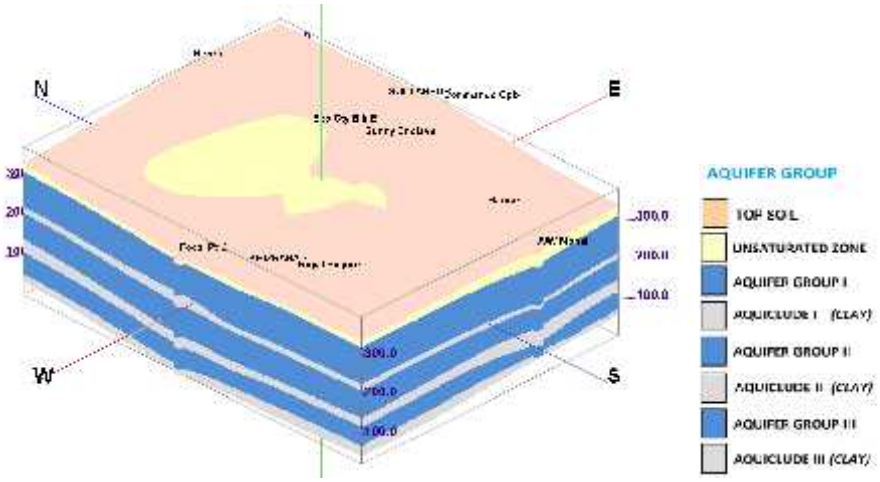


3-D Lithological Fence Diagram

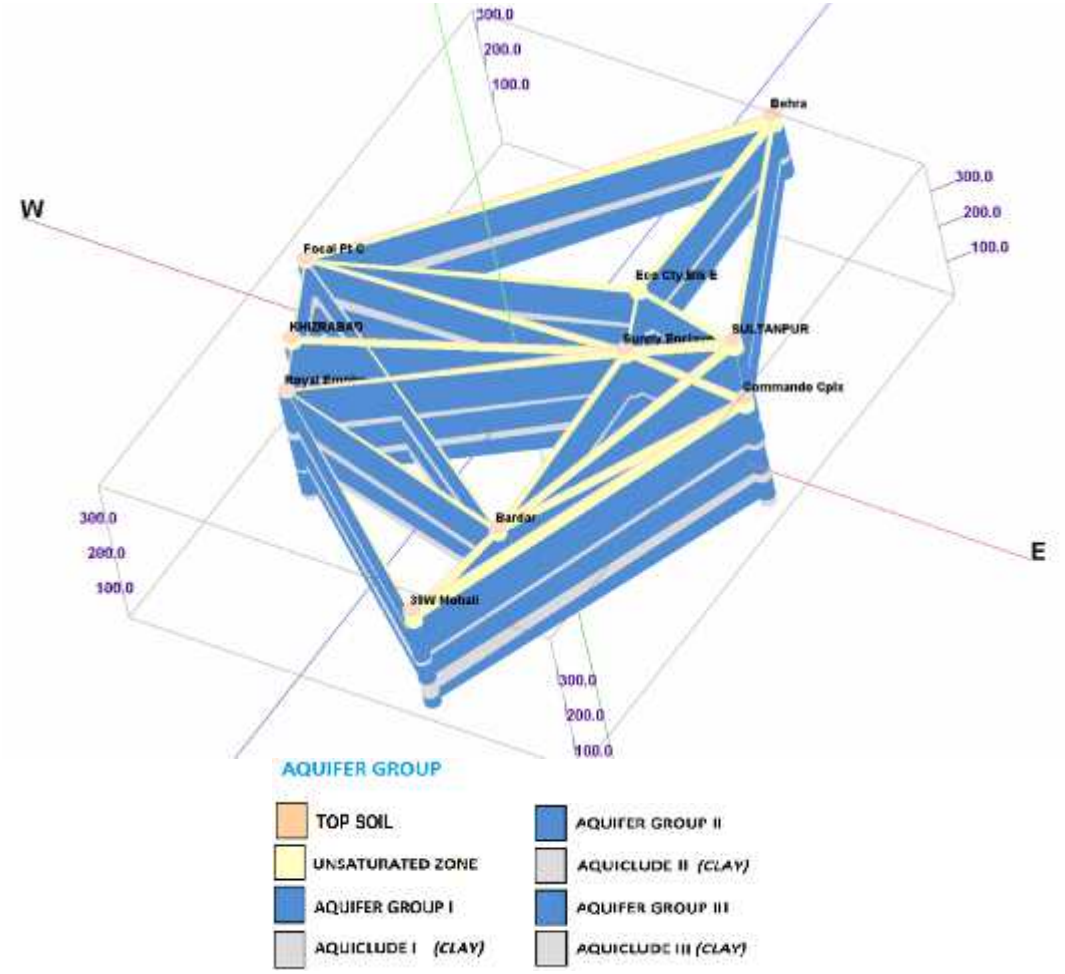


