केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

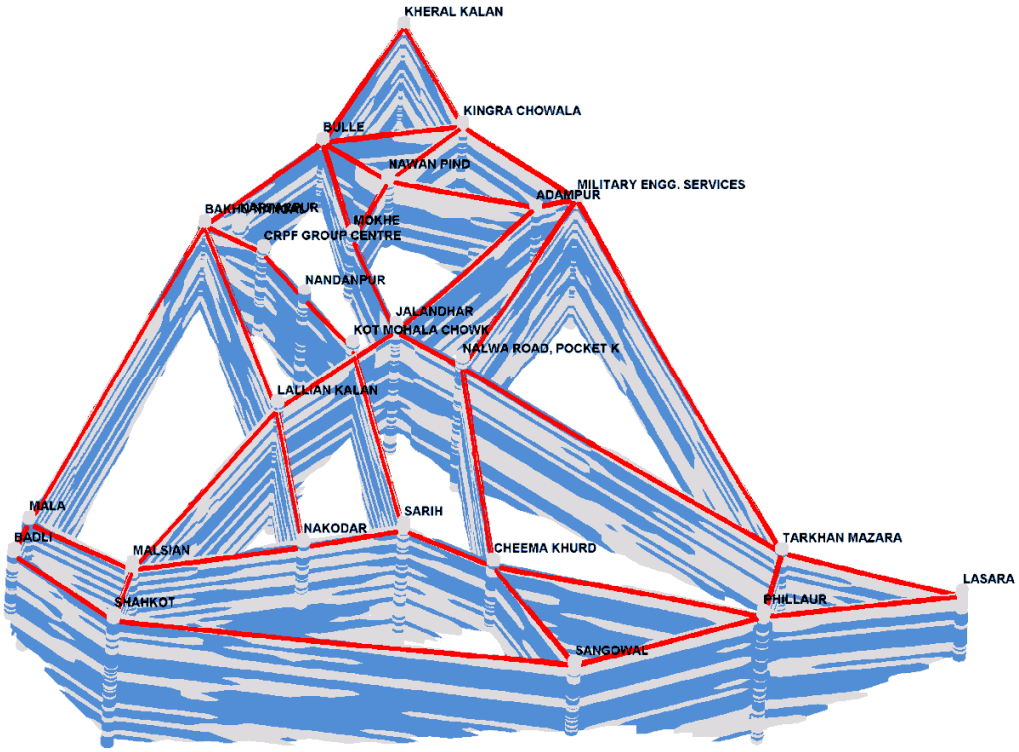
AQUIFER MAPPING AND MANAGEMENT PLAN

Jalandhar District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING & MANAGEMENT PLAN OF JALANDHAR DISTRICT, PUNJAB



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2018

AQUIFER MAPPING AND MANAGEMENT PLAN
JALANDHAR DISTRICT
(2633.50 Sq Km)

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PROJECT TEAM

Regional Director	Anoop Nagar	
Nodal Officer	Tejdeep Singh , Sr. Hydrogeologist	
Executive Engineer	L. Ramakrishna	
Report Compilation & Hydrogeology	Roopesh G.Krishnan , Scientist 'B'(Jr.HG)	
Geophysics		**Chemical Quality**
S.K. Kapil, Scientist 'D' (Sr.GP)		Rishi Raj, Assistant Chemist
NAQUIM Punjab Team	Rakesh Rana , Scientist-D	Gyanendra Rai STA (HG)
Acknowledgement	M.L Angurala, Scientist 'D' (Sr.HG)	

1.0 INTRODUCTION

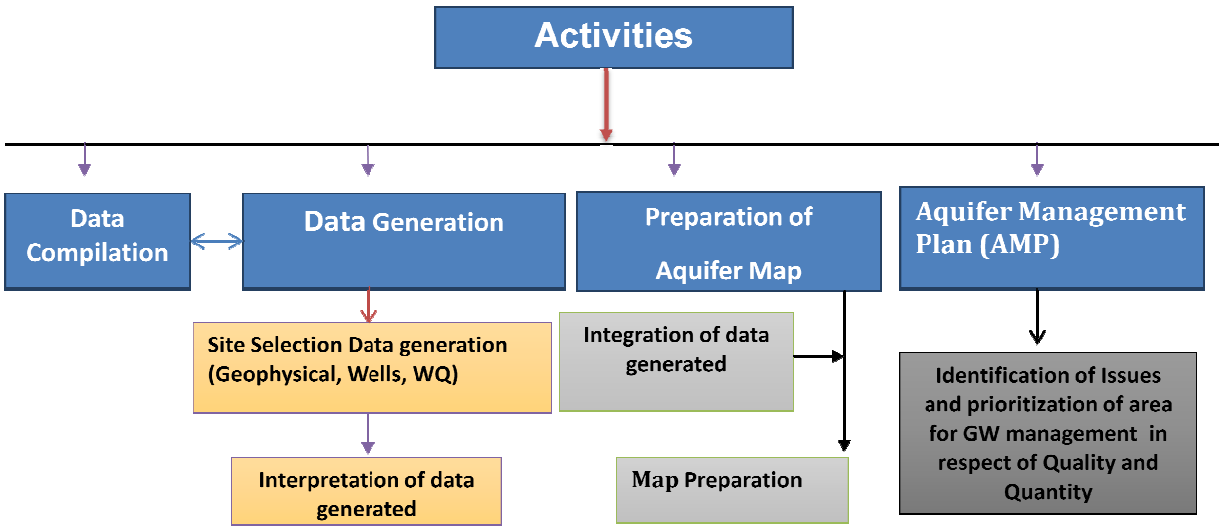
The primary objective of the Aquifer Mapping can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst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

Jalandhar is located on the intensively irrigated plain between Beas and Sutlej rivers of Punjab State. The area falls in the Survey of India Toposheet Nos. 44 M/4,7,9,10,11,12,15 and 16, lies between 30^0 58' 16" to 31^0 36' 53" North latitude and 75^0 04' 42" to 75^0 57' 48" East longitude covering an area of 2633.50 sq km (Fig.1). It is bounded by Hoshiarpur in North, Ludhiana and Moga in South, Kapurthala in East and parts of SBS Nagar, Kapurthala and Hoshiarpur in West. The area is well connected by road and rails. Jalandhar was the capital of Punjab from India's independence (1947) until Chandigarh was built in 1953. The elevation of land surface ranges between 245m above m.s.l. in northwest to 212 m a.msl at towards southeast. Topographically, it is a leveled plain sloping towards south - south east direction..

The district comprises four Tehsils namely Jalandhar-I, Phillaur, Jalandhar-II,Nakodar & Shahkot . There are eleven administrative development blocks namely Adampur, Bhogpur, Rurka kalan, Jalandhar-East, Jalandhar-West, Lohian Khas, Nakodar, Nurmahal, Phillaur, Shahkot & Dharamkot. Total number of villages exists in the district is 941 (Inhabited village is 922 and Uninhabited village is 19).

The total population of the district is 2,193,590 as per 2011 census which constitutes 7.9% of the state population. The total rural population is 1,032,419 and the urban population is 1,161,171 and the decennial growth rate is 11.76 % (2001-2011). Population density of district is 836 persons/sq. km.

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 45^0 C (in May/June) to 2.5^0 C in December/January.

The normal annual rainfall is 703 mm in 28 days which is unevenly distributed over the district. The average annual rainfall in the district is 570 mm. The rainfall in the district in general increases from the south-west towards the north-east and varies from 551.3 mm at Nakodar to 892.3 mm at Adampur. About 70 per cent of the annual normal rainfall in the district is received during the period July to September. Monthly wise rainfall is given in below table.

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

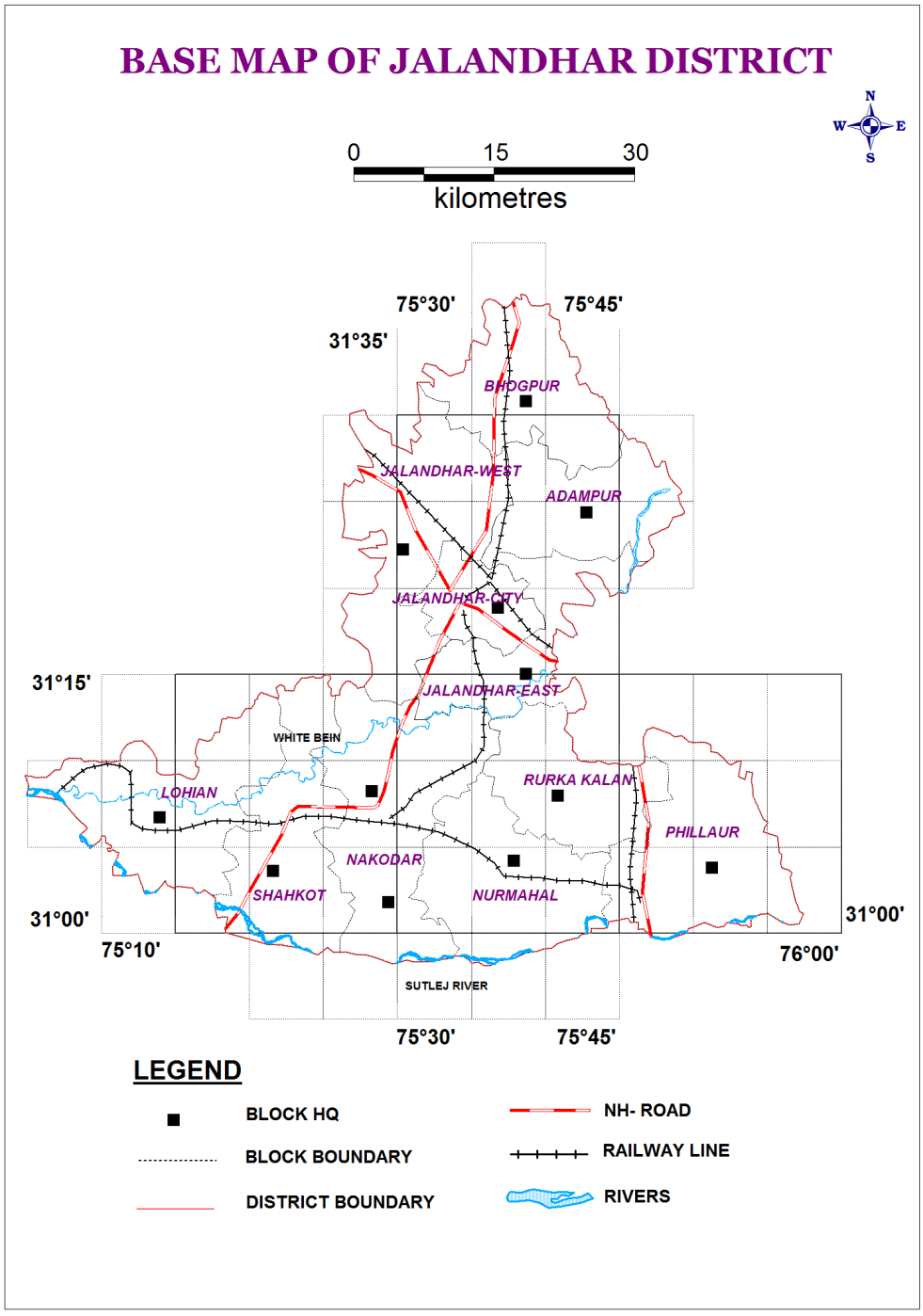
Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2012	93.7	1.8	3.2	13.9	0.2	1.9	91	79.2	107.5	0.7	0	6.2
2013	6.4	84.2	10.3	6	7.4	166.3	117.5	151.8	34.7	5.5	2.6	1.2
2014	4	18.4	16.4	11	6.9	6.1	95.3	40	84.3	10.2	0	18.7
2015	22.5	40	64.9	40.8	24.4	30.6	65	40.3	44.5	3	0	0
2016	10.6	8.9	27.1	1.3	14	26.8	131.5	136.4	15.2	2.4	0.5	0

1.6 Geomorphology & Soil Type

The study area is part of Bist Doab Tract, which is inter alluvial plain between Beas and Satluj River and has almost flat topography with gentle slope towards southwest. Physiographically, the district is characterized by two distinct features i.e. vast upland plain and Satluj flood plain. It exhibits gradational landforms, mainly fluvial, formed by the deposition of

sediments. The width of the flood plain varies according to the amount of shift experienced by the river. It is widest in the Nakodar tehsil. The district is mainly drained by the river Satluj and its tributaries –East (White) Bein and West (Black) Bein. The area is almost flat terrain without any conspicuous topographical features.

Fig.1: Base map of Jalandhar District



Geomorphologically the area is divisible into three types of land forms i.e

1. Older Alluvial plain
2. Aeolian surface (Sand dunes and Aeolian sheets),
3. Older and Active flood plain

These land forms are delineated on the basis of relief, pedological, lithological and vegetation variations (GSI, 2005-2006).

Older Alluvial plain: This is the oldest and dominant geomorphologic unit of the area. It is higher in elevation and has almost a flat topography. Older Alluvial plains are basically the aggradational product of the fluvial action of the ancestral rivers of the Indus System. These plains are presently being modified by erosional action of the various forces as well as anthropogenic activities. These plains are well drained, they have fertile soils and also their groundwater conditions are favorable for the development of tubewell irrigation, thus making them agriculturally the most productive.

Aeolian surface: The Aeolian surface includes sand dunes and Aeolian sheets.

Sand dunes: Sand dunes occur in the form of low mounds. Their morphology has been modified by human activity. At number of places these have been leveled by the local people to reclaim land for cultivation.

Aeolian sheet**:** It comprises of thin cover of Aeolian sand over the Older Alluvium. The original slope and form of the Aeolian sheets has been highly modified by the agricultural activities of the farmers.

Older flood plain: It is the low land area developed below the adjoining alluvial plain, along the Satluj River locally known as Bet area.

Active flood plain: It is the youngest geomorphic unit developed in Holocene times and comprises active flood plains of the river Satluj.

Landforms: The landforms developed include palaeochannel and river bank escarpment, river channel and point bars developed in the meandering course of the Satluj river.

Study area is occupied by two types of soils a) tropical arid brown and b) arid brown soils. Tropical brown soils are found in major parts of the area whereas arid brown soils are found in south western part of the area especially in Lohian and part of Shahkot block. Along the river Satluj, fluvient type of soil is found.

1.7 Land Use/ Land Cover

The main classes are Built Up land, Agricultural land, forestland, Land under non agriculture use, and water body. The landuse pattern of the study area is given in below table

Land use pattern of Jalndhar District, Punjab

Type of Land use	Area (hectares)
1. Total Geographical area	263350
2. Forest	5600
3. Land put to non-agricultural use	29350 (11 %)
4. Net area sown	234000 (89 %)
5. Gross cropped area	414000
6. Cropping intensity	177%

(Source: Statistical Abstract, Punjab, 2015)

1.8 River System and Water Resources

The main river Sutlej flows in southern part of the study area . White bein (East) drains the central parts and flowing in north-west to south-east direction and are ephemeral, draining monsoon water. Drainage and water bodies are shown in Fig.2.

The Bist Doab Canal System is the major source of canal irrigation. The network of Jalandhar branch (irrigate northern and central parts) and Phillaur distributary of Nawashahar branch (Fig.3). In all there are 41 canals having total length of 604.40 km. of which Best Doab canal is 43 km long. With 'Remodeling of Phillaur distributaries system in Nakodar area and Construction of super passage over Nasrala choe near Adampur will increase the capacity of the channel by 20% and to avoid the damages to the crops and adjoining abadies during flood season.

1.9 Agriculture & Irrigation

Agriculture is the main stay of the people of this area and its inhabitants depend heavily for their livelihood on agriculture and its allied occupations.

The study area can legitimately take pride in being one of those districts of Punjab State enjoying the fruits of irrigated agriculture to the maximum extent. Irrigation is an essential input for intensive agriculture and to increase the yields. It is, therefore, necessary to improve the water resources and utilize them properly. Besides, the importance of irrigation to agriculture has become all the more important with the new farm technology.

Net area sown in the district is 234000 ha which constitutes 91% of the total area. Area sown more than once is 181000 bringing the total cropped area (Gross sown area) to 414000 ha. Paddy constitutes main kharif crop whereas the wheat is the main Rabi crop. Perusal of historical data reveals that the paddy cultivation has increased about 85 times since 1950-51 against wheat cultivation, which has increased only 1.7 times. Average yield of paddy cultivation has increased from 806 kg/ha to 3948 kg/ha where as wheat crop average yield has increased from 958 kg/ha to 4325 kg/ha over the period of last 50 years. Thus, it has given further stress on ground water.

Net Irrigated area is 2,34,000 ha and Gross Irrigated Area is 4,14,000 ha and Irrigation intensity is 177%.

a. Canal Water Irrigation

The study area is not under canal command irrigation.There is no irrigation by Sirhind Doab Canal in this area as it acts only as feeder canal. The network of Jalandhar branch and Phillaur distributary of Nawashahar branch have no contribution towards irrigation.

b. Ground Water Irrigation

With a large part of the study area is not under canal command the contribution by tube wells is bound to be greater than the surface water irrigation. Net area irrigated by Tubewells and wells are 2,34,000 ha.

1.10 Industries

The area has industries which generates large quantity of solid as well as liquid waste. High quantity of lead, chromium, manganese and iron content is found in water sample of East White Bein (Tangri, GSI, 2003).

1.11 Quarrying

Unplanned, localized quarrying of river sand from channel bed of the Satluj River is carrying out at number of places. This unplanned quarrying of sand causes the change in river profile. Quarrying of brick clay results in removal of top fertile soil thus rendering large land infertile.

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 the district. Salient features of the projects are enumerated below:

a) Artificial recharge to ground water in Channian village of Jalandhar district (1998-99). The cost of the project was Rs. 9, 89,384/-. The spare canal water and surface runoff generated during monsoon, accumulated in the village ponds was recharged through existing dug well.

b) Pilot project for artificial recharge to ground water from Bist – Doab canal System in Nurmahal area, District Jalandhar (1999-2000). The cost of the project was Rs. 11, 62,000/-. In Nurmahal block water level has declined between 5 to 6 m in last 17 years. The spare water of Phillaur and Sarih distributary during monsoon period was recharged to the ground through 6 vertical shafts. Annual water available for recharge was around 1.62 mcm.

c)Scheme for rainwater harvesting to recharge to ground water in D.C. Office Complex, Jalandhar city (2004-05). The cost of the project was Rs. 4, 80,000/-.

Rooftop rain water harvesting can be adopted in all buildings of the district. Types of recharge structures suitable are; Trenches and injection wells. Injection wells of 40 to 60 m depth can be constructed depending upon the local hydrogeological conditions.

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 Jalandhar District

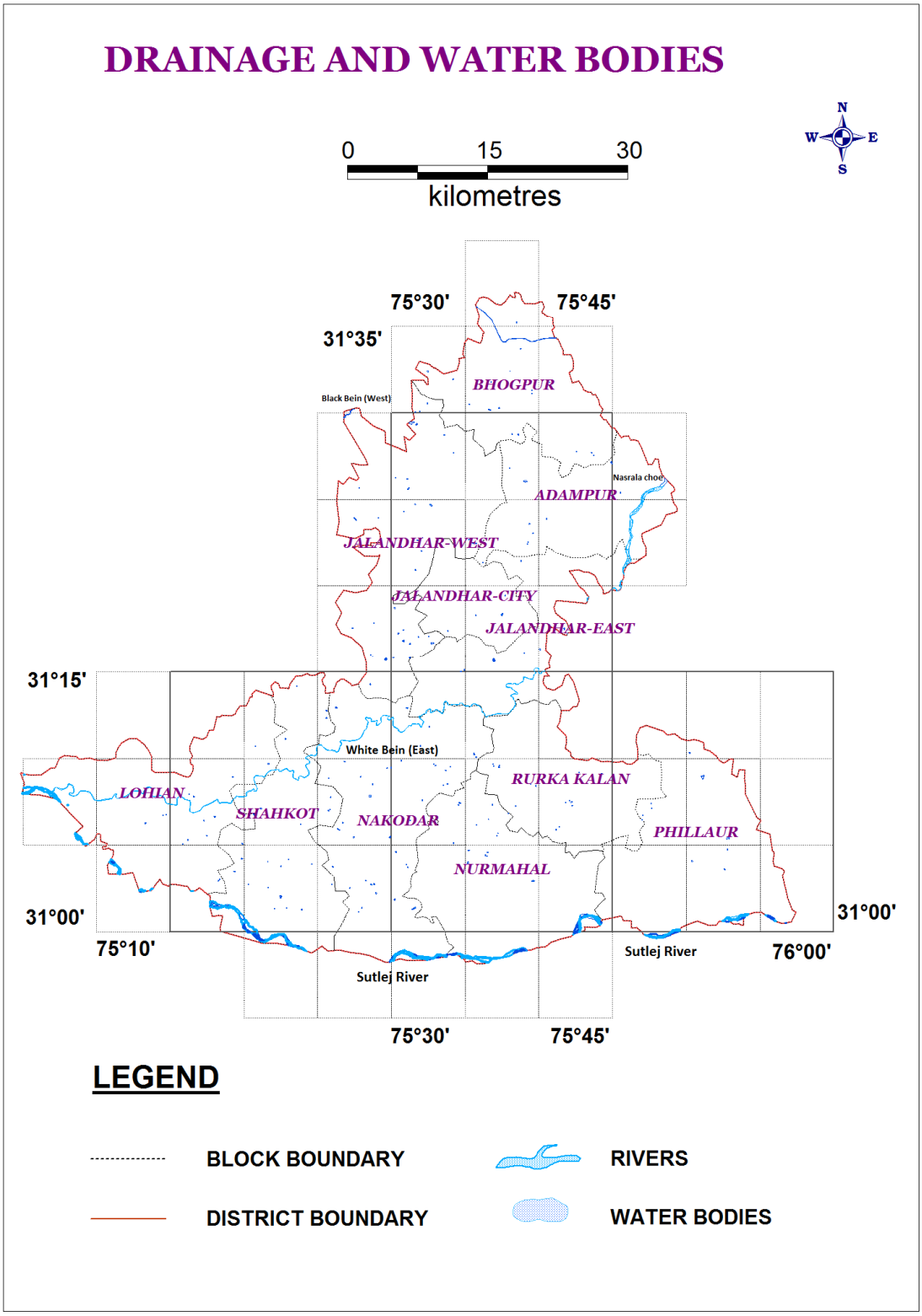
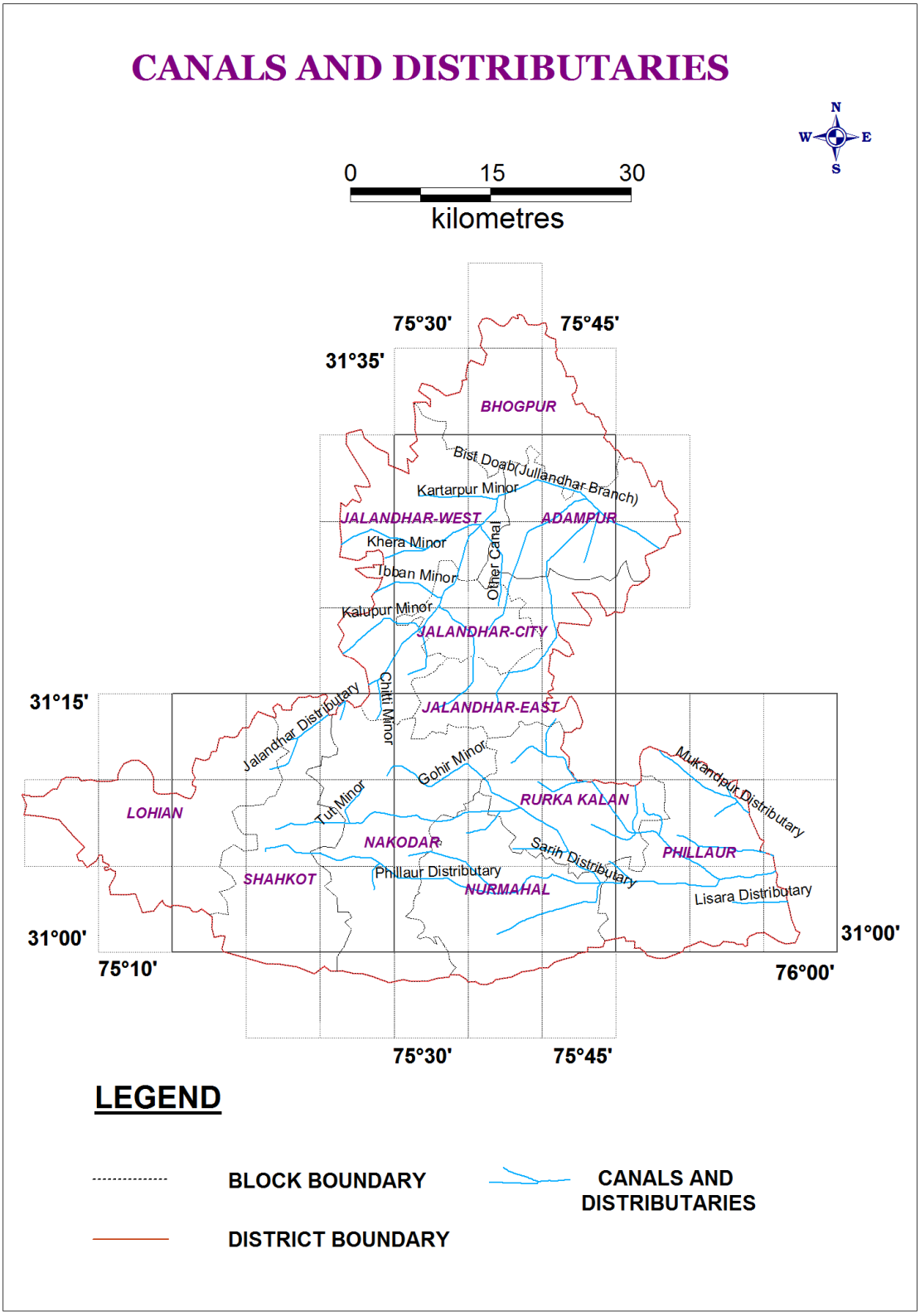


Fig.3: Canal and Distributaries of Jalandhar District



2.0 DATA COLLECTION AND GENERATION

2.1 Geology and Hydrogeological data:

The Study area forms part of the Punjab basin of the Indus super-basin of the vast Indo-Gangetic Plain and is occupied by Quaternary to present day sediments of fluvial as well as Aeolian origin. These Quaternary sediments unconformably overlie the Siwalik Group of rocks, which in turn overlie the crystalline basement. Deep drilling by Oil and Natural Gas Commission at Adampur in the adjoining Jalandhar District has revealed the total thickness of sediments including Lower Siwaliks overlying the Crystalline basement as about 2515m (Datta et.al.1964) The Quaternary deposit can be broadly classified under two distinct categories viz., Fluvial deposits and Aeolian deposits. The former can be further classified into (i) Older Alluvium and (ii) Younger Alluvium. The Aeolian deposits occur as sand dunes and sheets .The generalized stratigraphic sequence of the area is given below,

Generalized Lithostratigraphy, Jalandhar & Kapurthala District (Pahuja and Gupta, 1991, 92)

Age	***Lithological Unit***	***Lithological Characteristics***
Present to Recent	*Aeolian Sediments(A2 & A3)*	Brownish yellow, micaceous sand with silt, clay and calc. Siliceous concretions Kankar.
	Newer Alluvium (F3)	Pebbly, fine to coarse, grey, micaceous sand, silt with subordinate amounts of clay & kankar
	DIASTEM	
Recent to Sub-Recent	*Newer Alluvium (F2)*	Reddish brown silty sand bed with occasional pebbles.
	DIASTEM	
Sub-Recent to Pleistocene	*Older Alluvium (F1)* *Aeolian (A1)*	Pebbly, fine to coarse, grey, micaceous sand, Alternating bands of golden brown, silty clay, sand and silt with Kankar upper horizon is rusty red due to oxidation

-----Basement not exposed----

Sub surface geological formations comprise of fine to coarse grained sand, silt, clay and kankar (Fig.5). Principle Aquifer is Alluvium and Major aquifer in this area is Older Alluvium (Fig.4). CGWB has carried out ground water exploration up to a depth of 354 meters at villages Malsian, Lallian Kalan and Kheral kalan and depth of 408 m and 419 m at village Pir Dar and Sinder. Under Ground water exploration eleven exploratory wells and twenty two piezometers were constructed in the district. The drilling was carried down to a depth of 419 m and well was constructed down to 382m. The yield of test well was 670 lpm with draw down of 4.75 m. Ten to eleven granular zones were encountered down to the drilled depth. Transmissivity value of the aquifer ranged from 1028 to 5750m^2/day. And storativity value ranges from .001 to .006.The hydraulic conductivity value in the district varies from 38 to 90m/day. The value of storage coefficient worked out to be 1.18x10^{-3} to 6.0 x 10^{-3}. CGWB has revealed the presence of 3

aquifer groups down to a depth of 350m. These aquifer groups comprise of fine to medium grained sand.

Water table elevation ranges from 205 m to 240 m above msl. The ground water flow direction is from north east to south west. The gradient of water table elevation is steeped in north east part and gentle in south west part of the study area. The gradient of ground water table is 1.08 m/km in north east and 0.45 m/km in south west.

2.1.1 Water Level Behavior

Fourteen monitoring stations of Central Ground Water Board (CGWB) (12 Piezometers and 2 Dug wells) and *Forty eight* monitoring stations (52 Piezometers) of State government departments represent first aquifer. *Seven* monitoring stations of CGWB (7 Piezometers) and *four* monitoring stations (4 Piezometers) of State government departments represent Second aquifer Third aquifer is represented by 12 (piezometers) monitoring station of CGWB . Depth to water level in the area ranges from 7.25 to 35.33 m bgl during pre-monsoon period (Fig.6) and 6.85 to 34.50 m bgl during post monsoon period (Fig.7). The major parts (Central ,Western, Eastern and Northern) water levels are >20 m, northern and southern parts having water levels are in the range of 10 to 20 m, in the north eastern part in a portion where, water levels are <10 m bgl. Seasonal water level fluctuation shows a rise and fall in the range of 2.10 to (-) 2.22 meters respectively during the year 2016 (Annexure-I). Net change in water levels Long-term net change of water levels indicates a general decline (negative change) in the large part of the district and it is up to 8.18m. The maximum fall is observed in parts of Nakodar and Shahkot blocks.

Fig.4: Major Aquifer

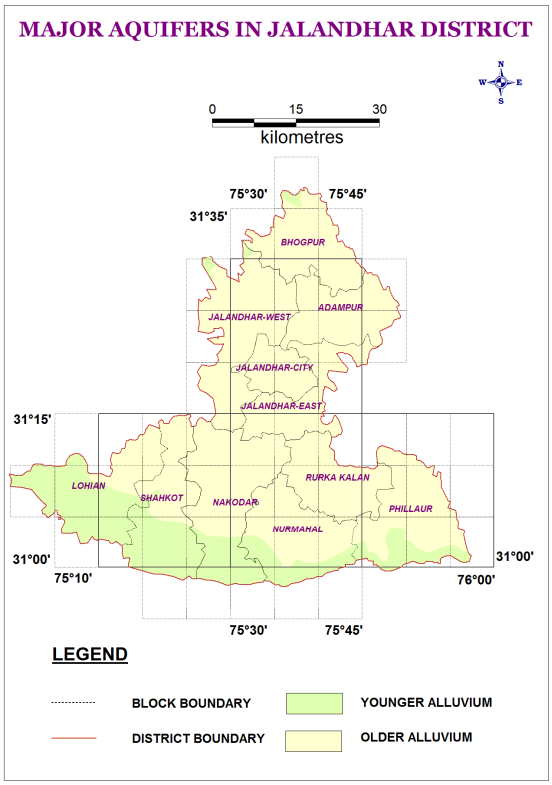


Fig.5: Hydrogeology of Jalandhar District

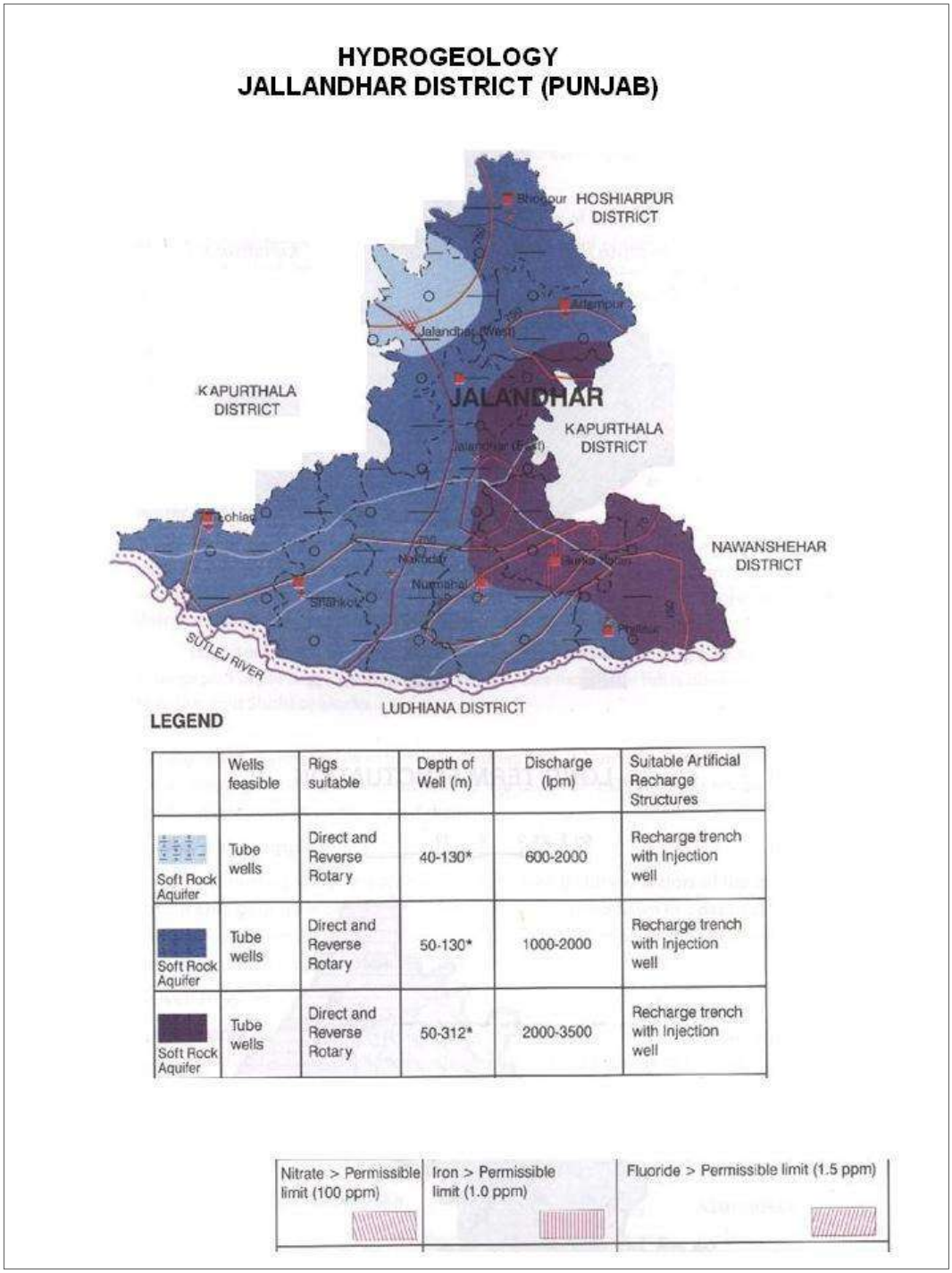


Fig.6: Depth to Water level Pre Monsoon, 2016

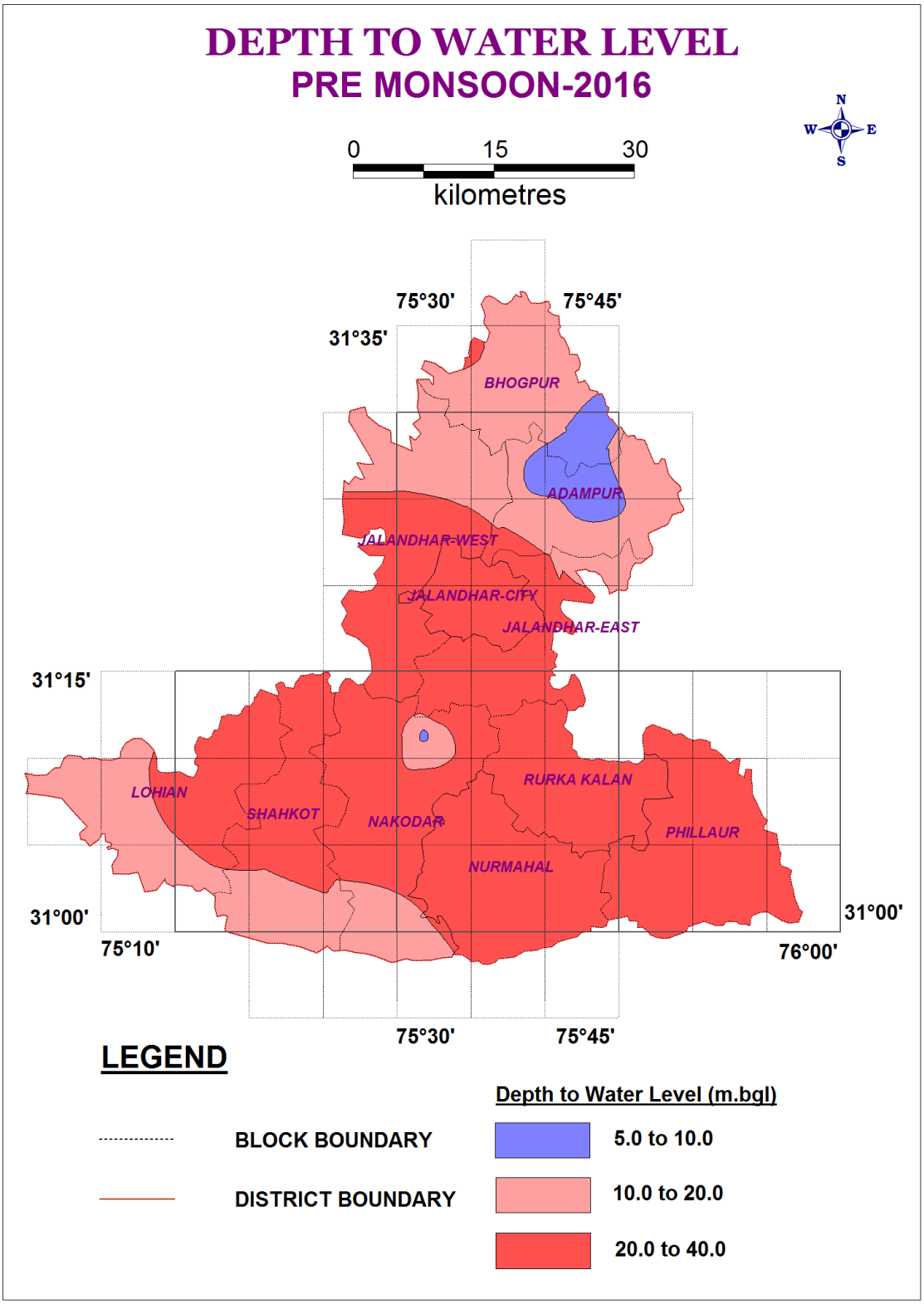
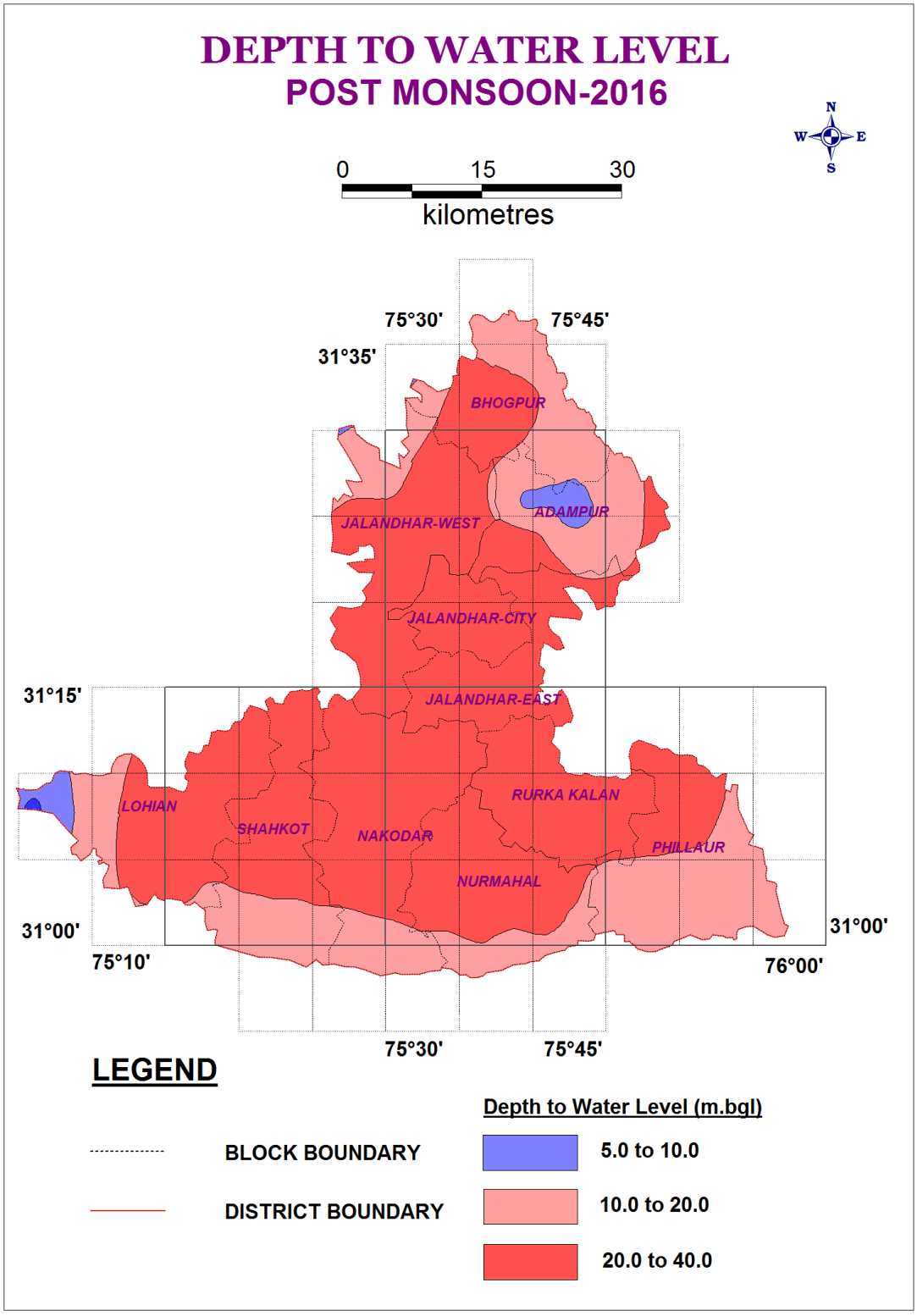


Fig.7: Depth to Water level Post Monsoon, 2016



2.2 Water Quality Data:

Ground water quality of shallow aquifer (Aquifer-I) is assessed on the basis of chemical data of National Hydrograph Network stations i.e. NHNS monitored during Pre monsoon period. Fifteen groundwater samples are collected and analyzed during NHNS, 2016, given in Annexure-II. The chemical quality of deeper aquifers has to be assessed during ongoing groundwater exploration programme under NAQUIM. An Isotope study having been carried out in the district under Hydrology Project Phase-II by National Institute of Hydrology (NIH) for validation of the aquifer groups, mechanism of recharge to aquifers and for the age determination of the aquifer water.

Chemical data of ground water from shallow aquifer indicates that ground water is alkaline and fresh. The electrical conductivity (EC) values ranges from 300 to 1120 µS/cm at 25^{o}C. The EC values more than 1000 µS/cm have observed in Lallian kalan (1120 µS/cm at 25^{o}C) and where the EC value less than 1000 µS/cm are at all locations respectively. 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 for iron at few places. The chloride concentration in ground water varies broadly between 10.37 mg/l at Sarih and also 110.6 mg/l at Lallian kalan. Ground water with iron concentration above permissible limit 1.5 mg/l are found mainly in Kharal kalan (8.62) ,Adampur (6.96), and Nakodar (3.87) whereas Arsenic found within permissible limit in all sampling locations . Nitrate values above permissible limit 45 mg/l are found mainly in Phillaur (55) and Allawalpur (45).

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 (-2.60) to 3.08 meq/l. Analysing mechanism and equipments used for chemical analysis are given in 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)	

	Total Dissolved Solids (TDS)	Flame photometric method 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

2.3 Geophysical data:

Surface and Subsurface geophysical investigations have been carried out in alluvial tracts over parts of Jalandhar district. The aim of the electrical sounding (VES) has to delineate fresh water - saline water interface laterally as well as vertically. The borehole loggings have been conducted in 18 exploratory wells to delineate the granular zones upto depth of 410m.

2.4 Exploratory drilling State - Data Availability:

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

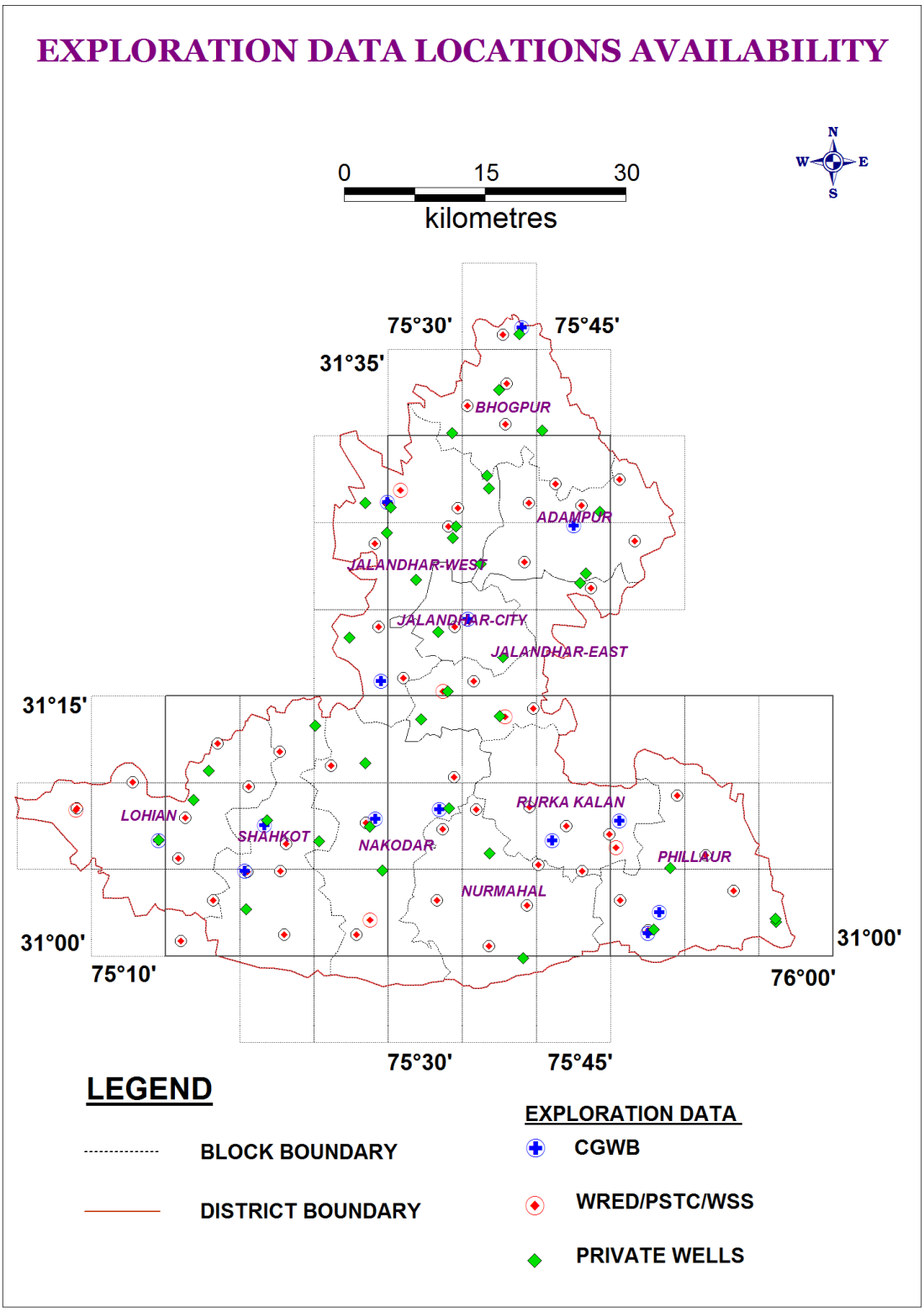
Data Availability of Exploration Wells of Jalandhar district

Sl.No	Source of data	Depth Range (m)				***Total***
		< 100	100-200	200-300	>300	
1	CGWB	11	3	6	12	**32**
2	WRED/WSS/PSTC	46	4	0	0	**50**
3	PRIVATE WELLS	10	27	3	11	**51**
Total		**67**	**34**	**9**	**23**	**133**

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 Aquifer-I and the depth more than 300m. The grids/ formations devoid of groundwater exploration are identified as data gaps and these are to be filled by data generation.

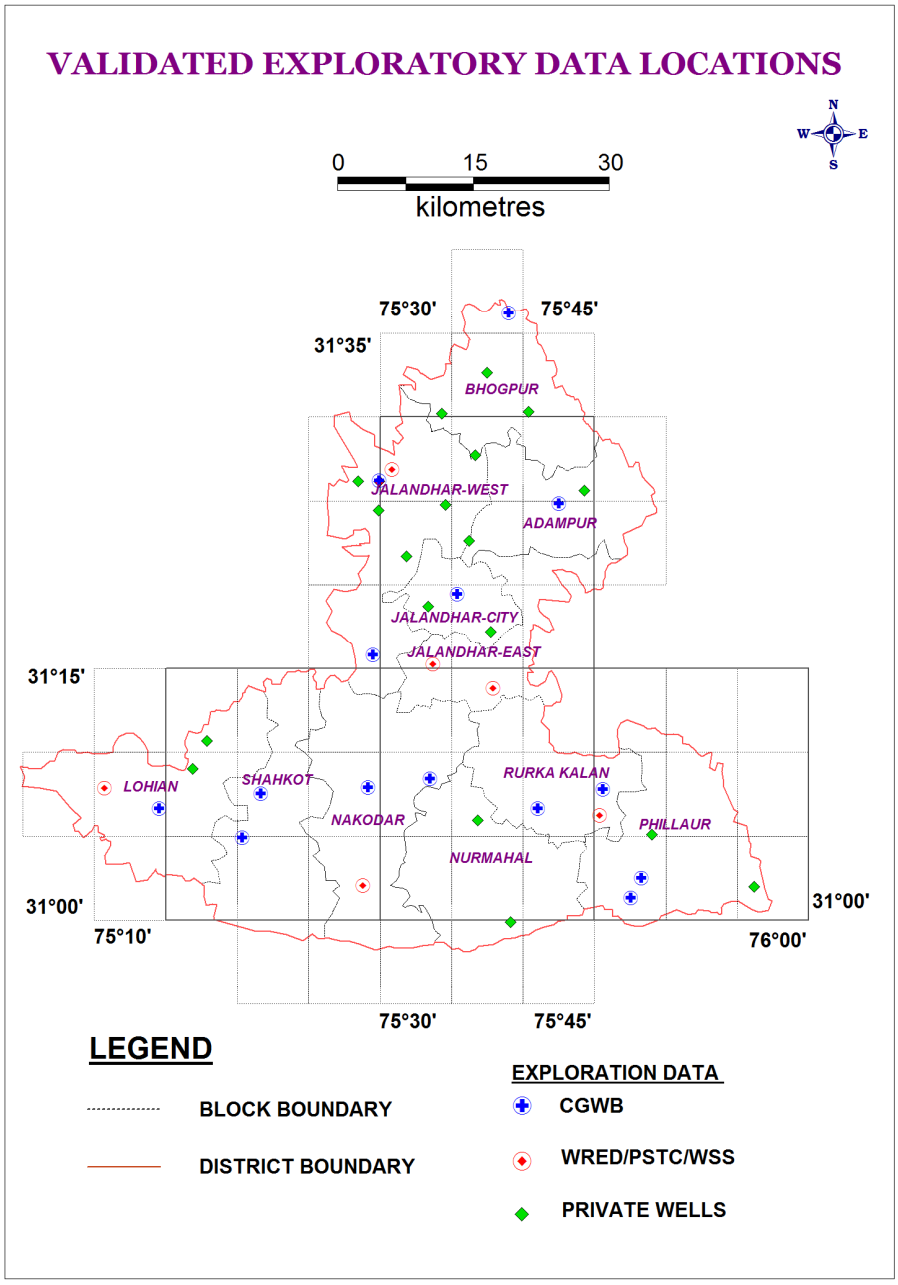
Fig.8: Locations of exploration data availability



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.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-III. Three dimensional locations of validated exploratory wells with litholog are given in Fig.11.