WATER LEVEL

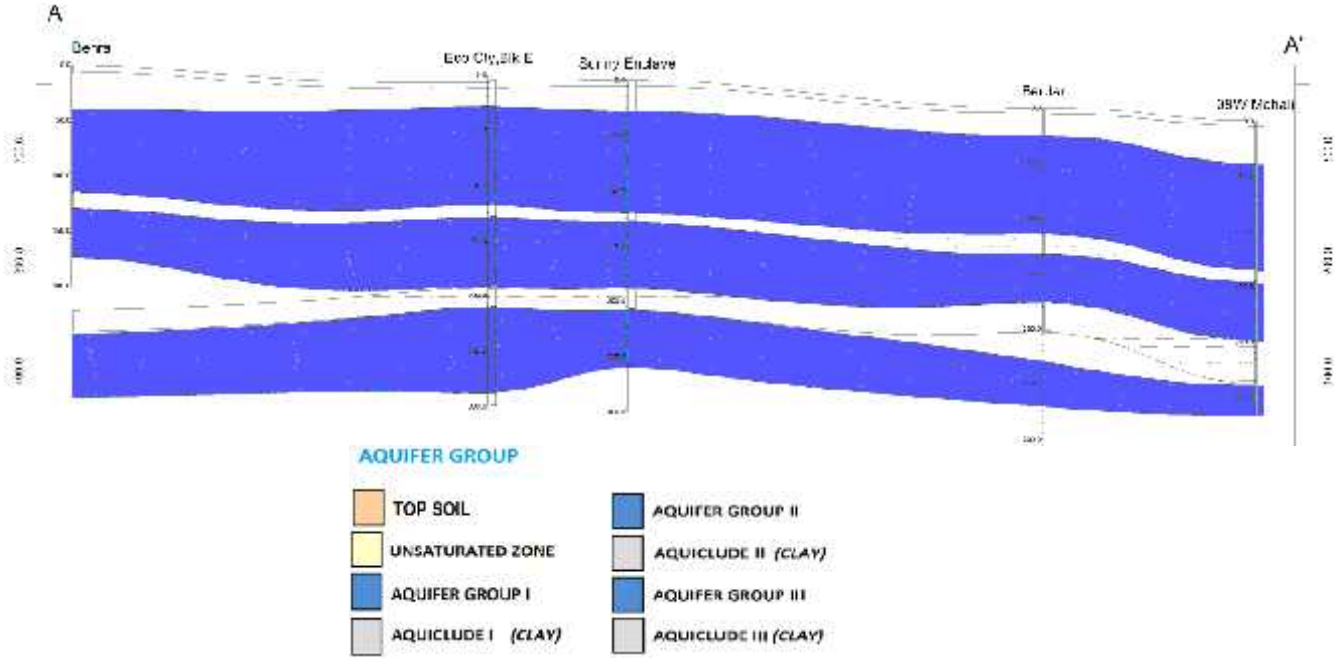
3-D Aquifer Disposition Model of Sialba Majri Block