Fig.10: Elevation contour map

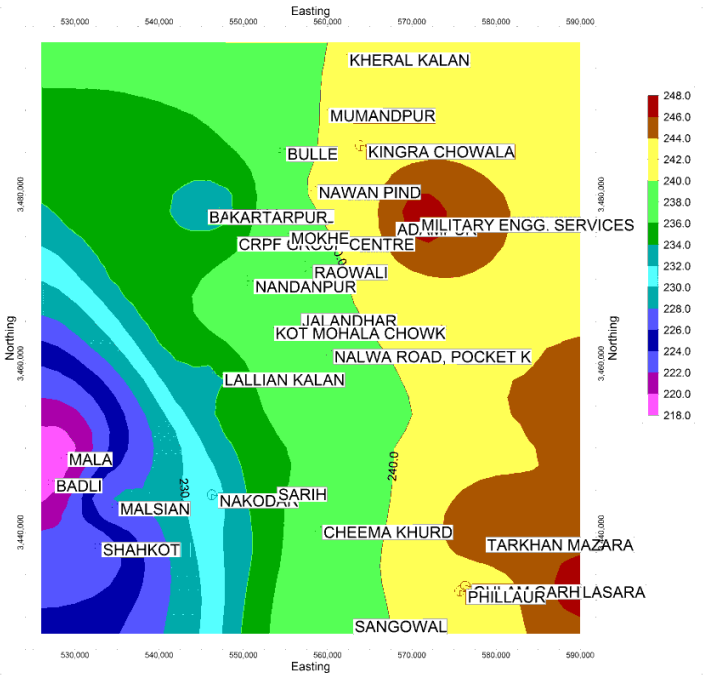
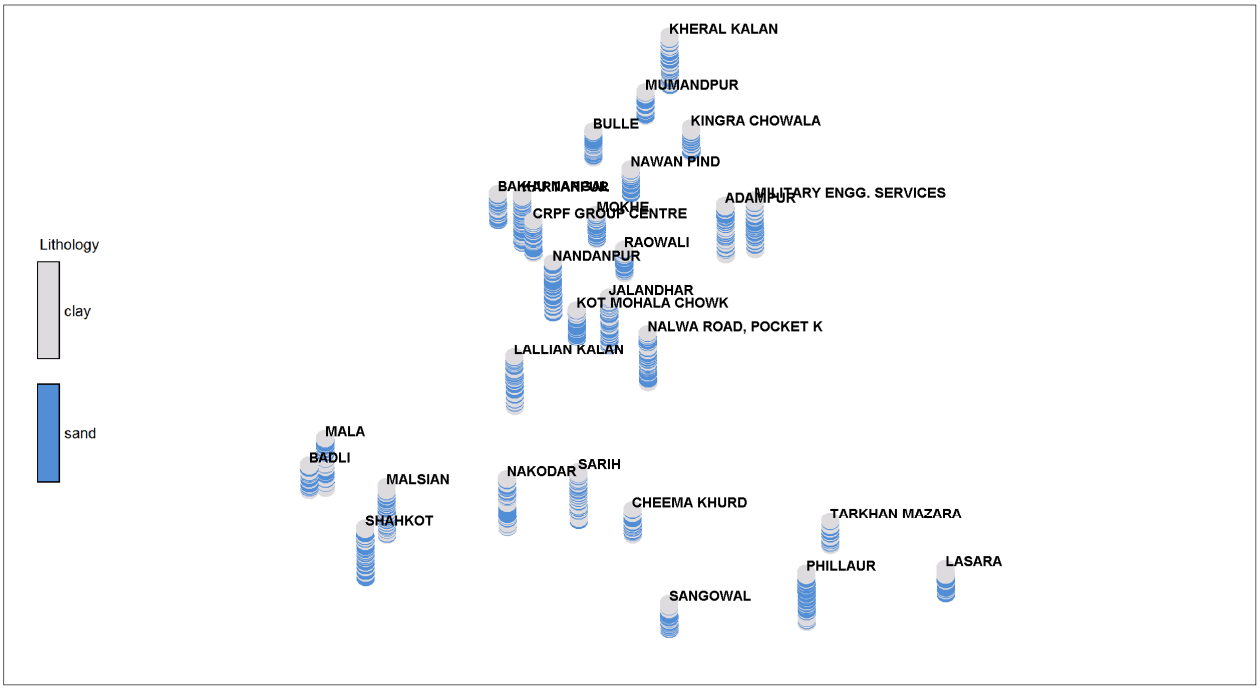


Fig.11: Three dimensional locations of validated exploratory wells with litholog



3.1 Sub Surface Disposition

3.1.1 Previous Work:

Ground water at shallow depth occurs under unconfined to semi confined and confined conditions in deeper aquifers.

The area is underlain by formations of Sub- recent to Quaternary age comprising of alluvium deposits belonging to vast Indus alluvial plains. Sub surface geological formations comprise of sand, gravel, pebbles, Kankar and clay. Ground water is fresh at all levels in the district. Central Ground Water Board has drilled 11 exploratory boreholes along with equal no of observation wells besides 22 piezometers to delineate and determine potential aquifer zones, evaluation of aquifer characteristics etc. Ground water exploration undertaken by CGWB has revealed the presence of 3 aquifer groups down to a depth of 419m. These aquifer groups comprise of fine to medium grained sand. The first granular zone forms the water table aquifer and occurs upto 115 m below ground level and below that clay layer starts getting thickened about 12 -34 m depth and is considered as Unconfined Aquifer. The second aquifer occurs between 130 and 195 m depth, the third exist between 215 and 333 m depth down wards and 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. Total thickness of the alluvium is more because bedrock has not been encountered up to 419 m depth in the district.

Table- 2: The Aquifer Parameters of Jalandhar District

Aquifer Group	**Discharge 'Q' (lpm)**	**Transmissivity 'T' (m^2/day)**	**Storativity**
1^{st} Group	5670	5750	6×10^{-3}
II^{nd} Group			
II^{nd} Group	1408-2340	480-931	10.05×10^{-4} - 16.39×10^{-5}
III^{rd} Group	2986	1080 - 1709	5.08×10^{-4}

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

Data Validation of Exploration Wells of Jalandhar District

Sl.No	Source of data	Depth Range (m)				***Total***
		< 100	100-200	200-300	>300	
1	CGWB	0	0	1	10	**11**
2	WRED/WSS/PSTC	4	2	0	0	**6**
3	PRIVATE WELLS	0	24	3	10	**37**
Total		**4**	**26**	**4**	**20**	**54**

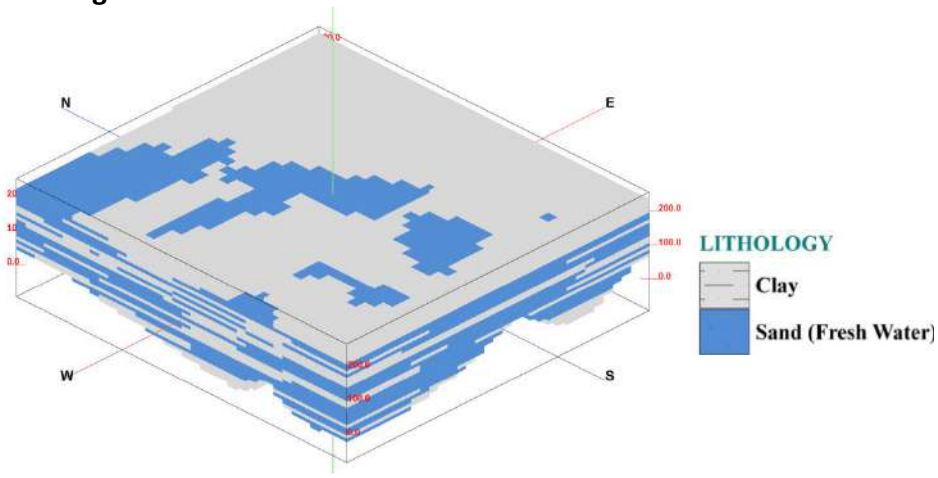
3.1.2 Present NAQUIM Study:

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,c & 14 respectively. The aquifers are composed of fine to medium sand with clay intercalations. The granular zones are extensive. (Annexure IV).

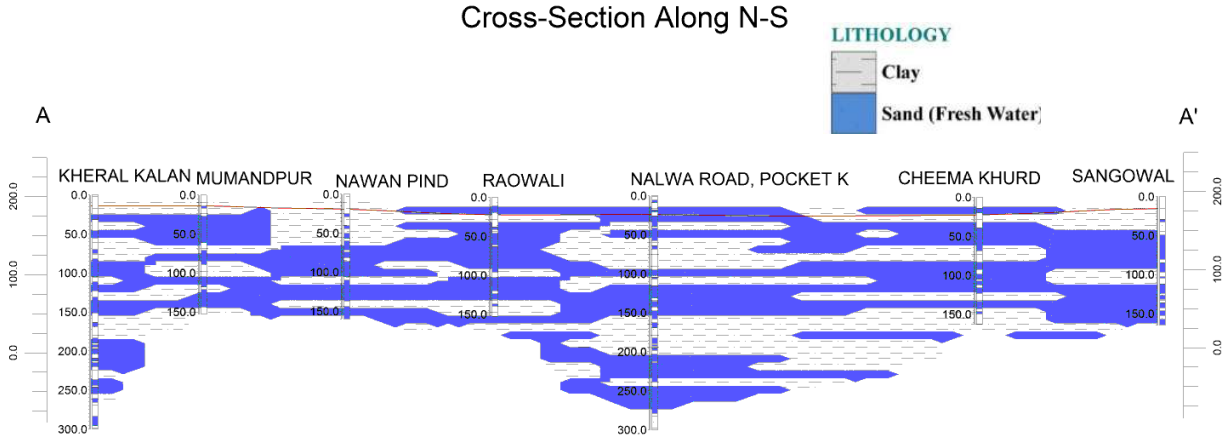
Based on geophysical borehole logging and use of resistivity profiling followed by the depth soundings at few selected places, for the present study and will be referred from time to time as it is obviously the higher resistivity beds represents freshwater zone in contrast in low resistive beds indicating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

Fig.12: 3-Dimension Lithological Model



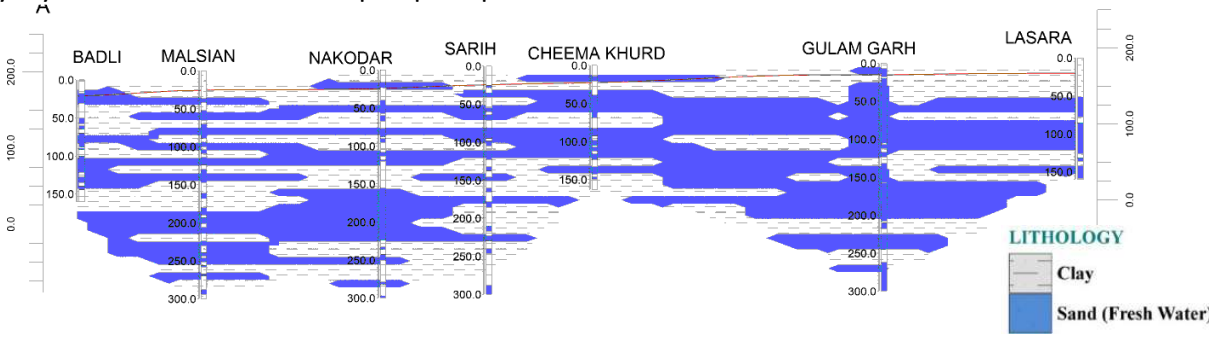
The major aquifer system of the district is quaternary alluvial deposits of Sutlej basin, having older alluvium and newer alluvium mainly comprises of sand, silt and clay admixed with kankars. The top surface layer and soil is mainly silty clay. The lithology shows the variation in lithology thickness i.e. thick clay layers inter bedded with sand except at few locations in Sutlej river basin. In north- eastern 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,c: 2-Dimension Lithological Sections

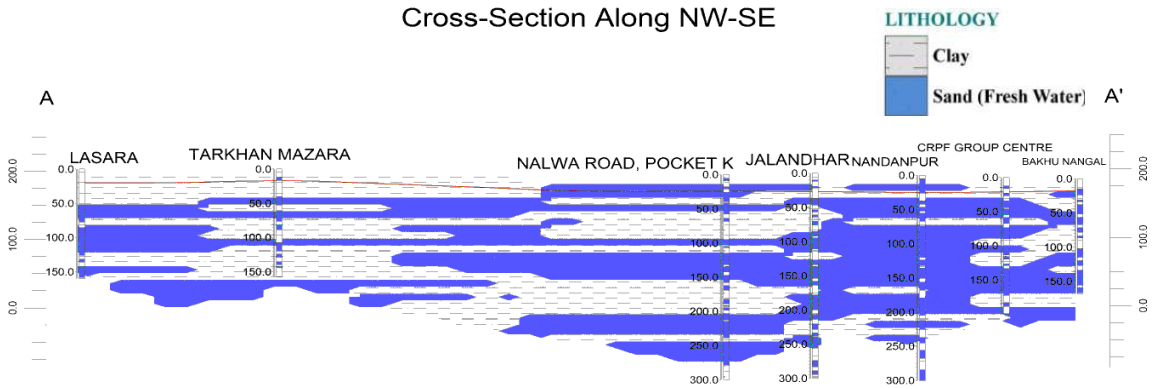


On the basis of lithologs geological sections has been drawn along N-S direction, indicates that surface soil of 4 to 15 m thickness is an admixture of clay with intercalation of sand lenses. There are 5 well defined granular zones up to 50 - 250 m depth separated by laterally extensive

clay layers 5 – 20 m thick. The top sand beds are fine to medium grained while the lower ones are medium to coarse in texture. The overall lithological section shows the variation in lithology thickness i.e. thin clay layers inter bedded with sand except at location Nawanpind where thick clay layers were identified at top depth up to 30m.



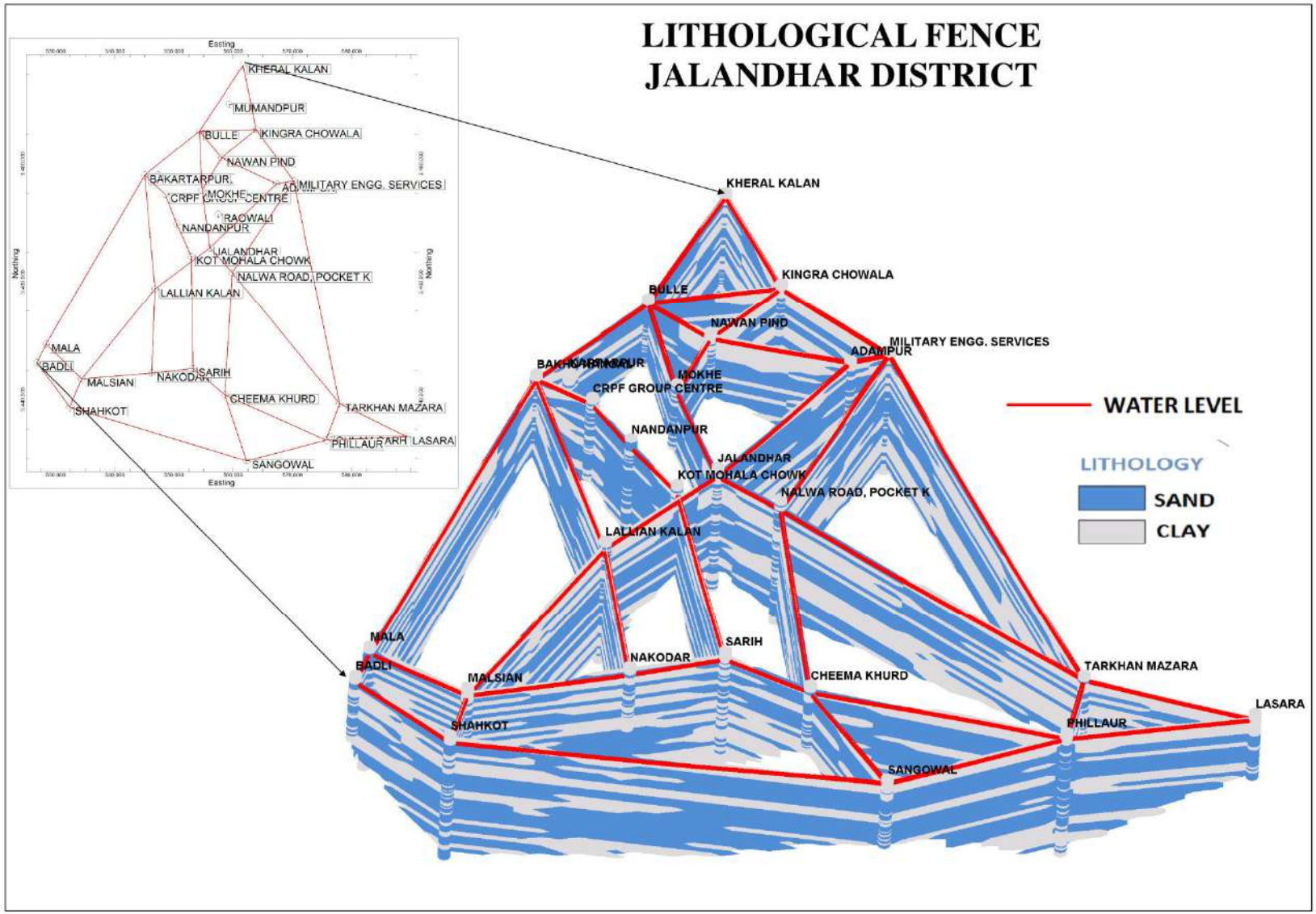
Study of the Sutlej River lithological section indicates that surface soil of 10 to 35m thickness is an admixture of clay and sand. Thicknesses of clay beds are prominent at locations Lasara, Sarih and Malsian. There are 3 well defined granular zones up to 300 m depth separated by laterally extensive clay layers 5 – 20 m thick. The third clay bed occurring at 130 m is alternating with equally extensive thin sand layers. The top sand beds are fine to medium grained while the lower ones are medium to coarse in texture. The lithology shows the variation in thickness i.e. thin clay layers inter bedded with sand except at location Gulamgarh , Cheema & Lasara where thick clay layers were interbedded with sand.



On the basis of lithologs geological sections has been drawn along NW-SE direction, indicates that surface soil of 4 to 40 m thickness is an admixture of clay with intercalation of sand lenses. There are 4 well defined granular zones up to 50 - 270 m depth separated by laterally extensive clay layers 5 – 20 m thick. Thickness of clay bed is increases towards NW direction and Sand horizons are more prominent in South Western part.

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



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 thin clay layer of about 1 to 4 m thick and is also underlain by clayey group which is about more than 12 m depth. Aquifer Group -I extends upto 113 m of depth and below that clay layer starts getting thickened about 12-35 m separating Aquifer Group -II ranges from 143 m to 215 m. Aquifer Group -III exists in this area extends from 246m to 300m separated by highly thick clay zones of 12 to 30 m thickness (Annexure V).

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 Jalandhar district, the aquifer grouping has been done using the sub-surface lithology and a three-dimensional aquifer model has been prepared shown in Fig.15. Aquifer disposition 3D fence diagram is also prepared using the aquifer model and are shown in Fig.16. The aquifer grouping, group thickness and granular zones encountered in the groups are given in table below

Aquifer Grouping in Jalandhar District

Aquifer Group	Avg. Range		Avg. Thickness		Avg. Granular Zones	
	From	To	Min	Max	Min	Max
Aquifer I	20	113	41	162	38	97
Aquifer II	143	215	26	135	20	91
Aquifer III	246	300	21	88	10	46

Fig.15: 3D Aquifer disposition Model

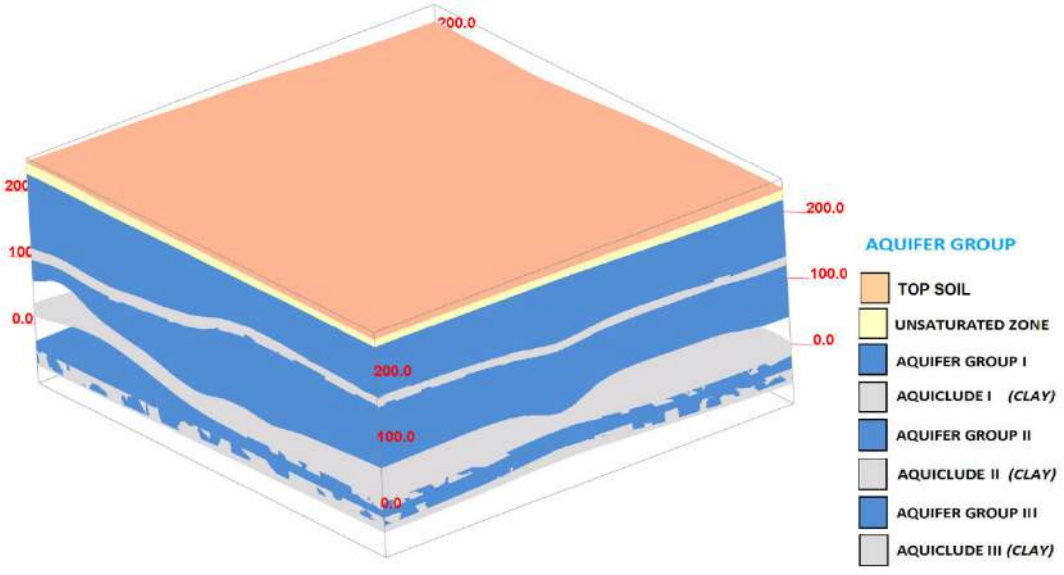
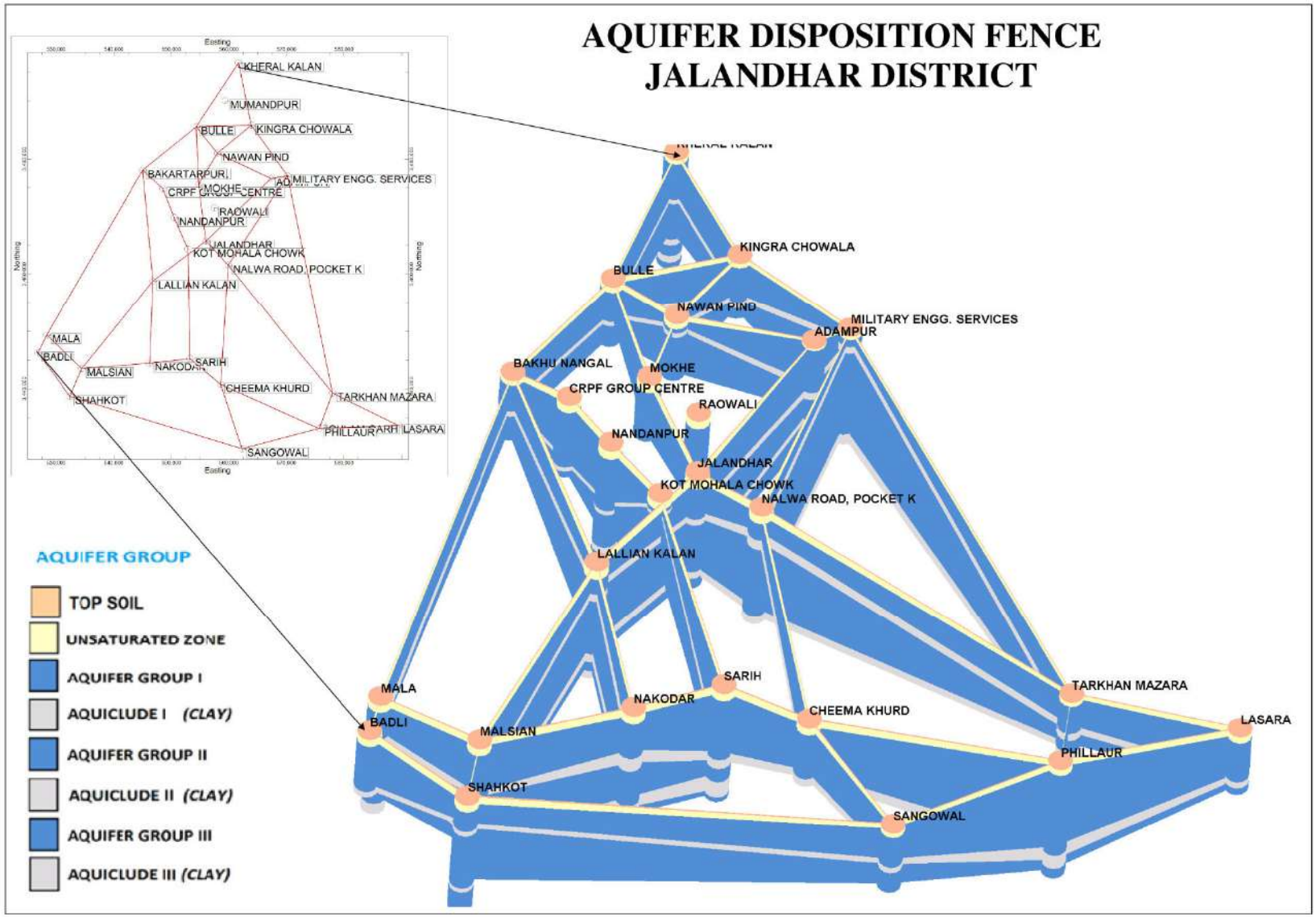


Fig.16: 3D Aquifer Disposition Fence



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 Jalandhar district has been assessed to be 209%. 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*
Adampur	112.85	199.73	2.44	202.17	3.04	-89.92	179	Over Exploited
Bhogpur	105.91	260.78	1.79	262.57	2.22	-157.10	248	Over Exploited
Rurka Kalan	105.46	209.97	2.08	212.06	2.62	-107.13	201	Over Exploited

Jalandhar-East	95.38	203.96	29.15	233.10	37.11	-145.69	244	Over Exploited
Jalandhar-West	177.40	314.50	9.74	324.24	12.38	-149.49	183	Over Exploited
Lohian	101.82	215.01	1.46	216.47	1.82	-115.02	213	Over Exploited
Nakodar	190.66	451.38	7.47	458.85	9.44	-270.17	241	Over Exploited
Nurmahal	157.07	288.73	1.96	290.69	2.47	-134.13	185	Over Exploited
Phillaur	176.20	306.22	12.59	318.81	15.84	-145.86	181	Over Exploited
Shahkot	81.36	194.75	5.58	200.33	7.09	-120.49	246	Over Exploited
TOTAL	**1304.10**	**2645.05**	**74.25**	**2719.30**	**94.04**	**-1434.99**	**209**	**Over Exploited**

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 17. 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	×	Sp. 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 17: Concept for Resource Estimation in Unconfined and Confined Aquifer System

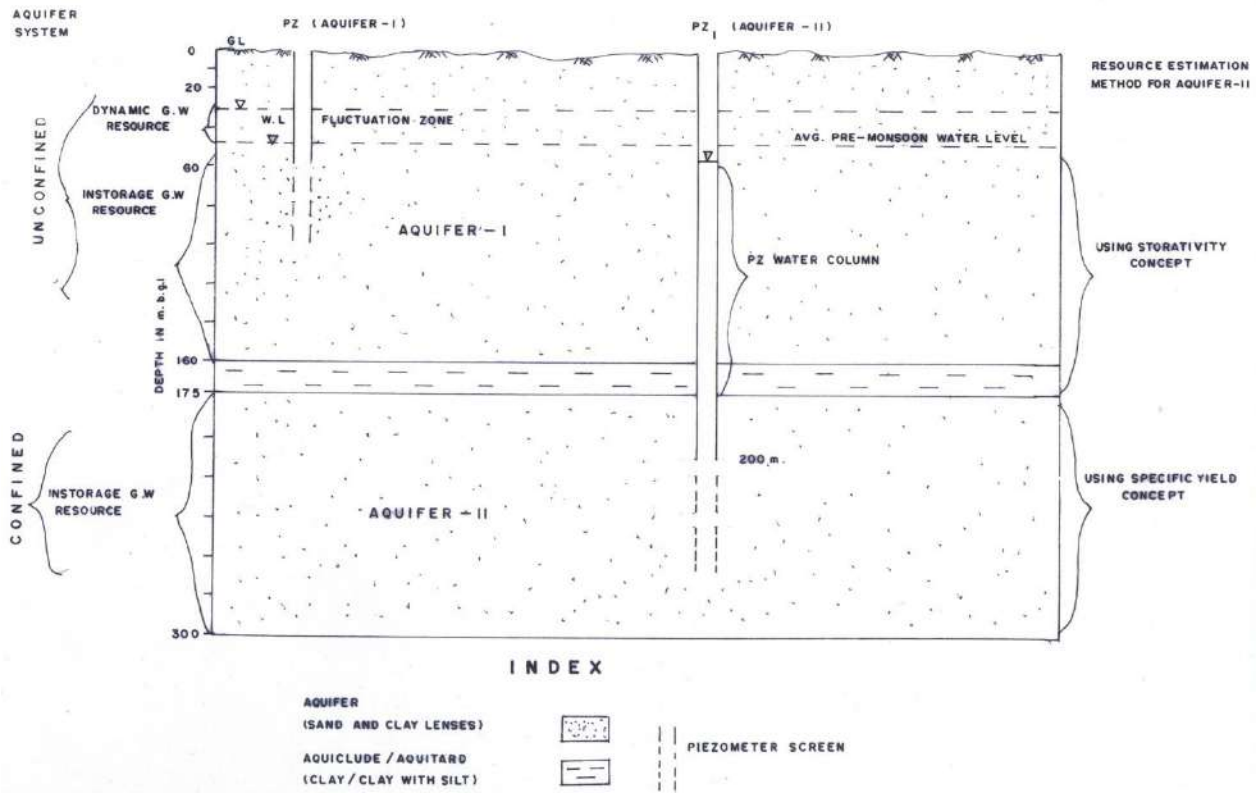


Table-4: Block Wise In storage Ground Water Resources in Unconfined Aquifer –I (Alluvium)

BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED AQUIFER –I											
S N.	Name of Assessment Unit	Areal extent (sq.km)				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) (9-8)	Thickness of the Granular Zone in AQUIFER GROUP-I below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources [(5)*(10)*(11)*] FRESH (mcm)
		Total Geographical Area	Assessment Area								
			Total	Fresh Water	Brackish/ Saline Water						
1	2	3	4	5	6	7	8	9	10	11	12
1	Adampur	204.2	204.2	204.2	0	11.46	131	119.54	79	0.072	1161
2	Bhogpur	178	178	178	0	12.96	111	98.04	58	0.072	743
3	Rurka Kalan	191.8	191.8	191.8	0	17.52	104	86.48	65	0.072	898
4	Jalandhar-East	256.2	256.2	256.2	0	28.04	111	82.96	50	0.072	922
5	Jalandhar-West	338.9	338.9	338.9	0	15.08	156	140.92	60	0.072	1464
6	Lohian	280.3	280.3	280.3	0	13.13	96	82.87	65	0.072	1312
7	Nakodar	353.3	353.3	353.3	0	26.64	160	133.36	64	0.072	1628
8	Nur Mahal	319.8	319.8	319.8	0	18.92	143	124.08	62	0.072	1428
9	Phillaur	270.3	270.3	270.3	0	14.62	160	145.38	87	0.072	1693
10	Shahkot	240.7	240.7	240.7	0	26.91	147	120.09	75	0.072	1300
Dist.Total (mcm)		**2633.5**	**2633.5**	**2633.5**	**0**						**12549**
Dist.Total (bcm)											**12.55**

bcm: billion cubic 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)															
Sr. No.	Name of Assessment Unit	Areal extent (sq.km)			Top Aquifer II (m bgl)	Depth to bottom of Aquifer II (m bgl)	Piezo-metric Head (m bgl)	Thickness of piezo-metric level(m bgl)	Total Thickness of confined aquifer down to explored depth (m) (9-8)	Thickness of the Granular Zone in confined aquifer down to explored depth (m)	Average Specific Yield	Average value of Storativity	In-Storage Ground Water Resources (Specific yield concept) [(5)*(11)*(12)]	In-Storage Ground Water Resources (Storativity concept) [(5)*(9)*(13)]	Total in-Storage Ground Water Resources (mcm) (14+15)
		Total Geographical Area	Assessment Area												
			Total	Fresh Water											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Adampur	204.2	204.2	204.2	143	198	15.2	182.8	55	35	0.072	0.000105	515	3.92	519
2	Bhogpur	178	178	178	130	220	20	200	90	40	0.072	0.000105	513	3.74	516
3	Rurka Kalan	191.8	191.8	191.8	120	170	21	149	50	35	0.072	0.0006	483	17.15	500
4	Jalandhar-East	256.2	256.2	256.2	140	250	30	220	110	90	0.072	0.000105	1660	5.92	1666
5	Jalandhar-West	338.9	338.9	338.9	170	268	19	249	98	82	0.072	0.000105	2001	8.86	2010
6	Lohian	280.3	280.3	280.3	105	180	16	164	75	30	0.072	0.000508	605	23.35	629
7	Nakodar	353.3	353.3	353.3	170	250	28	222	80	67	0.072	0.000121	1704	9.49	1714
8	Nur Mahal	319.8	319.8	319.8	112	186	21	165	74	26	0.072	0.000121	599	5.57	604
9	Phillaur	270.3	270.3	270.3	108	250	18	232	142	82	0.072	0.0006	1596	37.63	1633
10	Shahkot	240.7	240.7	240.7	90	270	30	240	180	70	0.072	0.000121	1213	6.99	1220
Dist.Total (mcm)		**2633.5**	**2633.5**	**2633.5**									**10889**	**123.43**	**110.12**
Dist.Total (bcm)													**10.89**	**1.23**	**11.01**

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

BLOCK WISE INSTORAGE GROUND WATER RESOURCES – CONFINED (AQUIFER III)

Sr. No.	Name of Assessment Unit	Areal extent (sq.km)			Depth to Top Aquifer III (m bgl)	Depth to bottom of Aquifer III (m bgl)	Thickness of piezo-metric level(m bgl)	Total Thickness of confined aquifer down to explored depth (m) (9-8)	Thickness of the Granular Zone in confined aquifer down to explored depth (m)	Average Specific Yield	Average value of Storativity	In-Storage Ground Water Resources (Specific yield concept) [(5)*(10)*(11)]	In-Storage Ground Water Resources (Storativity concept) [(5)*(8)*(12)]	Total in-Storage Ground Water Resources (mcm) (13+14)
		Total Geographical Area	Assessment Area											
			Total	Fresh Water										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Adampur	204.2	204.2	204.2	214	300	190.8	86	40	0.072	0.000508	588	19.8	608
2	Bhogpur	178	178	178	237	300	213.8	63	21	0.072	0.000508	269	19.3	288
3	Rurka Kalan	191.8	191.8	191.8	215	300	191.8	85	30	0.072	0.000508	414	18.7	433
4	Jalandhar-East	256.2	256.2	256.2	274	300	250.8	26	16	0.072	0.000508	295	32.6	328
5	Jalandhar-West	338.9	338.9	338.9	256	300	232.8	44	18	0.072	0.000508	439	40.1	479
6	Lohian	280.3	280.3	280.3	205	300	156.8	95	50	0.072	0.000508	1009	22.3	1031
7	Nakodar	353.3	353.3	353.3	279	300	255.8	21	16	0.072	0.000508	407	45.9	453
8	Nur Mahal	319.8	319.8	319.8	210	300	186.8	90	30	0.072	0.000508	691	30.3	721
9	Phillaur	270.3	270.3	270.3	262	300	238.8	38	25	0.072	0.000508	487	32.8	519
10	Shahkot	240.7	240.7	240.7	243	300	219.8	57	27	0.072	0.000508	468	26.9	495
Dist.Total (mcm)		**2633.5**	**2633.5**	**2633.5**								**5067**	**289**	**5356**
Dist.Total (bcm)												**5.07**	**0.29**	**5.36**

Table-7: Block Wise Total Availability of Groundwater Resources upto 300 m Depth and Volume of Unsaturated Zone

AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN JALANDHAR DISTRICT								
Sl.No	Block	*Volume of Unsaturated Zone up to Pre-monsoon WL (mcm)*	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources AQUIFER-I*	Fresh Groundwater Resources AQUIFER-I [(4)+(5)]	Fresh In-storage Groundwater Resources AQUIFER-II	Fresh In-storage Groundwater Resources AQUIFER-III	Total Availability of Fresh Groundwater Resources [(6)+(7)+(8)]
								mcm
1	2	*3*	*4*	5	6	7	8	10
1	Adampur	*34*	*112.85*	1161	1274.3	519	608	2400.7
2	Bhogpur	*32*	*105.91*	743	849.2	516	288	1654.1
3	Rurka Kalan	*48*	*105.46*	898	1003.1	500	433	1936.5
4	Jalandhar-East	*76*	*95.38*	922	1017.7	1666	328	3011.6
5	Jalandhar-West	*91*	*177.40*	1464	1641.4	2010	479	4130.5
6	Lohian	*77*	101.82	1312	1413.6	629	1031	3073.8
7	Nakodar	*102*	190.66	1628	1818.7	1714	453	3985.4
8	Nur Mahal	*81*	157.07	1428	1584.7	605	721	2910.8
9	Phillaur	*66*	176.20	1693	1869.4	1633	519	4022.2
10	Shahkot	*66*	81.36	1300	1381.1	1220	495	3096.1
Dist. Total (mcm)		**672**	**1304.10**	**12549**	**13853.2**	**11012**	**5356**	**30221.7**
Dist. Total (bcm)		**0.67**	**1.30**	**12.55**	**13.853**	**11.01**	**5.36**	**30.22**

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 and deep depths and they are the main source of irrigation. This will lead to its deepening of ground water levels in all blocks of Jalandhar 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.17 & 18) and is categorized as over-exploited. This declining water table trend, if not checked, would assume an alarming situation in the near future affecting agricultural production and thus economy. Ground Water Recharge and Conservation may be carried out in these areas to overcome the depletion.

Fig.17: Long term ground water table variation (Shallow Aquifer)

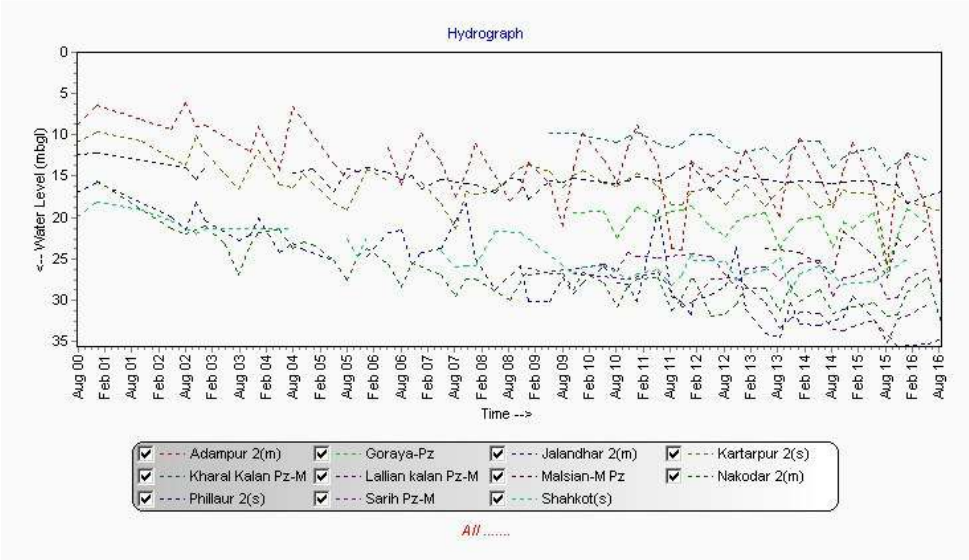
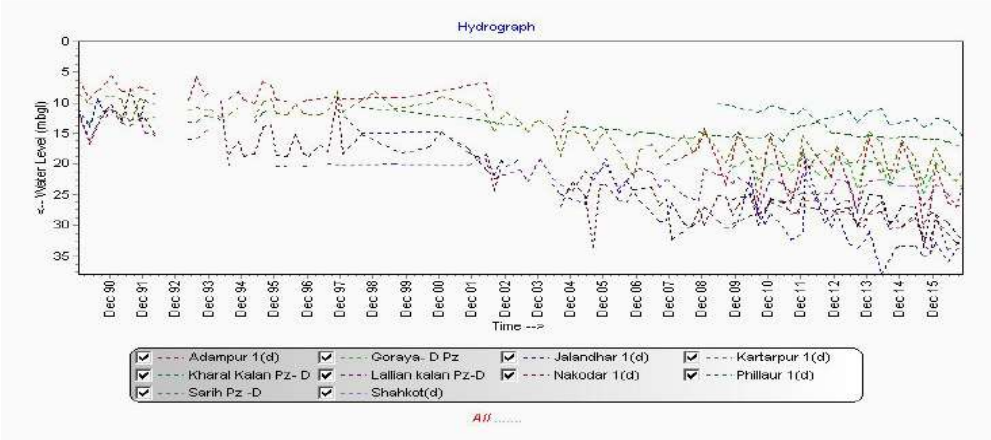


Fig.18: Long term ground water table variation (Deeper Aquifer)



5.2 Ground Water Quality

The ground water of the study area is alkaline in nature. Ground water in the area is fresh. Ground water with iron concentration above permissible limit 1.5 mg/l is found mainly in Kharal kalan (8.62), Adampur (6.96) & Nakodar (3.83).Nitrate above permissible limit 45 mg/l are observed in Phillaur (55) & Alawalpur (45). Flouride above permissible limit 1 mg/l are observed in Sarih (1.2) and Phillaur (1.0) as per NHNS sampling, 2015. 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	1229	4886	15560	20483	5762	80	**48000**
Deep TW	1096	3888	11157	10264	3907	0	**30312**
Total	**2325**	**8774**	**26717**	**30747**	**9669**	**80**	**78312**

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	712	6095	10229	30957	19911	10294	114	**78312**
Tubewells (%)	0.90	7.78	13.06	39.53	25.42	13.14	0.14	

Table-10: System of Ground water distribution device

	Open Water Channels			
Lined/pucca	*Unlined/kutcha*	*Underground Pipe*	*Others*	*Total*
2280	63818	12154	60	**78312**

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 Jalandhar District due to very low availability of volume of surplus water (26.54 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 63818 (out of 78312) tube wells (81.49 %) 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 61.28 % 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 2645.05 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 538.86 mcm (Table-11a) assuming that there is a need of crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks. The measure if implemented will bring down the ground water overdraft from 209 % to 159%. 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-11a: 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		
Adampur	112.85	199.73	179	40.69	3.26	35.5	79.45	101	1
Bhogpur	105.91	260.78	248	53.13	2.32	88.7	144.15	102	2
Rurka Kalan	105.46	209.97	201	42.78	1.74	51.8	96.32	101	1
Jalandhar-East	95.38	203.96	244	41.55	3.58	75.9	121.03	108	8
Jalandhar-West	177.40	314.50	183	64.07	2.78	63.0	129.85	102	2
Lohian	101.82	215.01	213	43.80	1.75	58.8	104.35	102	2
Nakodar	190.66	451.38	241	91.96	4.42	149.1	245.48	103	3
Nur Mahal	157.07	288.73	185	58.82	2.63	58.3	119.75	101	1
Phillaur	176.20	306.22	181	62.39	1.92	61.0	125.31	103	3
Shahkot	81.36	194.75	246	39.68	2.14	66.8	108.62	102	2
Total	**1304.10**	**2645.05**	**209**	**538.86**	**26.54**	**708.8**	**1274.2**	**103**	

Table-11b: Impact on Stage of Development (SOD) after applying various management strategies

Block	*Present SOD (%) as on 2013*	*Reduction in SOD (%) after unlined channel (%)*	*Resultant SOD (%) Col.(2 - 3)*	*Reduction in Stage of development after crop diversification by Maize/Soyabean (%)*	*Resultant SOD (%) Col.(2 - 5)*	*Reduction in Stage of development after Artificial recharge (%)*	*Resultant SOD (%) Col.(2 - 7)*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Adampur	179	43.27	135.73	31.6	147.4	3	176
Bhogpur	248	60.20	187.8	83.8	164.2	2	246
Rurka Kalan	201	48.68	152.32	49.2	151.8	2	199
Jalandhar-East	244	52.28	191.72	80	164	4	240
Jalandhar-West	183	43.34	139.66	35.5	147.5	2	181
Lohian	213	51.63	161.37	57.7	155.3	2	211
Nakodar	241	57.88	183.12	78.6	162.4	2	239
Nur Mahal	185	44.94	140.06	37.1	147.9	2	183
Phillaur	181	42.49	138.51	34.8	146.2	1	180
Shahkot	246	58.52	187.48	82.1	163.9	3	243
Total	**209**	**50.32**	**158.7**	**57.04**	**151.96**	**2.3**	**207**

By adopting all the management strategies resulting in total reduction in stage of groundwater development is 106%. Hence overall stage of development afterwards is 103 % and is given in Table.12.

Table-12: Overall Stage of Development (SOD) after reduction in Jalandhar District

Block	*Present Stage of development (%) as on 2013*	*Reduction in stage of development after unlined channel (%)*	*Reduction in Stage of development after crop diversification by Maize/Soyabean (%)*	*Reduction in Stage of development after Artificial recharge (%)*	*Total Reduction in Stage of development (%) (3 +4+5)*	*Stage of development afterwards (%) (2-6)*
1	**2**	**3**	**4**	**5**	**6**	**7**
Adampur	179	43.27	31.6	3	78	101
Bhogpur	248	60.20	83.8	2	146	102
Rurka Kalan	201	48.68	49.2	2	100	101
Jalandhar-East	244	52.28	80	4	136	108
Jalandhar-West	183	43.34	35.5	2	81	102
Lohian	213	51.63	57.7	2	111	102
Nakodar	241	57.88	78.6	2	138	103
Nur Mahal	185	44.94	37.1	2	84	101
Phillaur	181	42.49	34.8	1	78	103
Shahkot	246	58.52	82.1	3	144	102
Total	**209**	**50.32**	**57.04**	**2.3**	**110**	**103**

BLOCK WISE

AQUIFER MAPS

AND

MANAGEMENT PLAN

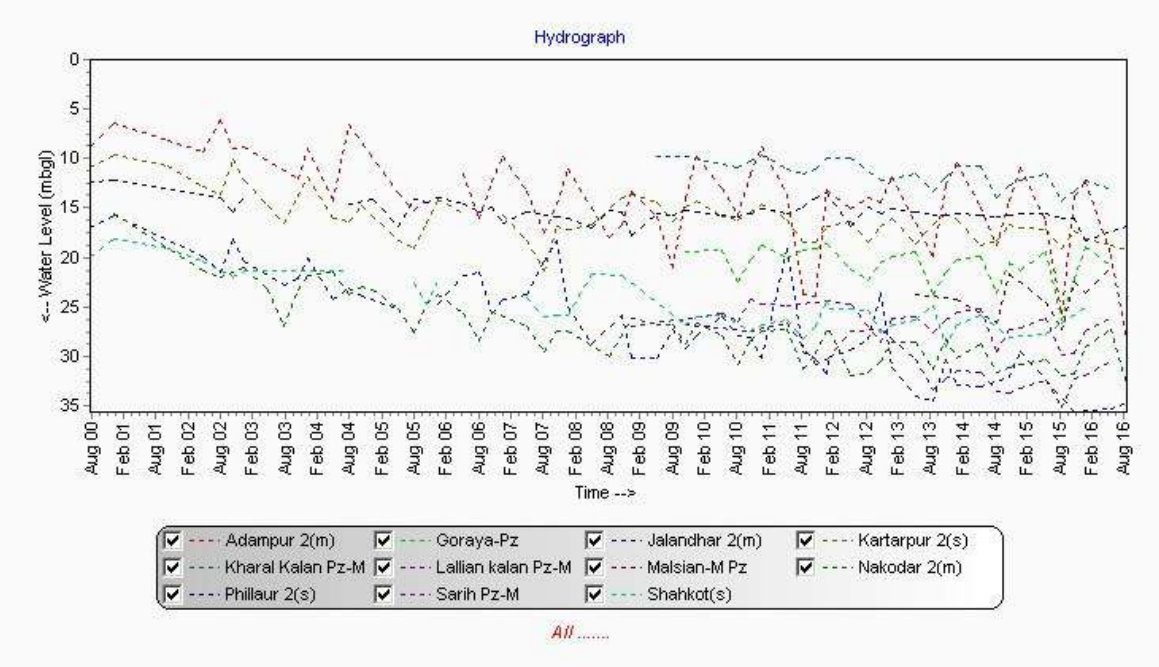
(PART-II)

I. Salient Information of Adampur Block

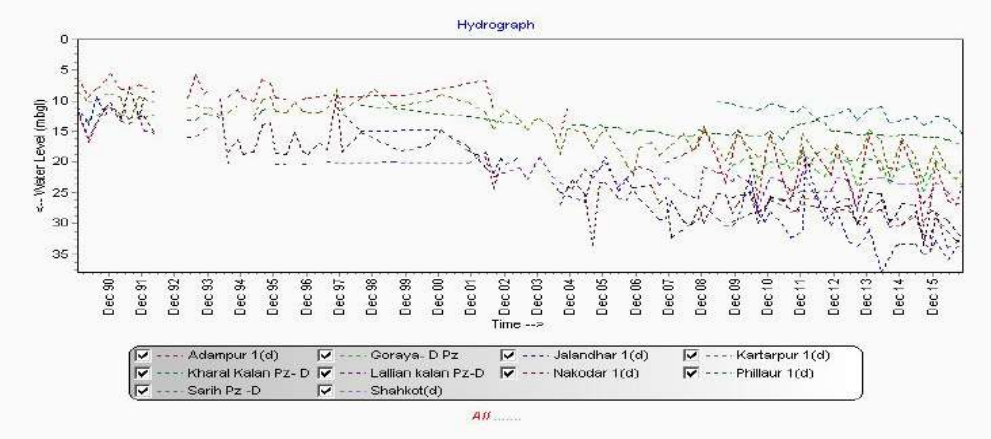
<table>
<tr><td>Block Area
(in Km^2)</td><td>204.20 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 3704
Rural Population: 94489
Total population: 98193</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 612 mm
Non-monsoon Rainfall : 170 mm
Annual Average Rainfall: 782 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Wheat, Rice, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 271.14 sq km
Net sown area: 176.36 sq km
Irrigation practices: Tube well
Cropping intensity: 154%
<u>Area under</u>
Ground water Irrigation: 176.36 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 271.14 sq km
Net Irrigated area: 176.36 sq km
Number and types of abstraction structures: 6121, 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>11.46 – 131.0</td><td>120</td><td>79</td><td>1274.30</td></tr>
<tr><td>Aquifer-II</td><td>143.0 – 198.0</td><td>55</td><td>35</td><td>519</td></tr>
<tr><td>Aquifer-III</td><td>214.0 – 300.0</td><td>86</td><td>40</td><td>608</td></tr>
</table>
Total Ground Water Resources available is 2400.70 mcm and total potential granular zones available are 154 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 199.73 mcm Domestic and industrial water supply: 2.44 mcm *Future water demands* Irrigation development potential : (-)89.92 mcm Domestic and industrial water supply up to 2025 years : 3.04 mcm Water Scarcity Villages: 71
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 7.25 – 26.7 m bgl Post Monsoon: 7.40 – 31.0 m bgl Seasonal Fluctuation: 0.25 – (-)4.30 m/yr **Aquifer-II &III** Pre Monsoon: 11.3 – 18.6 m bgl Post Monsoon: 3.50 – 35.78 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older 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	0	0	0	2	**2**
WRED/PSTC/WSS	4	7	0	1	**12**
PRIVATE	0	6	0	2	**8**
TOTAL	**4**	**13**	**0**	**5**	**22**

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 (11.46 -131 m)	Quarter-nary Alluvial deposits	Unconfined to confined	79	NA	NA	12 % (0.072)	1 NA
Aquifer-II (143 - 198 m)		Semi confined to Confined	35				
Aquifer-III (214 - 300 m)		Semi confined to Confined	40	NA	NA	NA	NA

* Well field proposed in this block (Site: Jandu Singha), NA : Not Available

Source: CGWB,2015 & PSTC,2008

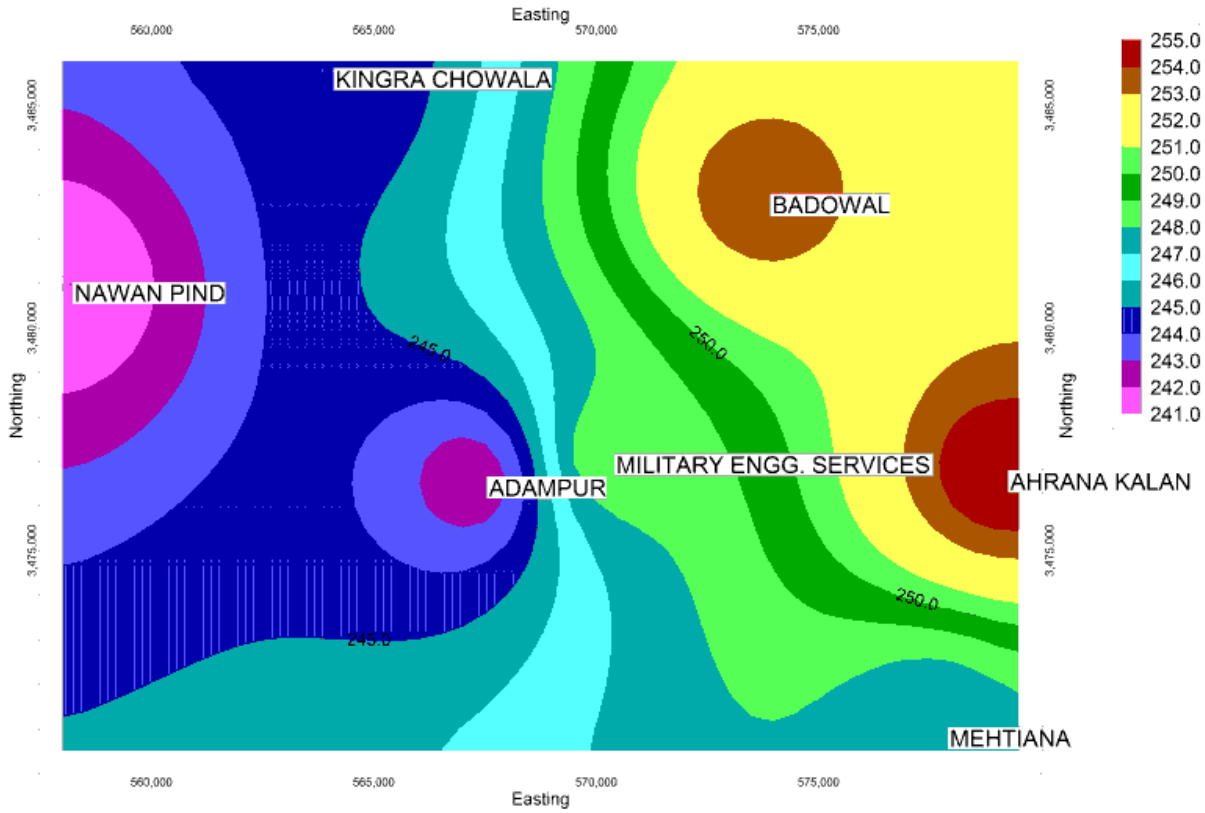
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