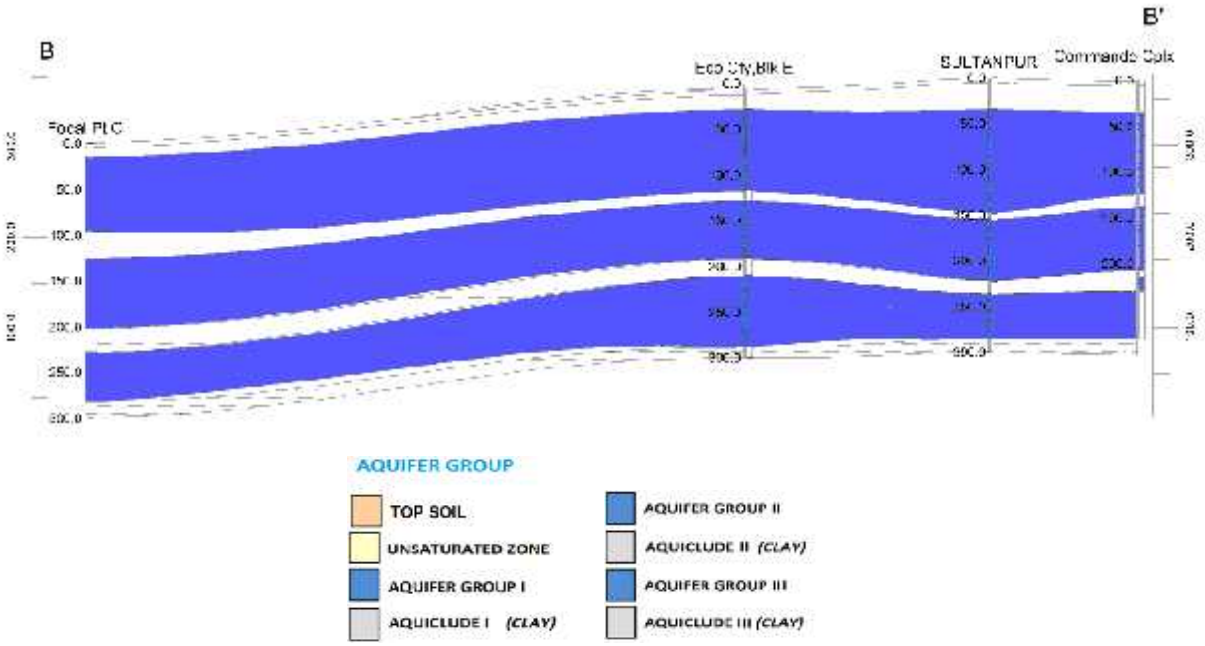
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Behra to 39 W mohali



Aquifer Cross section along Focal Pt to Commando Cplx



Ground water Resource, Extraction, Contamination and other issues in Sialba Majri Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	64.00 mcm
	In-storage Aquifer-I (Specific Yield Concept)	738.11 mcm
	In-storage Aquifer-II (Specific Yield Concept)	506.13 mcm
	In-storage Aquifer-II (Storativity Concept)	66.40 mcm
	In-storage Aquifer-III (Specific Yield Concept)	379.60 mcm
	In-storage Aquifer-II (Storativity Concept)	NA
	Total Resources	1754.24 mcm
Ground Water Extraction (as per 2013)	Irrigation	26.44 mcm
	Domestic & Industrial	1.94 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		3.45 mcm
Stage of Groundwater Development		44 %
Chemical Quality of ground water		Ground water in the area is seems to be fresh and fit for irrigation.
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.

Ground water Resource Enhancement Potential

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

Aquifer-I:

Volume of unsaturated zone after 3m upto a desirable depth: 99.82 mcm
Source water requirement/availability for recharge: *Rain, Canal, Irrigation return flow*
Types and number of structures: NA
Other interventions proposed*: NA*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Sialba Majri Block (292.90 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 5.57 mcm
Required Change in cropping pattern
Not Required
Alternate Water sources
Surface water sources: *Tanks, Ponds*
No.of Water tanks: 38
Location, details and availability from such sources outside the area: Not Available

Regulation and Control:

Punjab Subsoil Act for delay in paddy plantation should continue in the area.

Other interventions proposed, if any

Modern Irrigation Practices be adopted for Rabi crops. Some of the techniques are given in the table below (PAU, Ludhiana).

Sl.No	Techniques	Water Saving (%)	Crops
1	Mulching	17	Wheat
2	Bed Planting	18-25	Wheat
3	Use of Sprinkler and drip Irrigation	70-90	Sugarcane, Sunflower, Maize

Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.