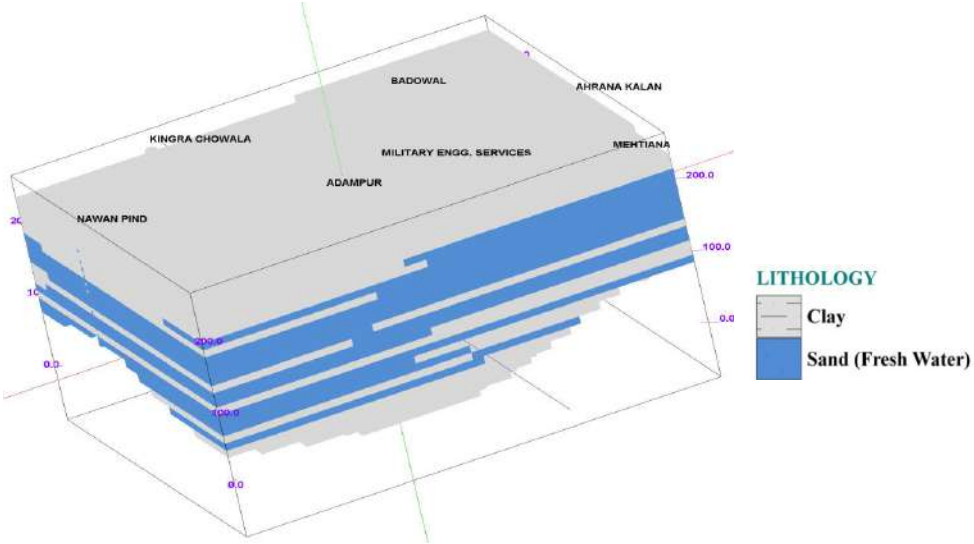
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED/PSTC/WSS	0	0	0	0	**0**
PRIVATE	0	0	0	2	**2**
TOTAL	**0**	**0**	**0**	**3**	**3**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

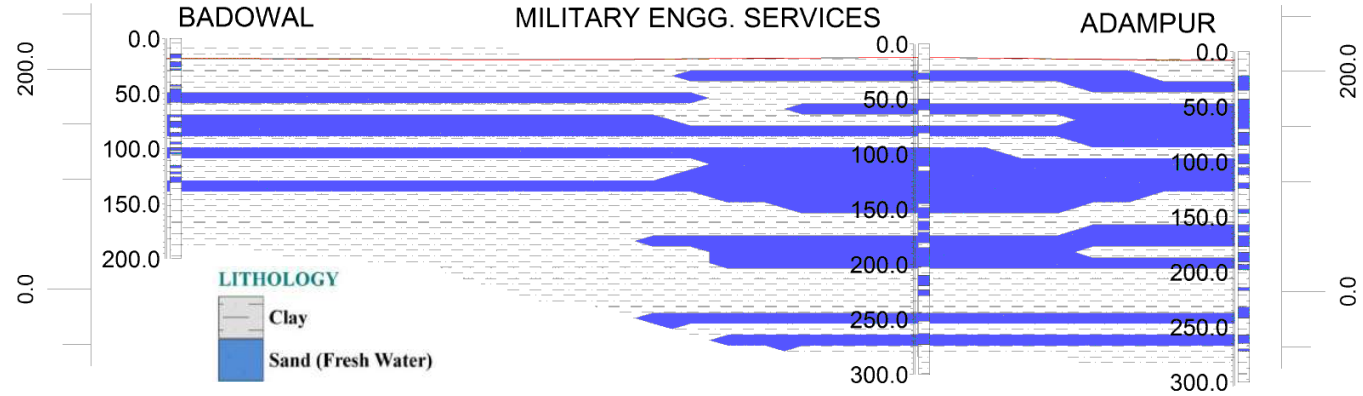
Elevation Map of Adampur Block



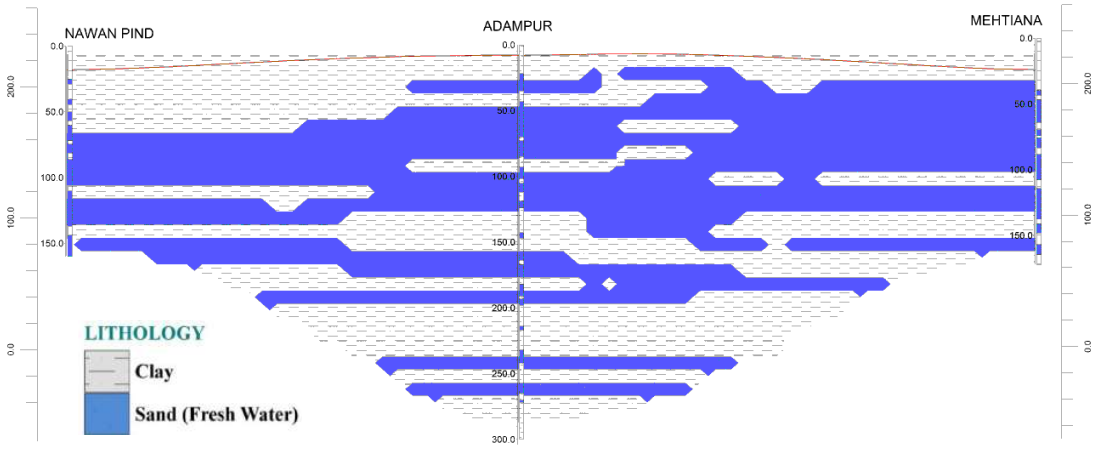
3-D Lithological model of Adampur Block



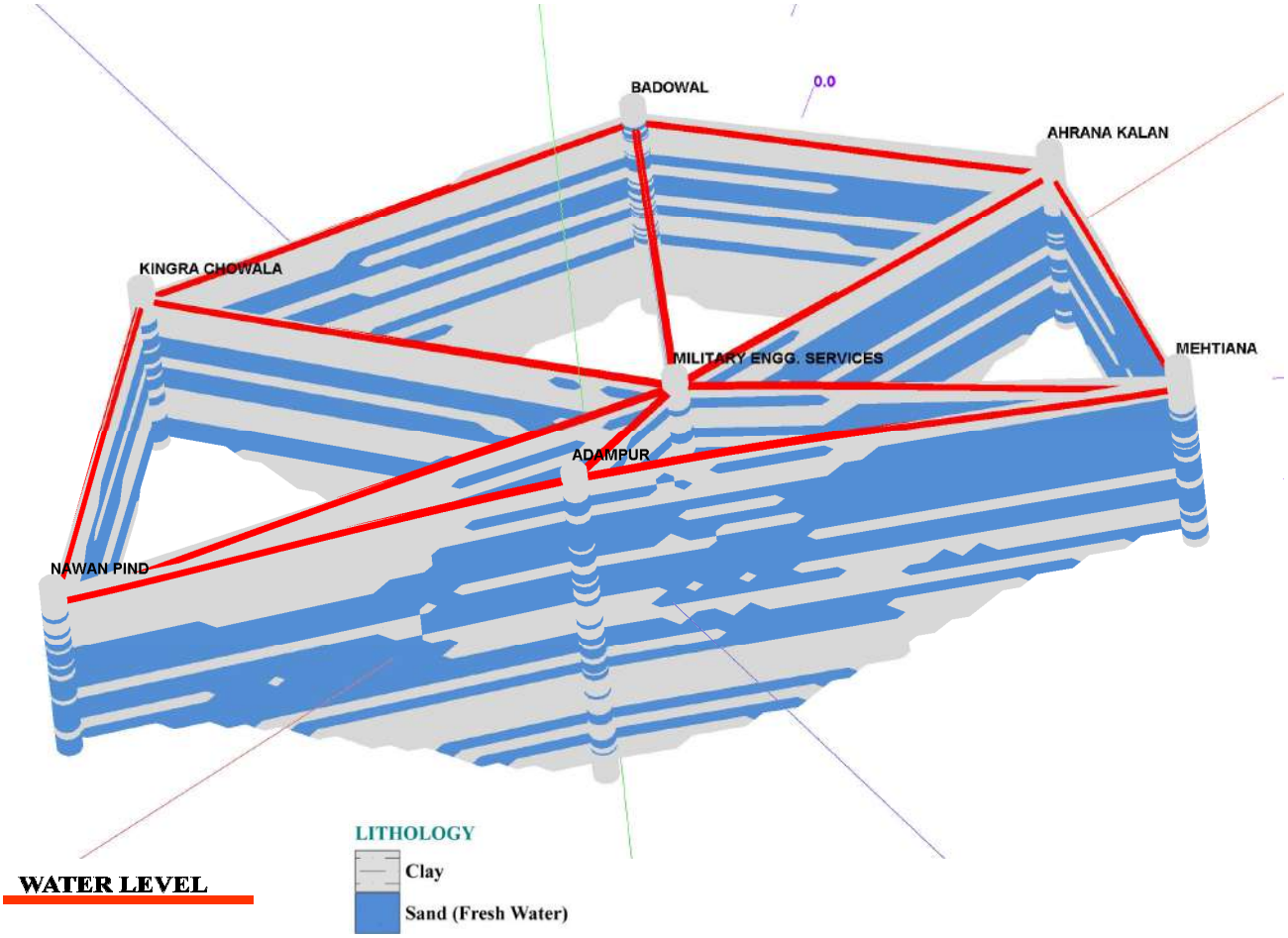
Lithological Cross section from Badowal to Adampur



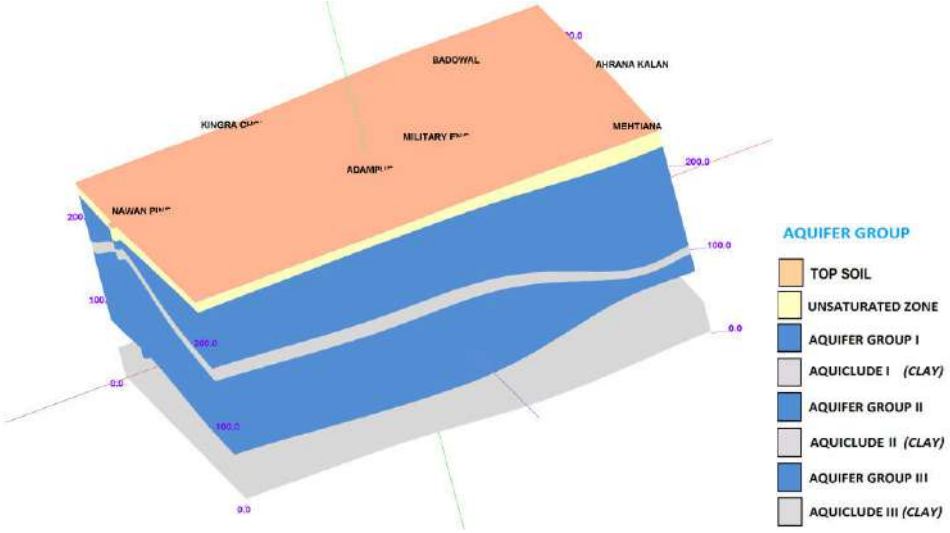
Lithological Cross section from Nawan pind to Mehtiana



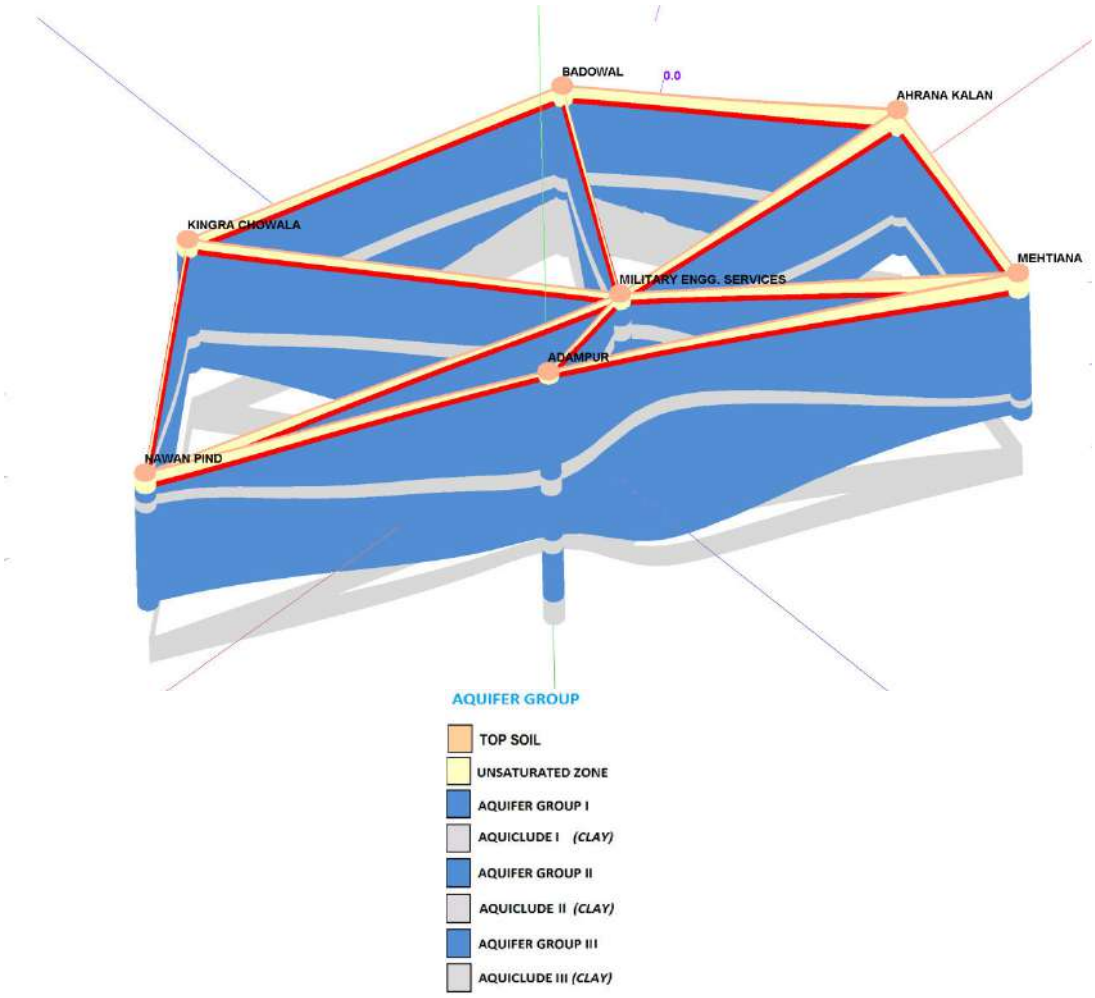
3-D Lithological Fence Diagram



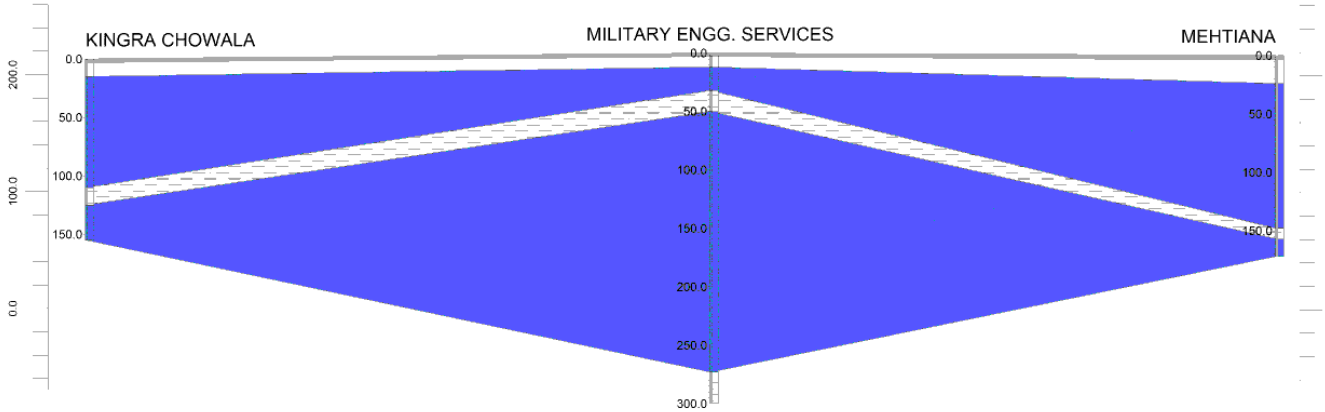
3-D Aquifer Disposition Model of Adampur Block



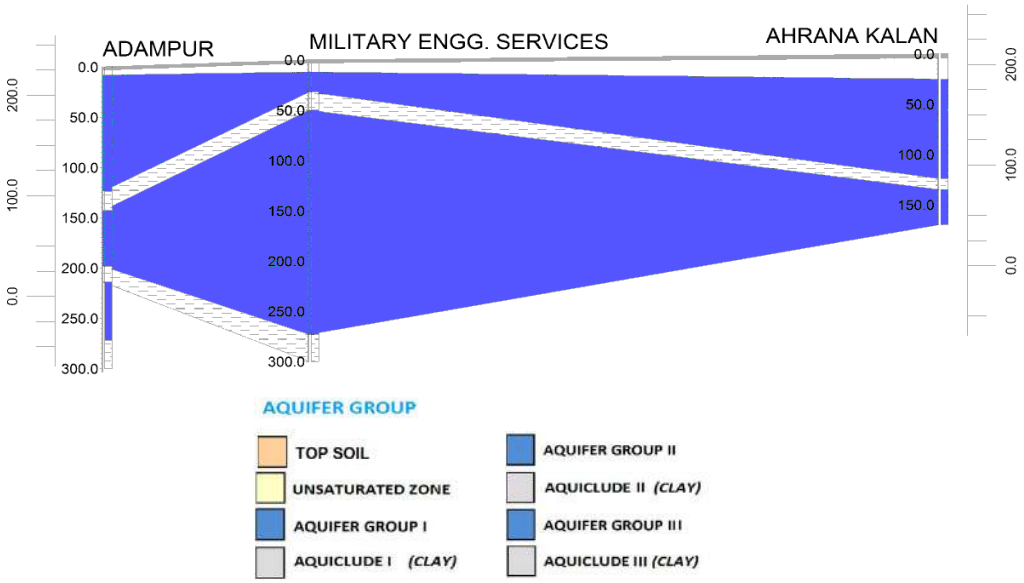
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along NW to SE



Aquifer Cross section along West to East



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	112.85 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1161 mcm
	In-storage Aquifer-II (Specific Yield Concept)	515 mcm
	In-storage Aquifer-II (Storativity Concept)	3.92 mcm
	In-storage Aquifer-III (Specific Yield Concept)	588 mcm
	In-storage Aquifer-II (Storativity Concept)	19.80 mcm
	Total Resources	2400.70 mcm
Ground Water Extraction (as per 2013)	Irrigation	199.73 mcm
	Domestic & Industrial	2.44mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		3.04 mcm
Stage of Groundwater Development		179 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature and pH ranges between 8.23 to 8.25. EC value of the ground water show wide variations and ranges from 215 µS/cm to 545 µS/cm at 25^0C.

	RSC values are varies from -1.49 to -0.31 meq/L and the area is fit for irrigation.
Ground water Contamination Issues	***Iron(mg/l):*** Adampur(6.96) ***Nitrate(mg/l):*** Allawalpur (45)
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: 34 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 3.26 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Adampur Block (204.20 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 40.69 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean.*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *45% of the total rice area needs to change i.e.* 35.5 sq km
Anticipated volume of water to be saved: 35.50 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigat-ion Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of develop-ment (%)*	*Reduction in Stage of develop-ment after Maize/ soya bean (%)*	*Crop Diversified area (%)*
112.85	199.73	202.17	80	35.50	35.50	164.23	179	31.60	45

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 22

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

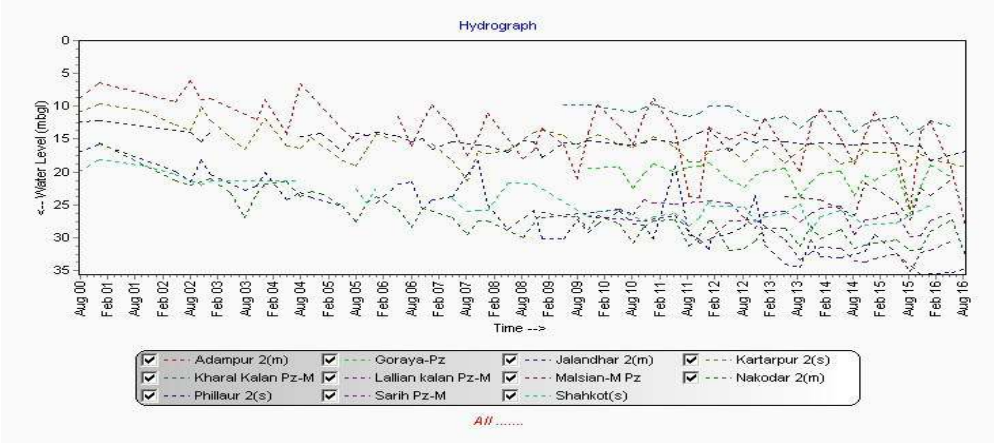
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

II. Salient Information of Bhogpur Block

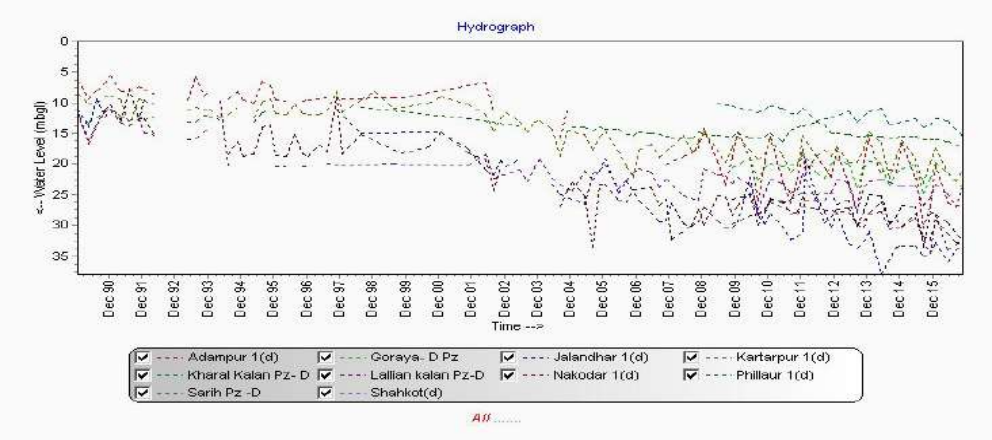
<table>
<tr><td>Block Area
(in Km^2)</td><td>372.40 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 0
Rural Population: 70503
Total population: 70503</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 647 mm
Non-monsoon Rainfall : 175 mm
Annual Average Rainfall: 822mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Wheat, Rice, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 281.71 sq km
Net sown area: 156.28 sq km
Irrigation practices: Tube well
Cropping intensity: 180%
<u>Area under</u>
Ground water Irrigation: 156.20 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 281.71 sq km
Net Irrigated area: 156.28 sq km
Number and types of abstraction structures: 7995, 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 300m 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>12.96 – 111.0</td><td>98</td><td>58</td><td>849.20</td></tr>
<tr><td>Aquifer-II</td><td>130.0 – 220.0</td><td>90</td><td>40</td><td>516</td></tr>
<tr><td>Aquifer-III</td><td>237.0 – 300.0</td><td>63</td><td>21</td><td>288</td></tr>
</table>
Total Ground Water Resources available is 1654.10 mcm and total potential granular zones available are 119 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	<u>*Existing Gross Ground water Draft as on 2013*</u> Irrigation: 260.78 mcm Domestic and industrial water supply: 1.79 mcm <u>*Future water demands*</u> Irrigation development potential : (-)157.10 mcm Domestic and industrial water supply up to 2025 years : 2.22 mcm Water Scarcity Villages: 57
Water level behavior	<u>*Aquifer wise water level*</u> **Aquifer-I** Pre Monsoon: 10.30 – 26.70 m bgl Post Monsoon: 10.20 – 31.00 m bgl Seasonal Fluctuation: (-)2.10 – (-)6.20 m/yr **Aquifer-II & III** No Monitoring station exist

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	1	1	1	**4**
WRED/PSTC/WSS	7	12	0	1	**20**
PRIVATE	0	6	0	0	**6**
TOTAL	**8**	**19**	**1**	**2**	**30**

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 (12.96-111 m)	Quarter-nary Alluvial deposits	Unconfined to confined	58	NA	NA	12 % *(0.072)*	NA
Aquifer-II (130 - 220 m)		Semi confined to Confined	40	931	2240		1.005×10^{-3}
Aquifer-III (237 - 300m)		Semi confined to Confined	21	NA	NA	NA	NA

* Well field proposed in the adjacent block NA : Not Available

Source: CGWB,2015 & PSTC,2008

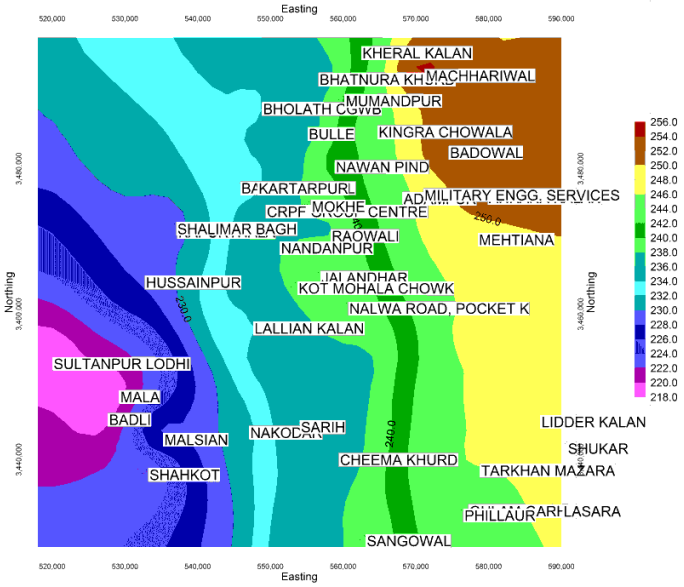
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

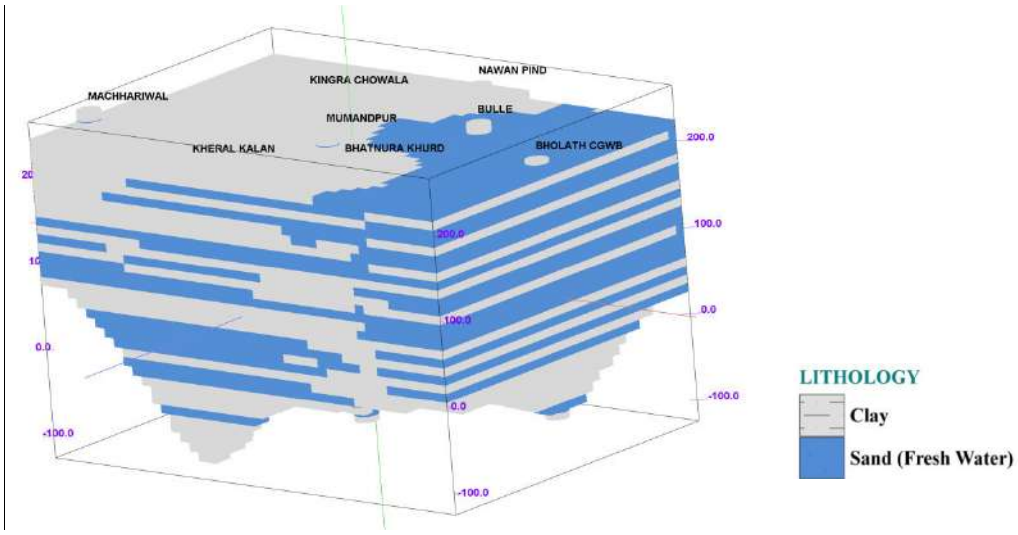
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	1	0	1	**2**
WRED/PSTC/WSS	0	7	0	0	**7**
PRIVATE	0	2	0	0	**2**
TOTAL	**0**	**10**	**0**	**1**	**11**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

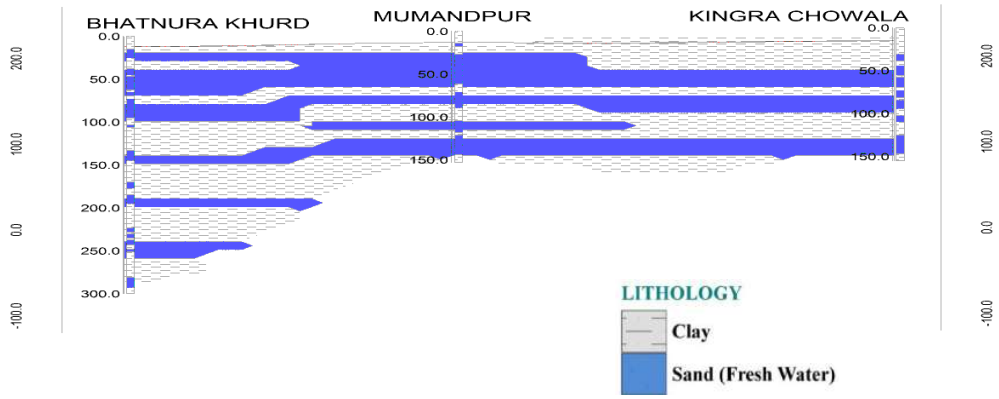
Elevation Map of Bhogpur Block



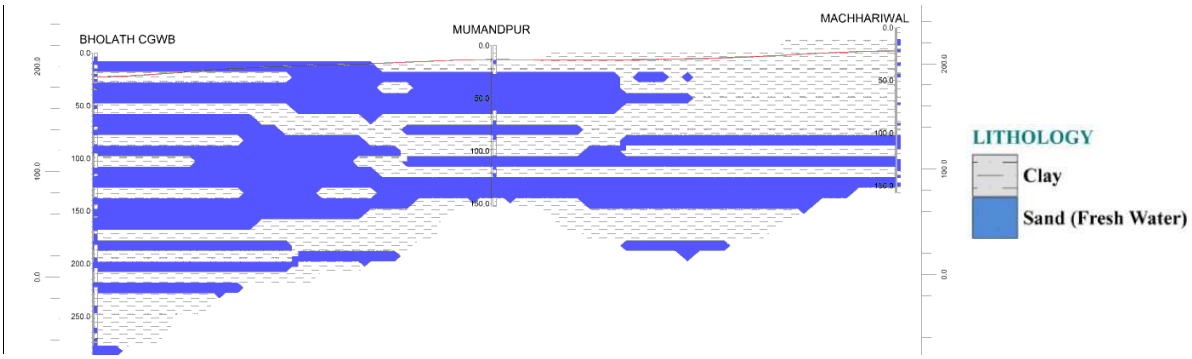
3-D Lithological model of Bhogpur Block



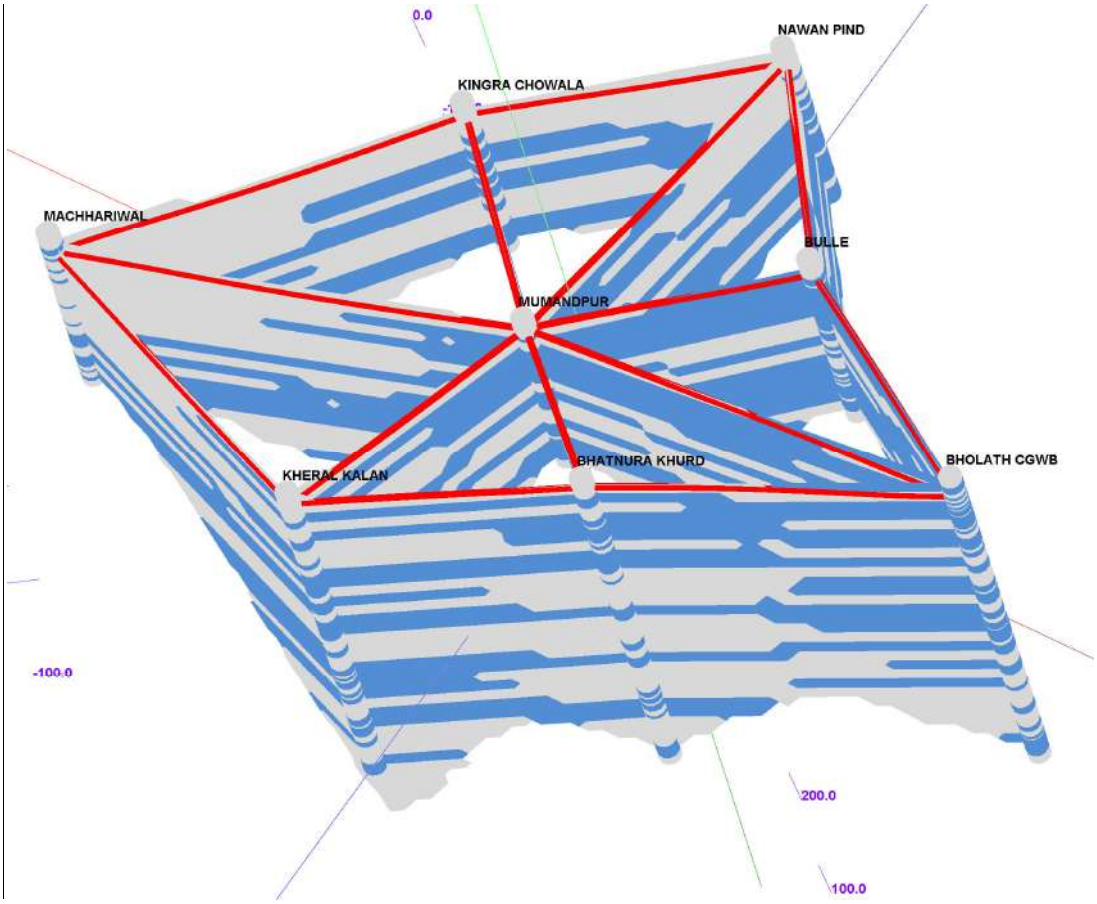
Lithological Cross section from Bhatnura khurd to Kingra Chowala



Lithological Cross section from Bholath to Machhariwal



3-D Lithological Fence Diagram



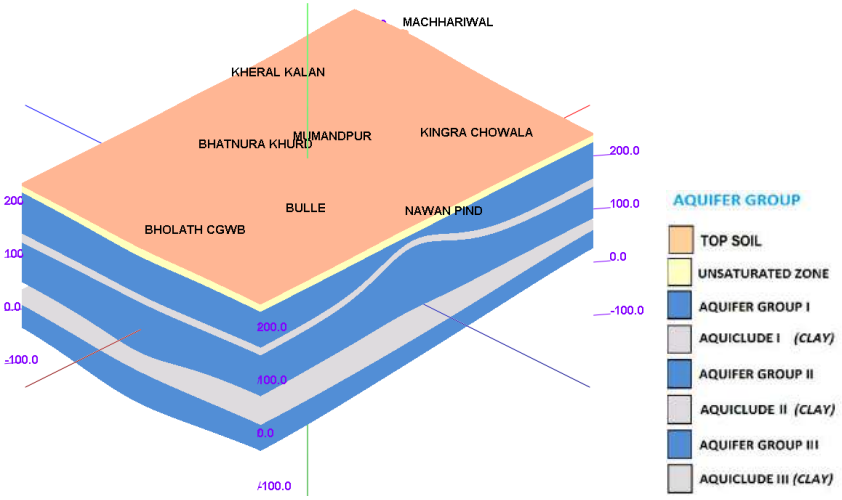
WATER LEVEL

LITHOLOGY

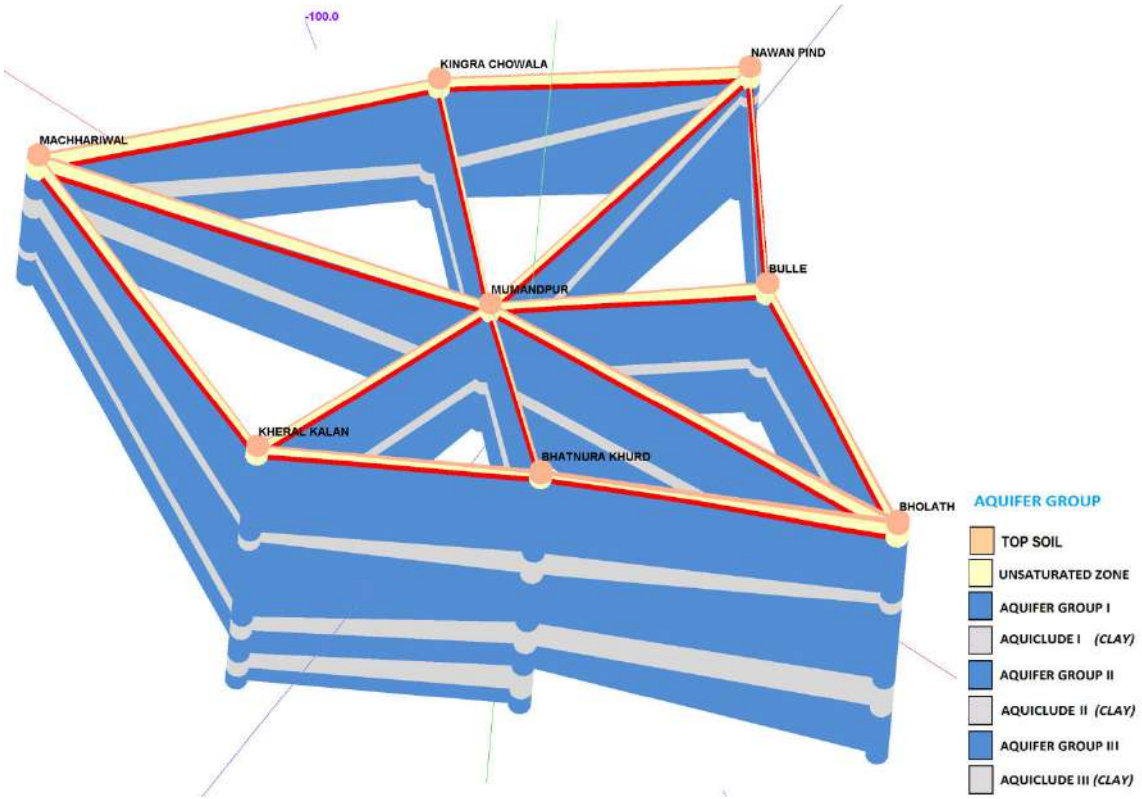
Clay

Sand (Fresh Water)

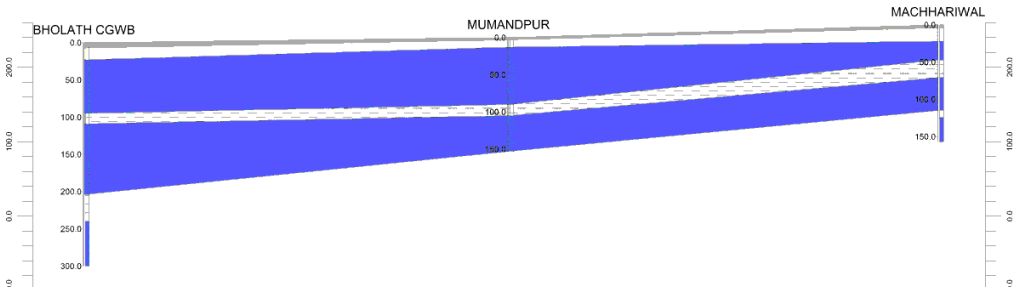
3-D Aquifer Disposition Model of Bhogpur Block



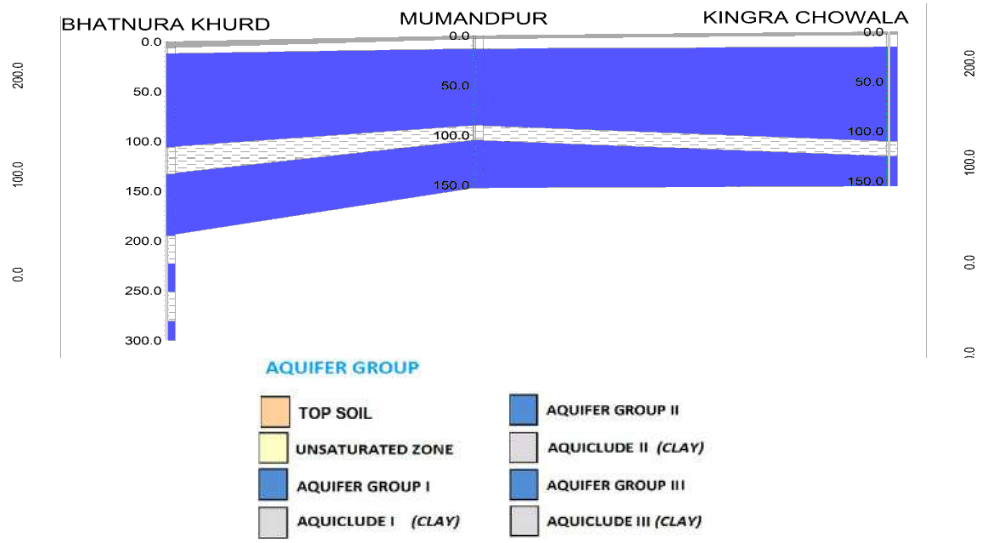
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along West to East



Aquifer Cross section along North West to South East



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	105.91 mcm
	In-storage Aquifer-I (Specific Yield Concept)	743 mcm
	In-storage Aquifer-II (Specific Yield Concept)	513 mcm
	In-storage Aquifer-II (Storativity Concept)	3.74 mcm
	In-storage Aquifer-III (Specific Yield Concept)	269 mcm
	In-storage Aquifer-II (Storativity Concept)	19.30 mcm
	Total Resources	1654.10 mcm
Ground Water Extraction (as per 2013)	Irrigation	260.78 mcm
	Domestic & Industrial	1.79 mcm

Future Demand for domestic & Industrial sector (2025) (as per 2013)	2.22 mcm
Stage of Groundwater Development	248 %
Chemical Quality of ground water	Ground water of Aquifer-I is alkaline in nature and pH value is 8.60 EC value of the ground water is 445 µS/cm at 25^0C. RSC value is 1.60 meq/L and the area is fit for irrigation. Ground water of Aquifer-II is alkaline in nature, potable for drinking and fit for irrigation. Ground water of Aquifer-III is alkaline in nature, potable for drinking and fit for irrigation.
Ground water Contamination Issues	***Iron(mg/l):*** Kharal kalan(8.62)
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: 32 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 2.32mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Bhogpur Block (372.4 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 53.13 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean .The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop*
Area coverage: *74% of the total rice area needs to change i.e.* 88.70 sq km
Anticipated volume of water to be saved: 88.70 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
105.91	260.78	262.57	120	88.70	88.70	172.08	248	83.80	74

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 17

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

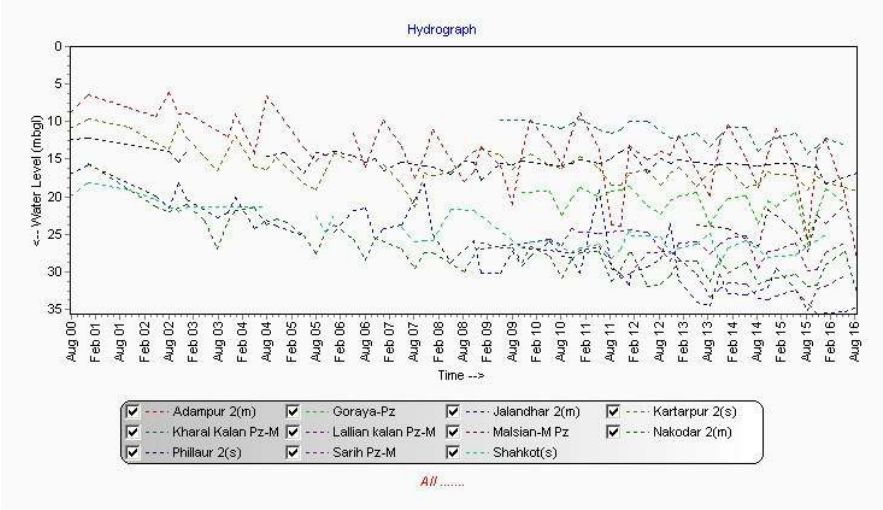
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

III. Salient Information of Rurka Kalan Block

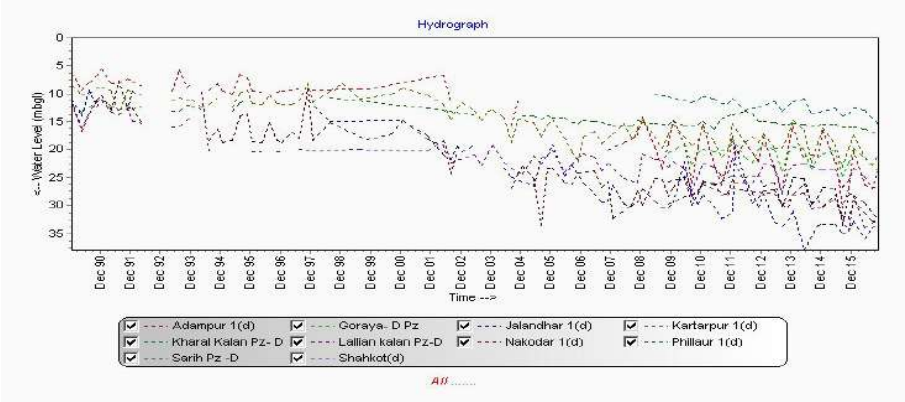
<table>
<tr><td>Block Area
(in Km^2)</td><td>191.80 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 8487
Rural Population: 82172
Total population: 90659</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 484 mm
Non-monsoon Rainfall : 159 mm
Annual Average Rainfall: 643 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 310.69 sq km
Net sown area: 166.36 sq km
Irrigation practices: Tube well and Canal Irrigation
Cropping intensity: 187%
<u>Area under</u>
Ground water Irrigation: 166 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 310.66 sq km
Net Irrigated area: 166.26 sq km
Number and types of abstraction structures: 7234, 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>17.52 – 104.0</td><td>86</td><td>65</td><td>1003.10</td></tr>
<tr><td>Aquifer-II</td><td>120.0 – 170.0</td><td>50</td><td>35</td><td>500</td></tr>
<tr><td>Aquifer-III</td><td>215.0 – 300.0</td><td>85</td><td>30</td><td>433</td></tr>
</table>
Total Ground Water Resources available is 1936.50 mcm and total potential granular zones available are 130 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 209.97 mcm Domestic and industrial water supply: 2.08 mcm *Future water demands* Irrigation development potential : (-)107.13 mcm Domestic and industrial water supply up to 2025 years : 2.62 mcm Water Scarcity Villages: 45
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 19.60 – 28.22 m bgl Post Monsoon: 20.70 – 31.26 m bgl Seasonal Fluctuation: (-)0.70 – (-)1.20m/yr **Aquifer-II &III** Pre Monsoon: 34.11 m bgl Post Monsoon: 35.36 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older 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	0	0	0	1	**1**
WRED/PSTC/WSS	2	0	0	0	**2**
PRIVATE	0	0	0	0	**0**
TOTAL	**2**	**0**	**0**	**1**	**3**

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 (17.52 -104 m)	Quarter-nary Alluvial deposits	Unconfined to confined	65	NA	NA	12 % *(0.072)*	NA
Aquifer-II (120 - 170 m)		Semi confined to Confined	35	NA	NA		NA
Aquifer-III (215 - 300 m)		Semi confined to Confined	30	1028	2074		5.08×10^{-4}

* Well field proposed in adjacent block , NA : Not Available

Source: CGWB,2015 & PSTC,2008

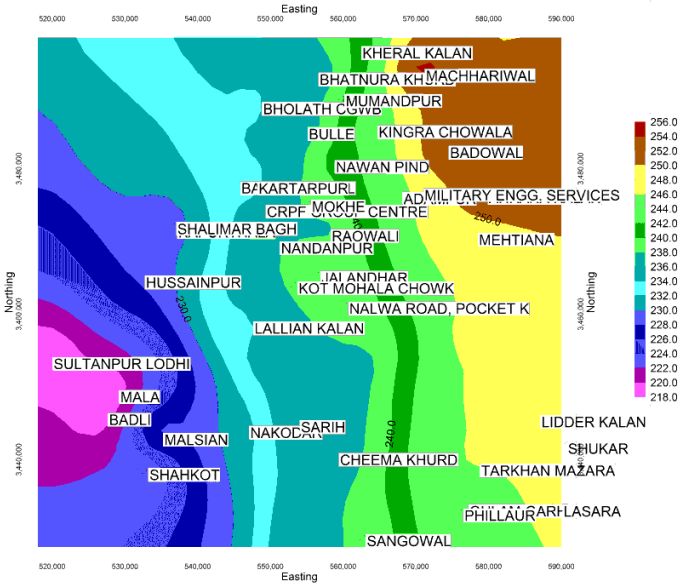
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

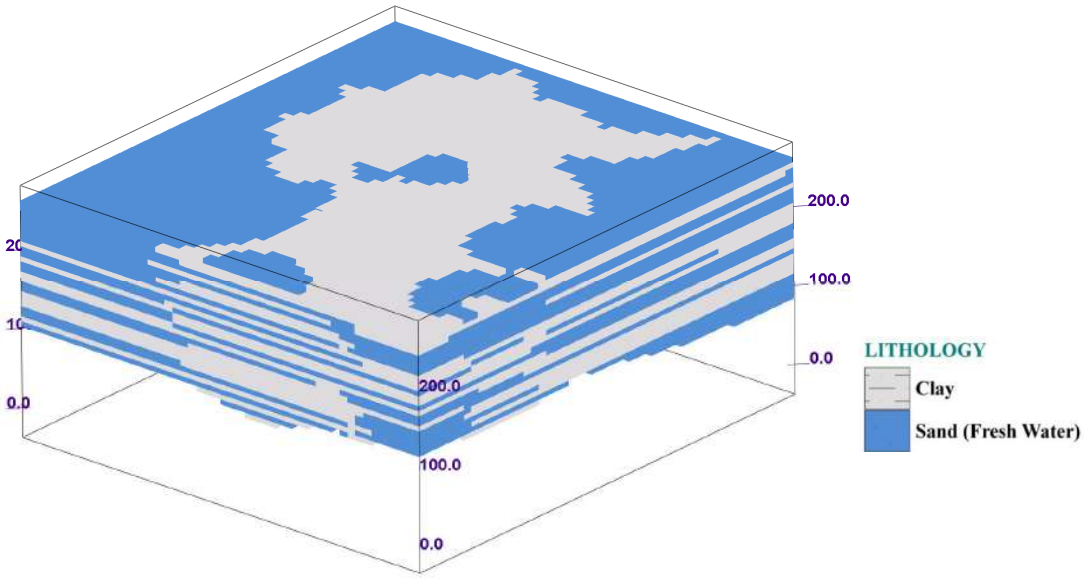
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED/PSTC/WSS	2	0	0	0	**2**
PRIVATE	0	0	0	0	**0**
TOTAL	**2**	**0**	**0**	**1**	**3**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

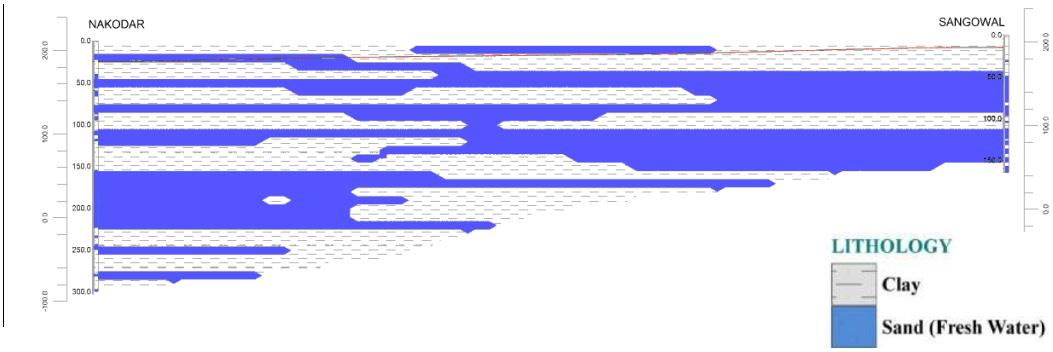
Elevation Map of Rurka Kalan Block



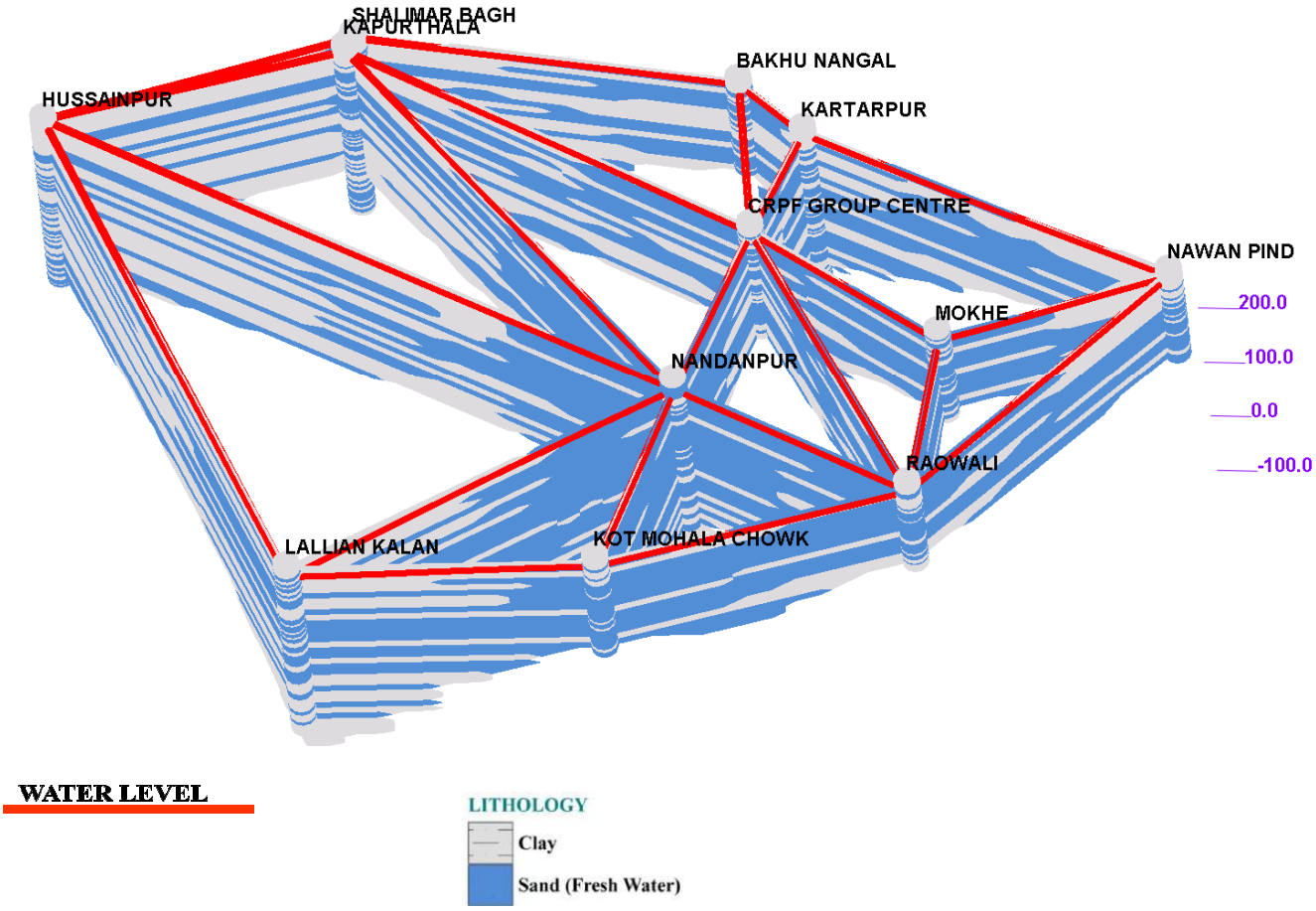
3-D Lithological model of Rurka Kalan Block



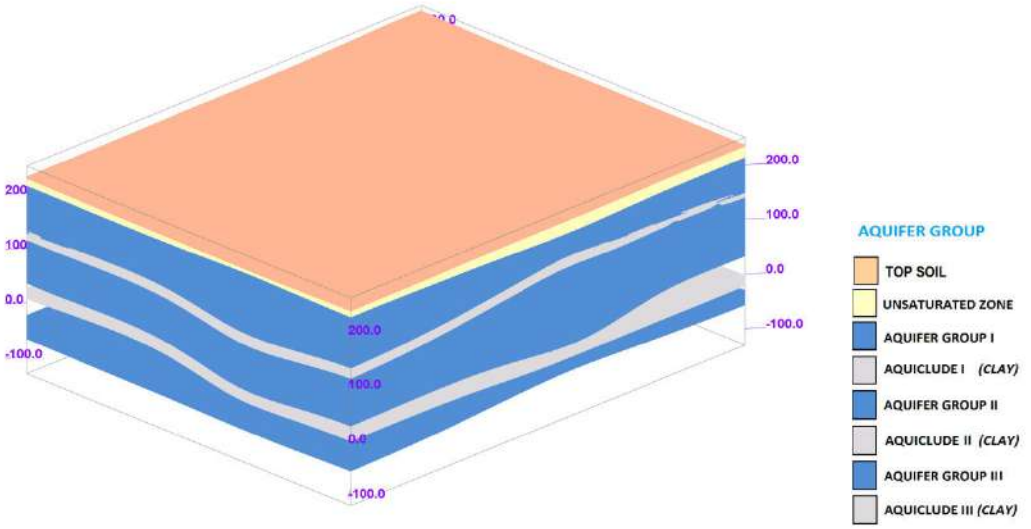
Lithological Cross section from Nakodar to Sangowal



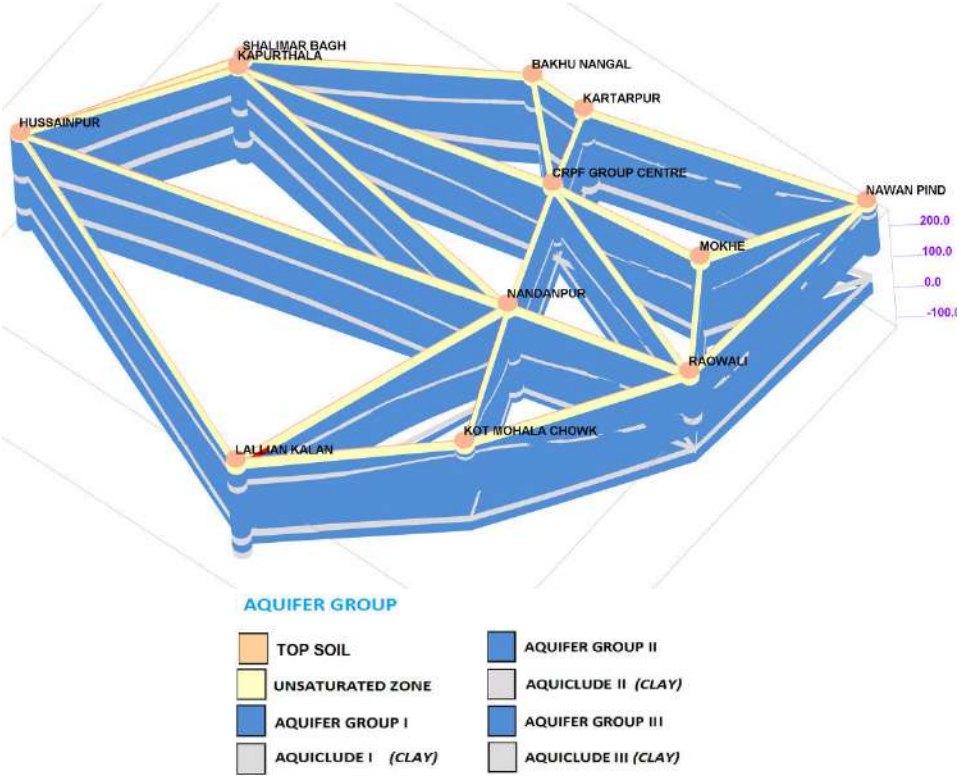
3-D Lithological Fence Diagram



3-D Aquifer Disposition Model of Rurka kalan Block



3-D Aquifer Disposition Fence Diagram



Ground water Resource, Extraction, Contamination and other issues in Rurka kalan Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	105.46 mcm
	In-storage Aquifer-I (Specific Yield Concept)	898 mcm
	In-storage Aquifer-II (Specific Yield Concept)	483 mcm
	In-storage Aquifer-II (Storativity Concept)	17.15 mcm
	In-storage Aquifer-III (Specific Yield Concept)	414 mcm
	In-storage Aquifer-II (Storativity Concept)	18.70 mcm
	Total Resources	1936.50 mcm
Ground Water Extraction (as per 2013)	Irrigation	209.97 mcm
	Domestic & Industrial	2.08 mcm

Future Demand for domestic & Industrial sector (2025) (as per 2013)	2.62 mcm
Stage of Groundwater Development	201 %
Chemical Quality of ground water	Ground water in the area is alkaline in nature and pH values are 8.54 to 8.85. EC value of the ground water is from410 to 1120 µS/cm at 25^0C. RSC value is -0.20 to 3.08meq/L and the area is 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: 48 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 1.74 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Rurka Kalan Block (191.80 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 42.78 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean .The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop*
Area coverage: *39% of the total rice area needs to change i.e.* 51.80 sq km
Anticipated volume of water to be saved: 51.80 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
105.46	209.97	250.22	132	51.80	51.80	158.17	201	49.20	39

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 24

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

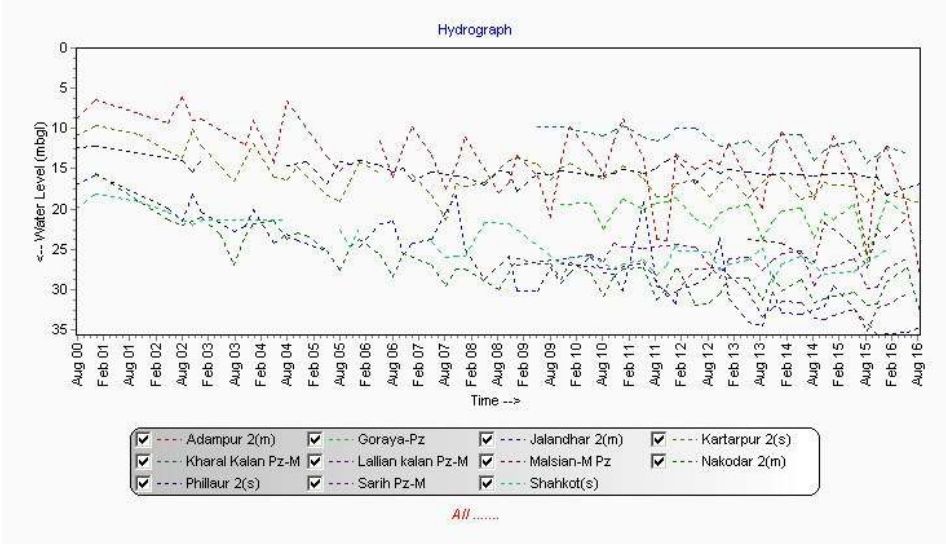
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

IV. Salient Information of Jalandhar East Block

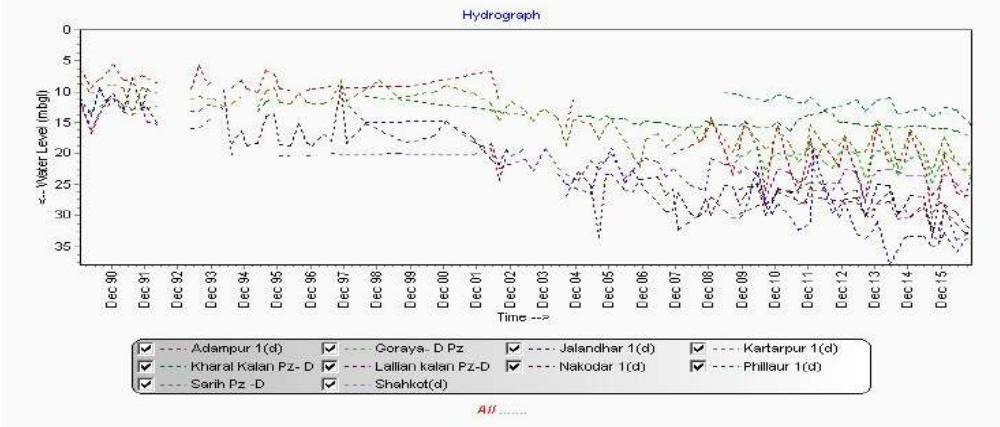
<table>
<tr><td>Block Area
(in Km^2)</td><td>256.20 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 30802
Rural Population: 115952
Total population: 146754</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 531 mm
Non-monsoon Rainfall : 157 mm
Annual Average Rainfall: 688 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Wheat, Rice, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 316.64 sq km
Net sown area: 184.42 sq km
Irrigation practices: Tube well
Cropping intensity: 172%
<u>Area under</u>
Ground water Irrigation: 184.42 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 316.64 sq km
Net Irrigated area: 184.42 sq km
Number and types of abstraction structures: 6269, 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>28.04 – 111.0</td><td>83</td><td>50</td><td>922</td></tr>
<tr><td>Aquifer-II</td><td>140.0 – 250.0</td><td>110</td><td>90</td><td>1666</td></tr>
<tr><td>Aquifer-III</td><td>274.0 – 300.0</td><td>26</td><td>16</td><td>328</td></tr>
</table>
Total Ground Water Resources available is 3011.60 mcm and total potential granular zones available are 156 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 203.96 mcm Domestic and industrial water supply: 29.15 mcm *Future water demands* Irrigation development potential : (-)145.69 mcm Domestic and industrial water supply up to 2025 years : 37.11 mcm Water Scarcity Villages: 90
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 26.60 – 35.18 m bgl Post Monsoon: 29.10 – 33.62 m bgl Seasonal Fluctuation: (-)1.10 – (-)3.10 m/yr **Aquifer-II &III** No Monitoring Stations

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older 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	0	0	1	0	**1**
WRED/PSTC/WSS	5	14	1	1	**21**
PRIVATE	0	6	1	1	**8**
TOTAL	**5**	**20**	**3**	**2**	**30**

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 (28.04 -111 m)	Quarter-nary Alluvial deposits	Unconfined to confined	50	NA	NA	12 % *(0.072)*	NA
Aquifer-II (140 - 250 m)		Semi confined to Confined	90				
Aquifer-III (274 - 300 m)		Semi confined to Confined	16	NA	NA	NA	NA

* Well field proposed in adjacent block , NA : Not Available

Source: CGWB,2015 & PSTC,2008

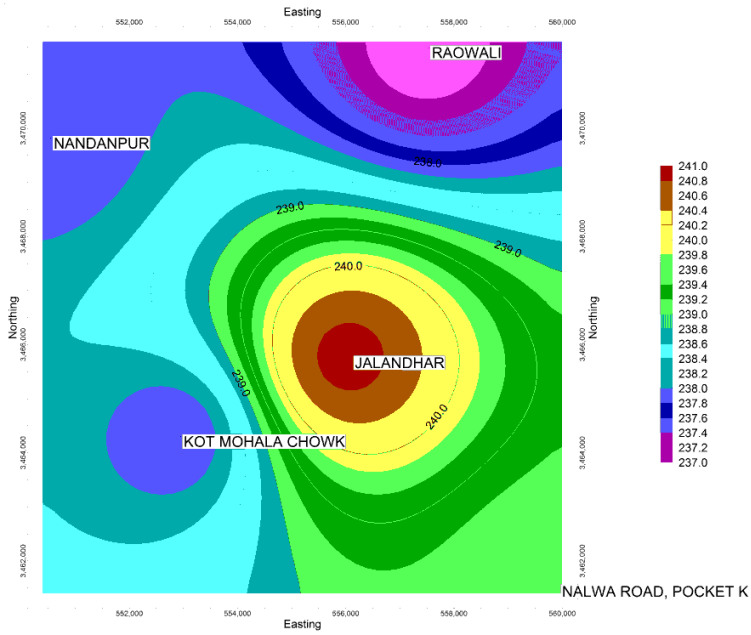
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

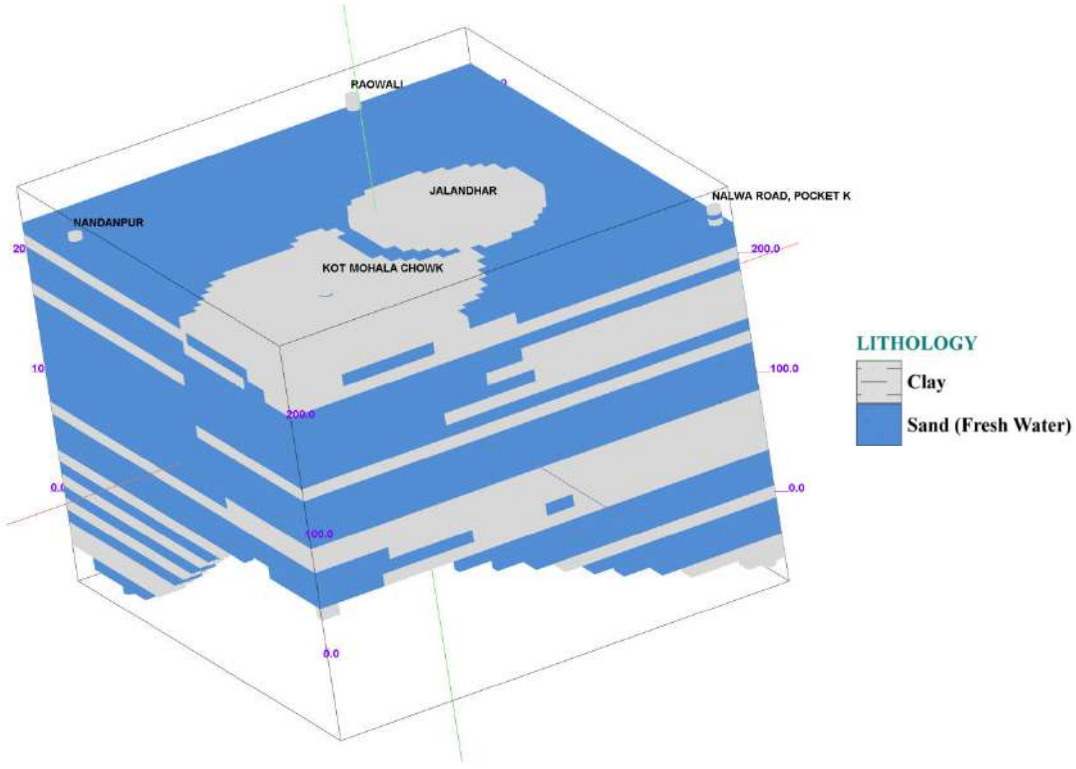
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED/PSTC/WSS	0	0	0	0	**0**
PRIVATE	0	0	1	1	**2**
TOTAL	**0**	**0**	**1**	**2**	**3**

The data is validated by selecting the deepest well in each quadrant (elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

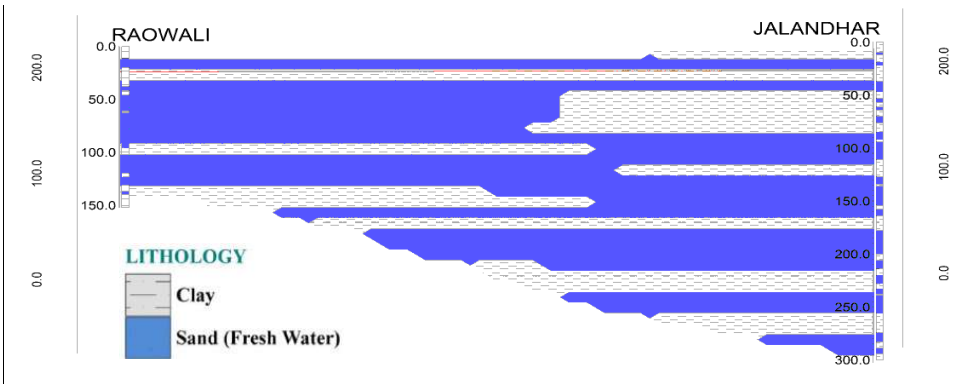
Elevation Map of Jalandhar East Block



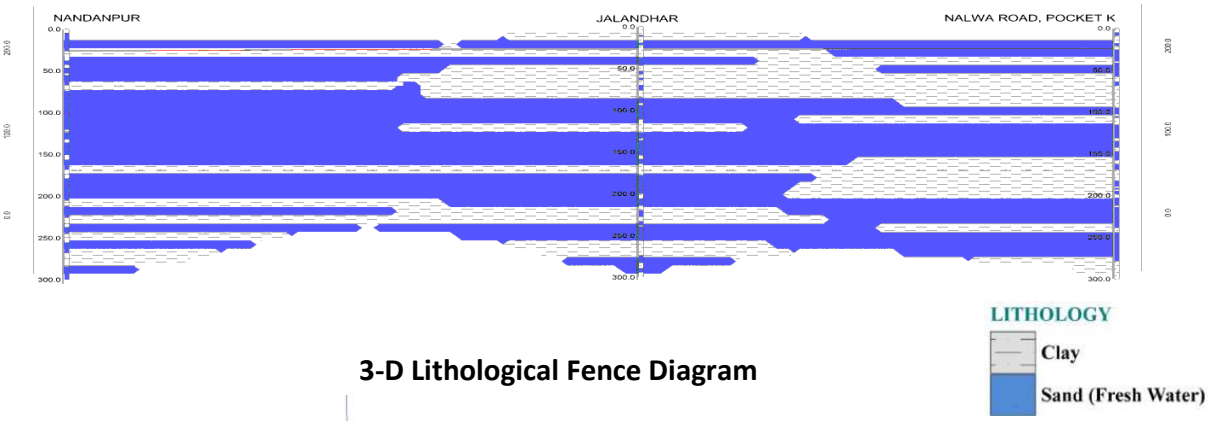
3-D Lithological model of Jalandhar East Block



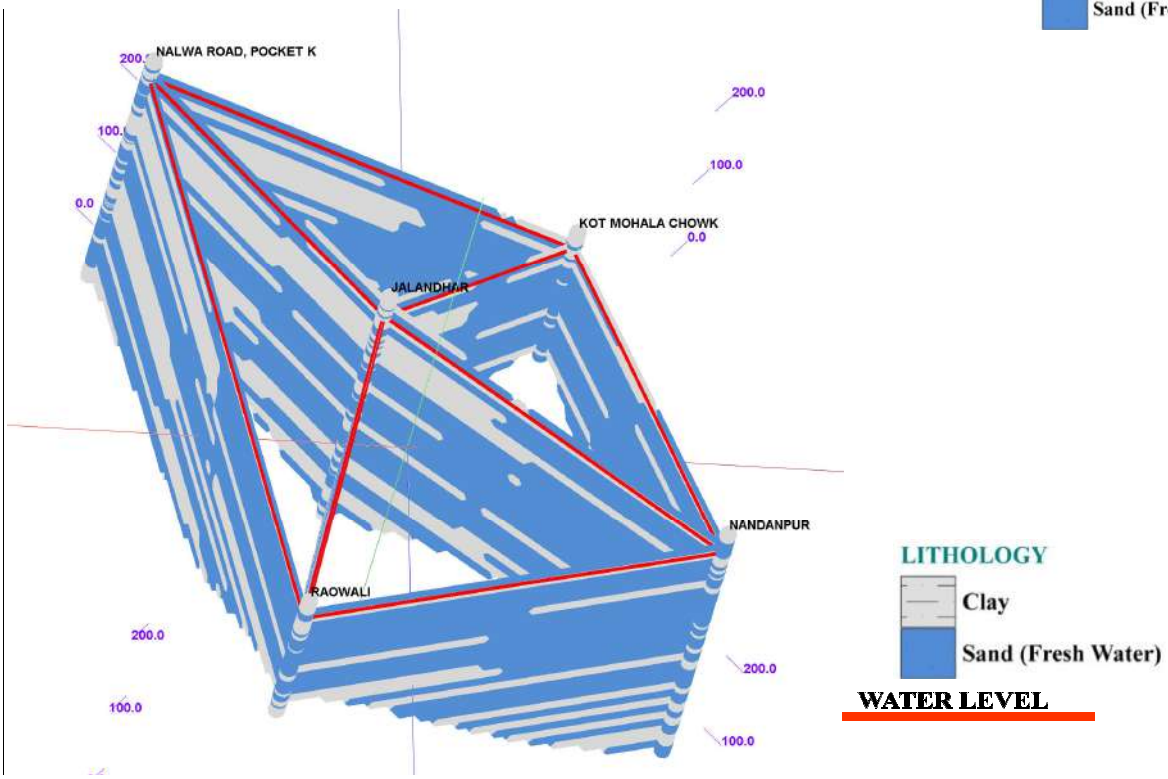
Lithological Cross section from Raowali to Jalandhar



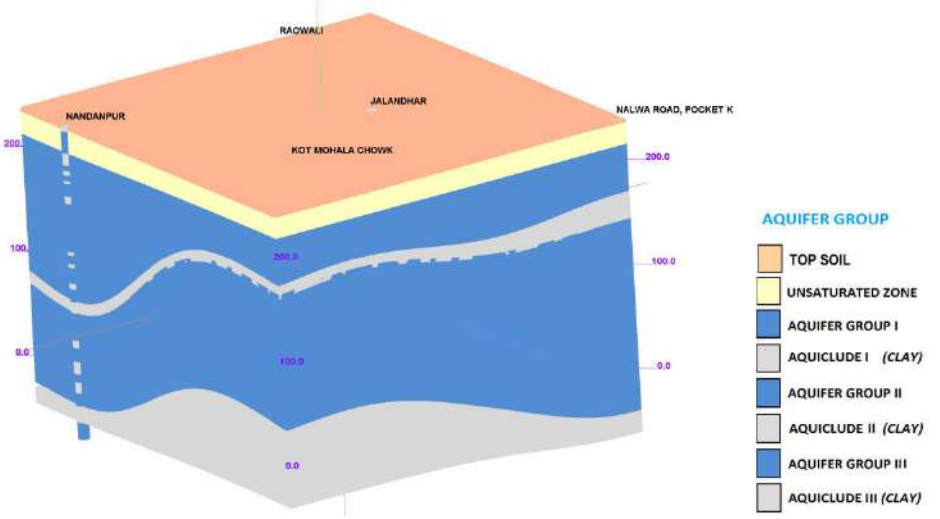
Lithological Cross section from Nandanpur to Nalwa



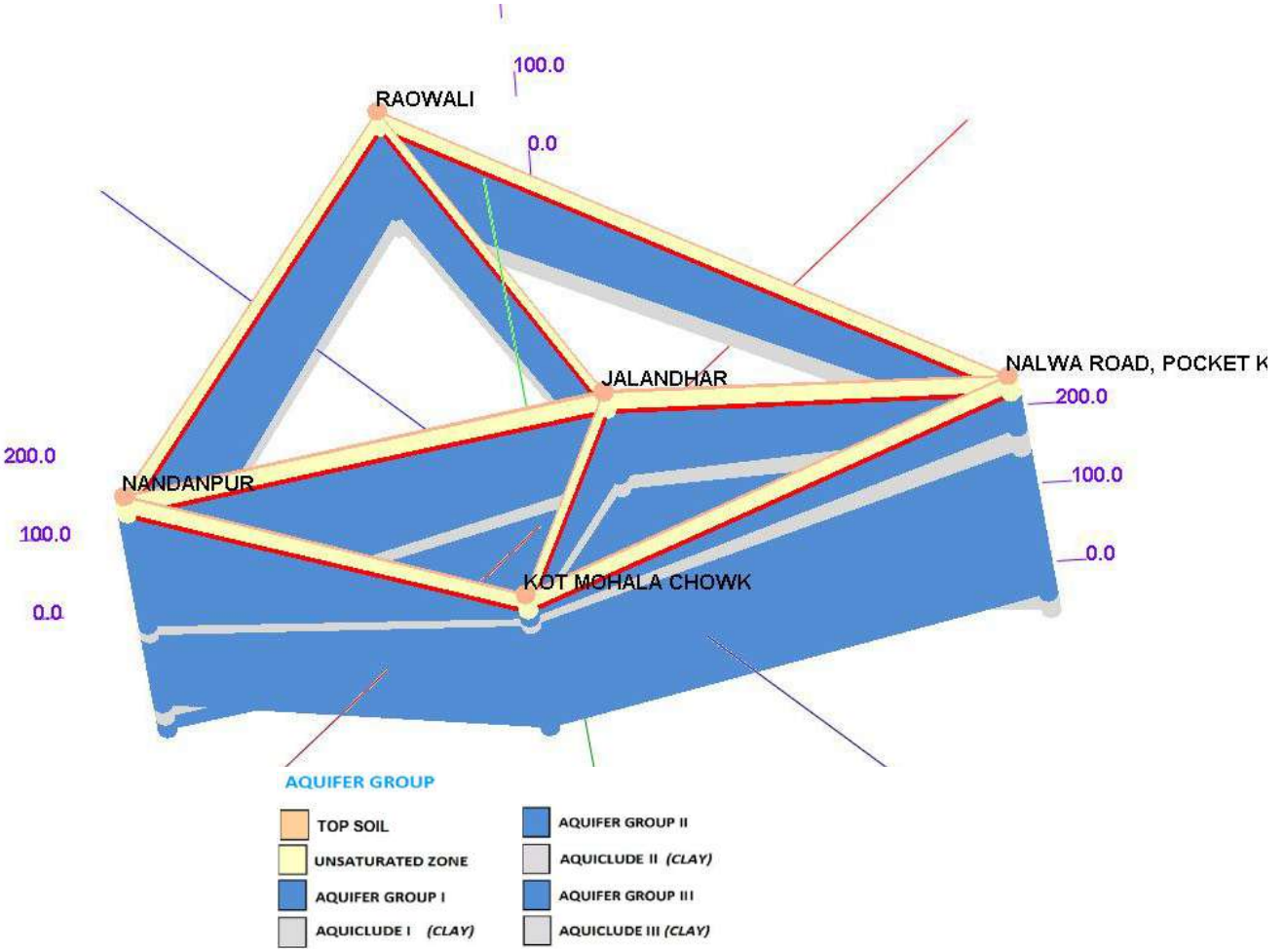
3-D Lithological Fence Diagram



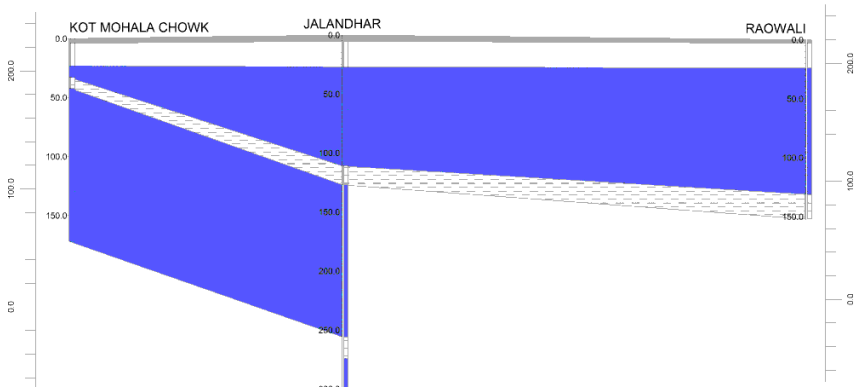
3-D Aquifer Disposition Model of Jalandhar East Block



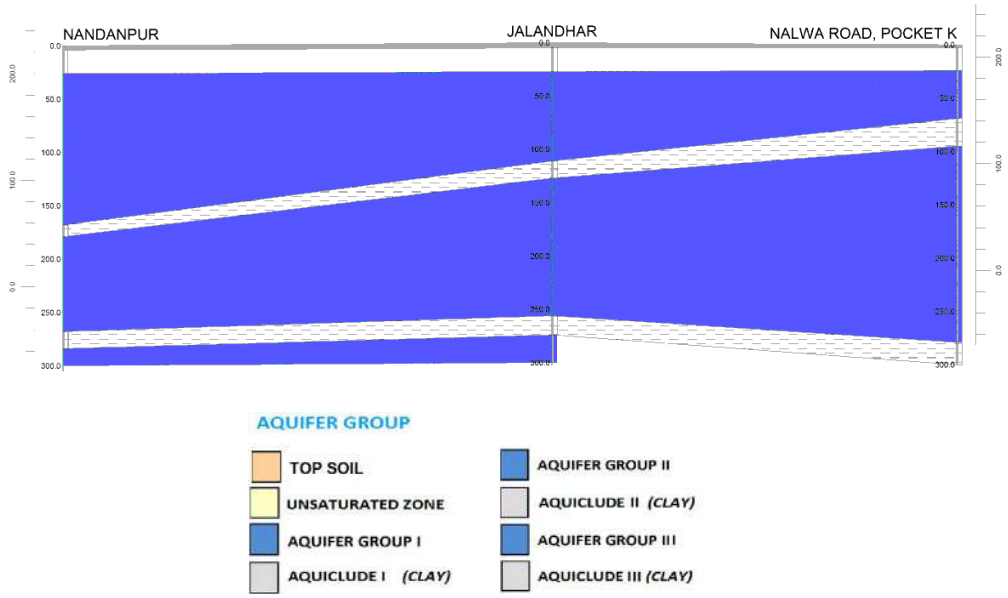
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along South West to North East



Aquifer Cross section along North West to South East



Ground water Resource, Extraction, Contamination and other issues in Jalandhar East Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	95.38 mcm
	In-storage Aquifer-I (Specific Yield Concept)	922 mcm
	In-storage Aquifer-II (Specific Yield Concept)	1660 mcm
	In-storage Aquifer-II (Storativity Concept)	5.92 mcm
	In-storage Aquifer-III (Specific Yield Concept)	295 mcm

	In-storage Aquifer-II (Storativity Concept)	32.60 mcm
	Total Resources	3011.60 mcm
Ground Water Extraction (as per 2013)	Irrigation	203.96 mcm
	Domestic & Industrial	29.15 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		37.11 mcm
Stage of Groundwater Development		244 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature and pH value is 8.52 .EC value of the ground water is 415 µS/cm at 25^0C. RSC value is 1.62 meq/L and the area is fit for irrigation.
Ground water Contamination Issues		Not Available (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: 76 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 2.25 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Jalandhar east Block (256.20 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 41.55 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean .The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop*
Area coverage:*72% of the total rice area needs to change i.e.* 75.90 sq km

Anticipated volume of water to be saved: 75.90 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
95.4	203.96	233.10	106	75.90	75.90	127.64	244	80	72

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 31

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

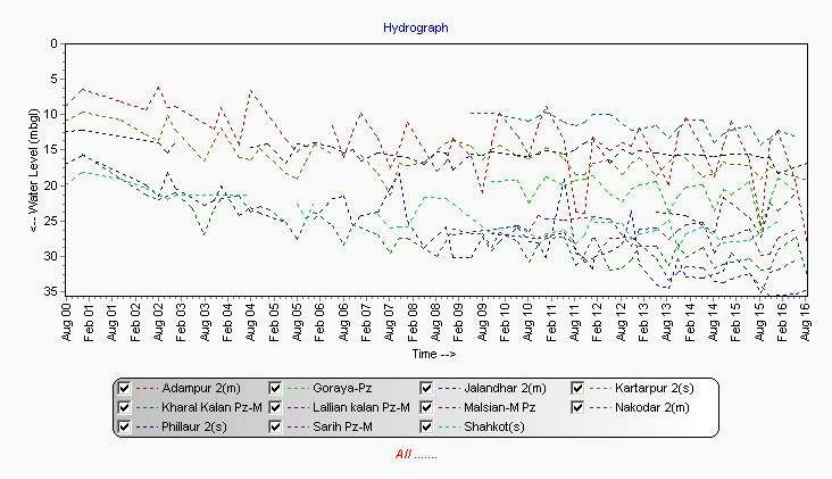
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

V. Salient Information of Jalandhar West Block

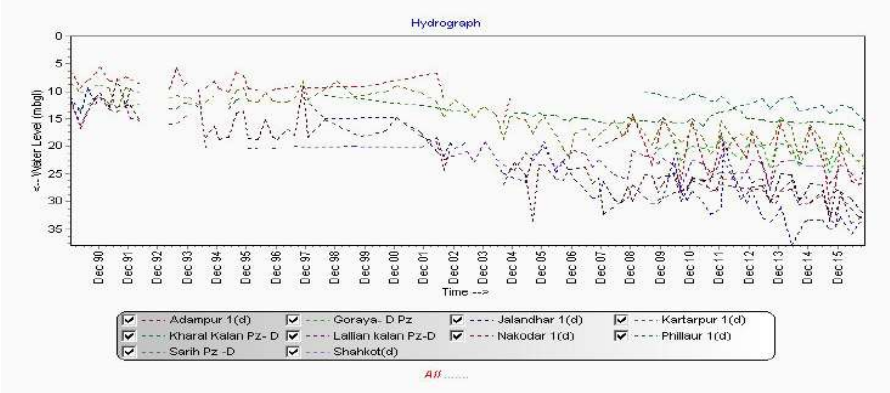
<table>
<tr><td>Block Area
(in Km^2)</td><td>338.90 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 11708
Rural Population: 127332
Total population: 139040</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 565 mm
Non-monsoon Rainfall : 174 mm
Annual Average Rainfall: 739 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 433.37 sq km
Net sown area: 279.46 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 155%
<u>Area under</u>
Ground water Irrigation: 279.46 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 433.47 sq km
Net Irrigated area: 279.46 sq km
Number and types of abstraction structures: 9605, 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 205 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>15.08 – 156.0</td><td>141</td><td>60</td><td>947.57</td></tr>
<tr><td>Aquifer-II</td><td>170.0 – 268.0</td><td>98</td><td>82</td><td>2010</td></tr>
<tr><td>Aquifer-III</td><td>276.0 – 300.0</td><td>24</td><td>18</td><td>479</td></tr>
</table>
Total Ground Water Resources available is 4130.50 mcm and total potential granular zones available are 130 m up to depth of 205 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 314.50 mcm Domestic and industrial water supply: 9.74 mcm *Future water demands* Irrigation development potential : (-)149.49 mcm Domestic and industrial water supply up to 2025 years : 12.38 mcm Water Scarcity Villages: 136
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 18.76 – 32.70 m bgl Post Monsoon: 18.64 – 34.50 m bgl Seasonal Fluctuation: (-)1.45 – (-)6.30 m/yr **Aquifer-II &III** Pre Monsoon: 33.62 m bgl Post Monsoon: 35.18 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	0	0	**0**
WRED/PSTC/WSS	4	9	1	0	**14**
PRIVATE	0	3	1	0	**4**
TOTAL	**4**	**12**	**2**	**0**	**18**

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 (15.08 -156 m)	Quarter-nary Alluvial deposits	Unconfined to confined	60	NA	NA	12 % *(0.072)*	NA
Aquifer-II (170 - 268 m)		Semi confined to Confined	82				
Aquifer-III (276 - 300 m)		NA	18	NA	NA	NA	NA

* Well field proposed in adjacent block , NA : Not Available

Source: Groundwater Exploration Report, CGWB,2015

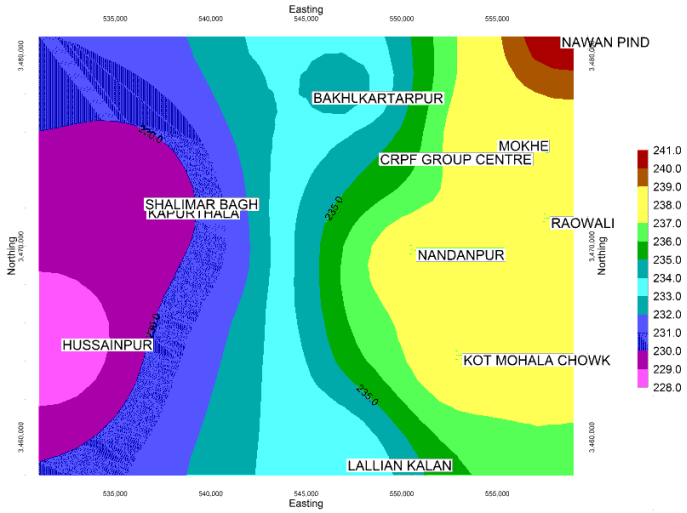
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

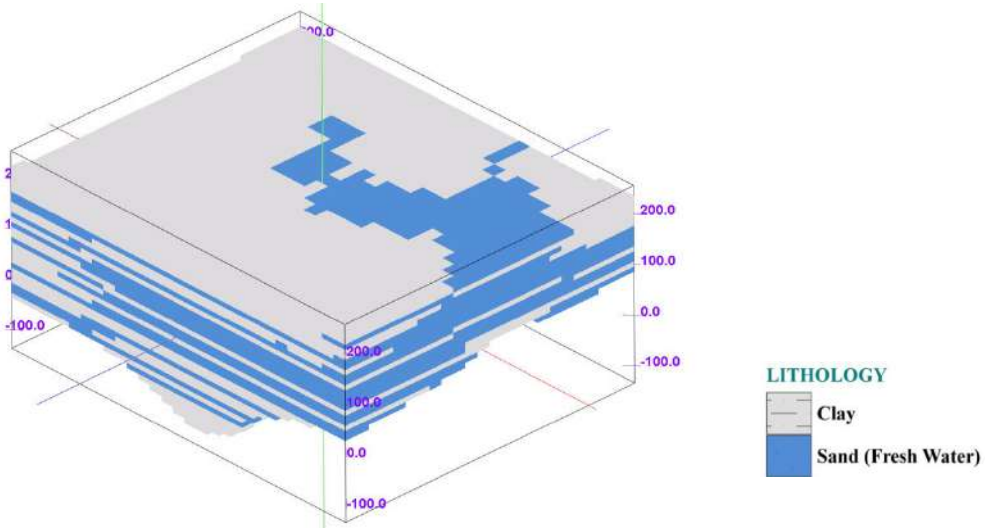
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED/PSTC/WSS	0	0	1	0	**1**
PRIVATE	0	3	2	0	**5**
TOTAL	**0**	**3**	**3**	**1**	**7**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

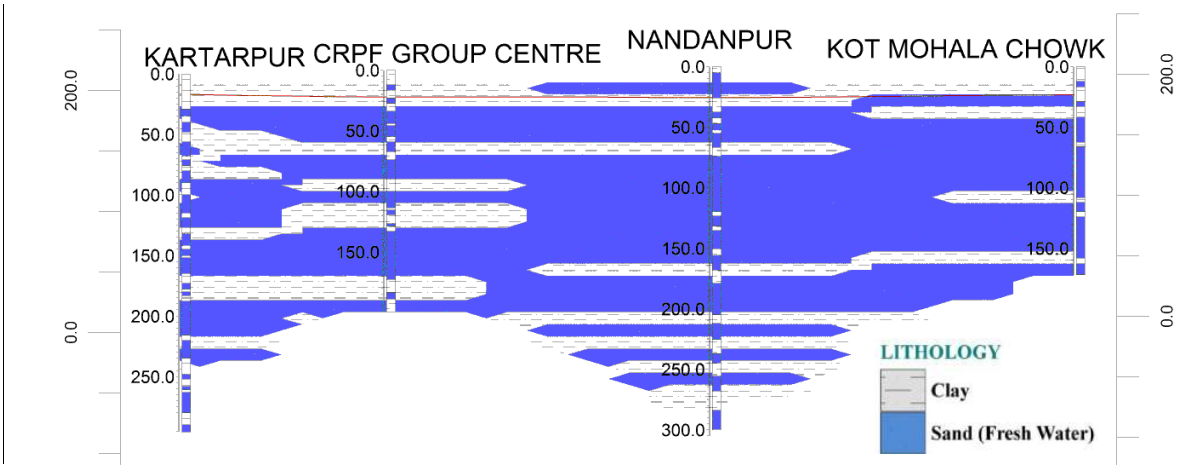
Elevation Map of Jalandhar West Block



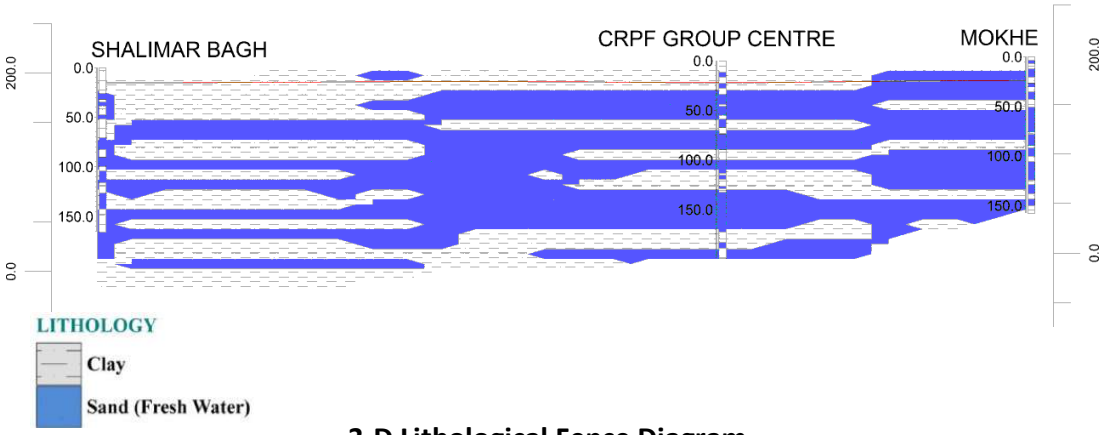
3-D Lithological model of Jalandhar West Block



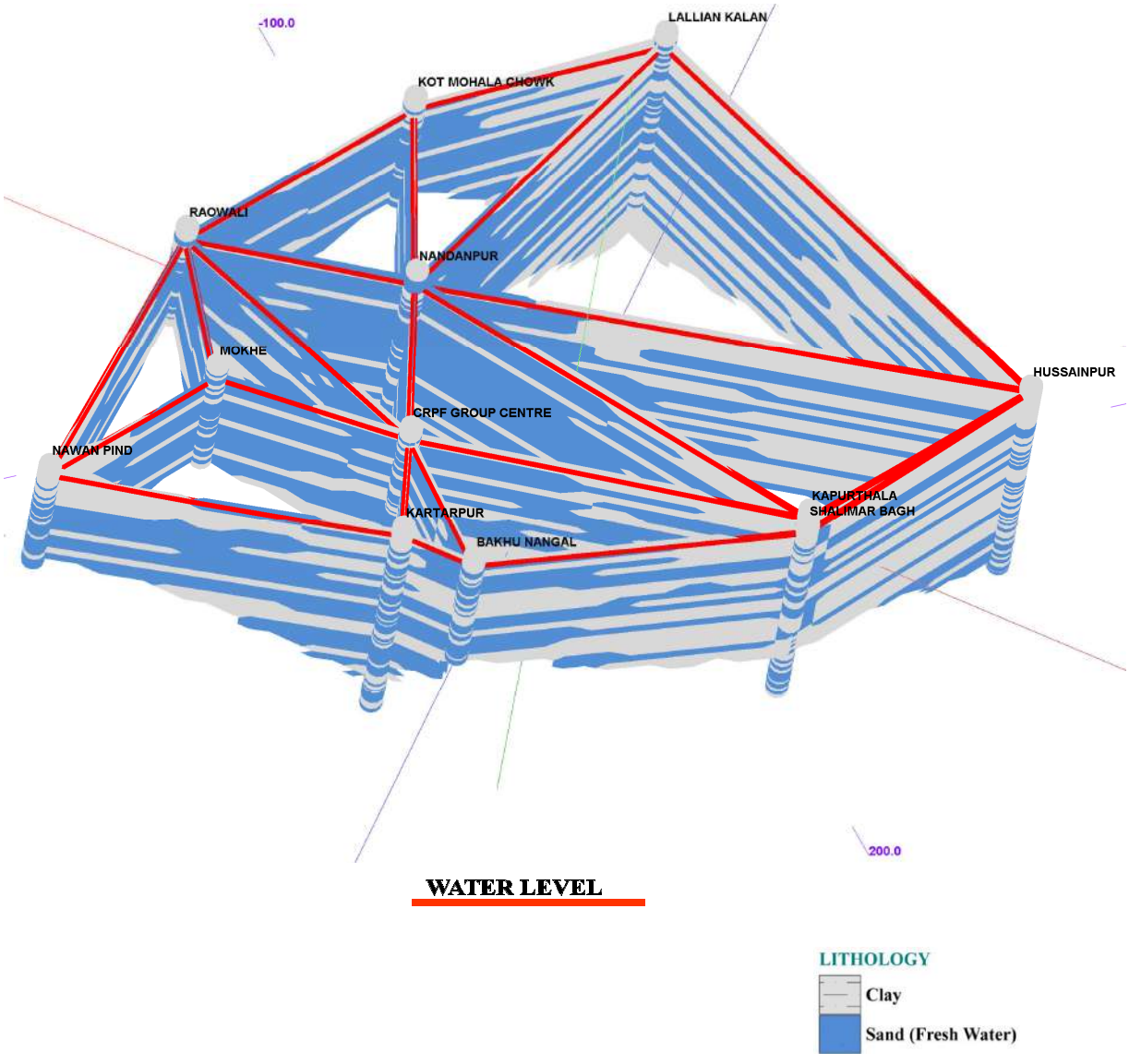
Lithological Cross section from Kartarpur to Kot Mohala



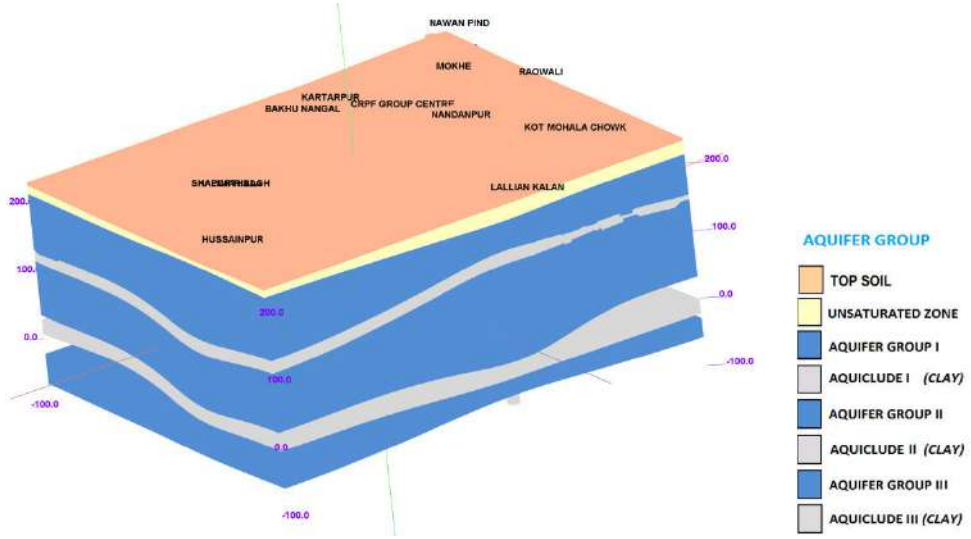
Lithological Cross section from Shalimar Bagh to Mokhe



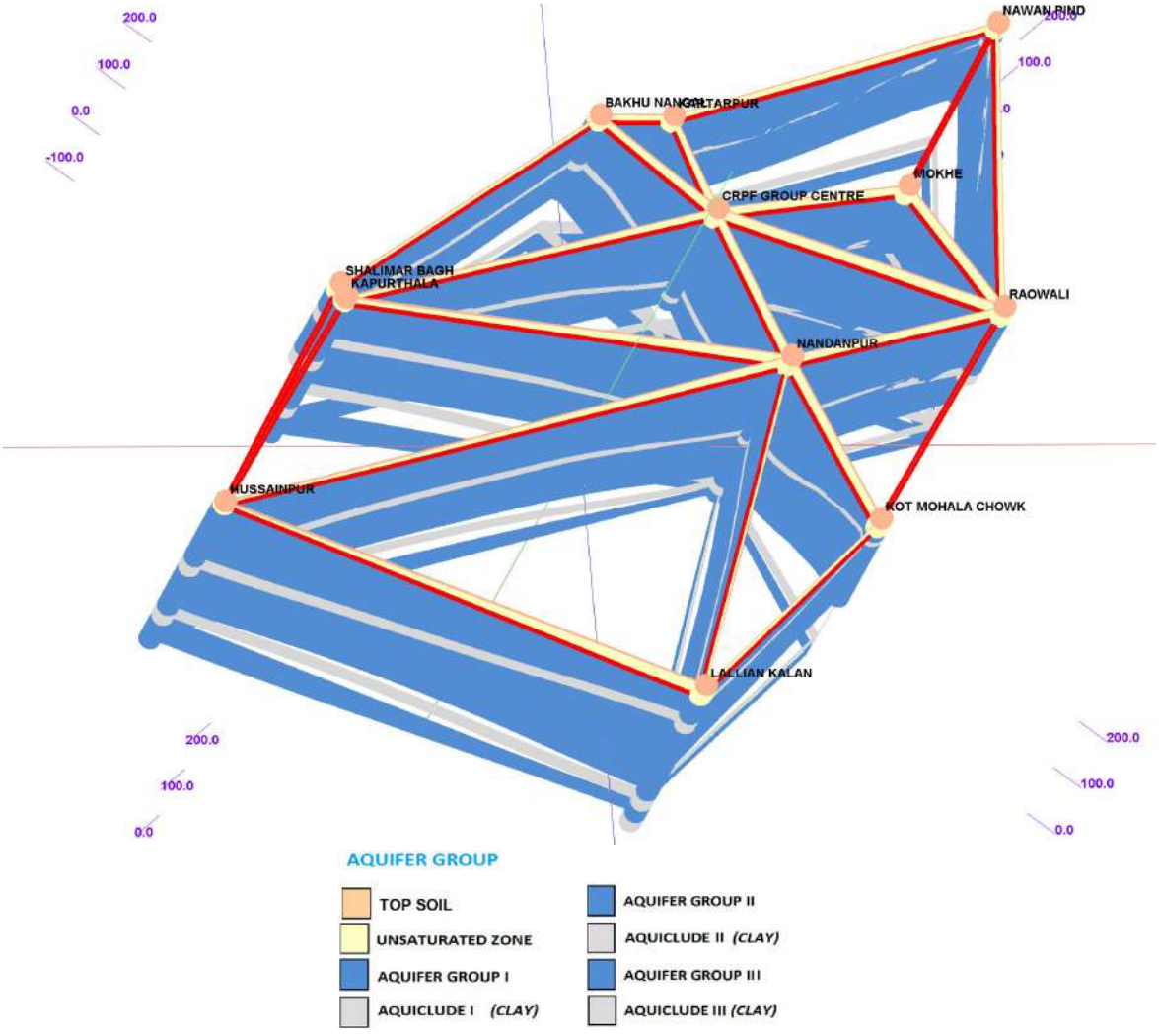
3-D Lithological Fence Diagram



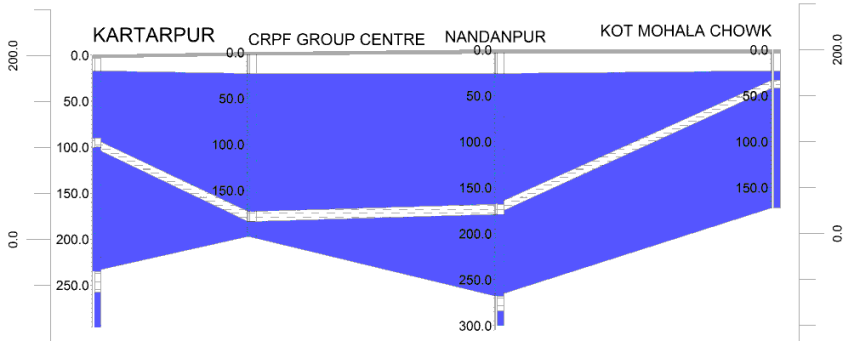
3-D Aquifer Disposition Model of Jalandhar West Block



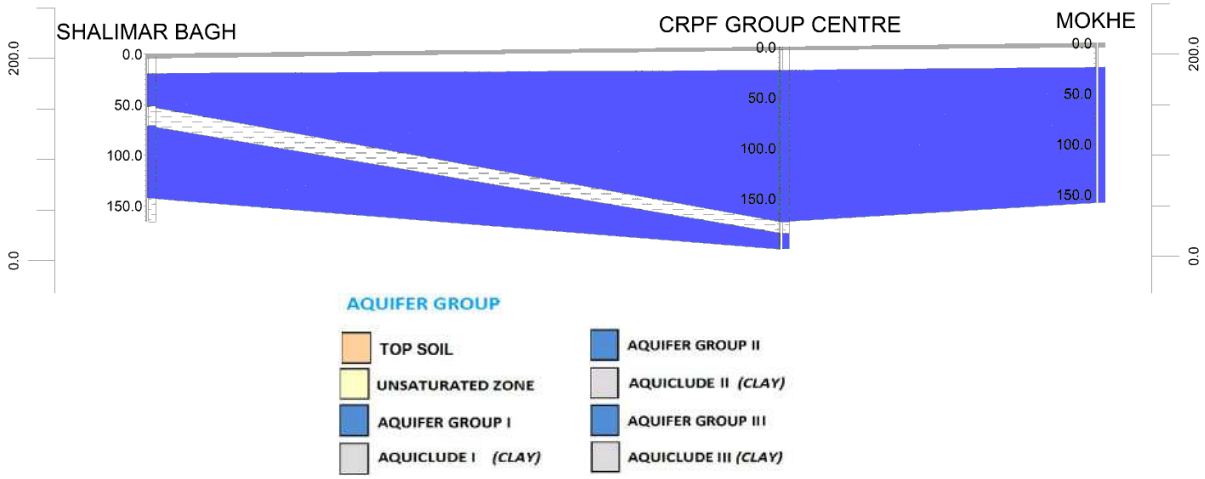
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Kartar pur to Kot Mohalla



Aquifer Cross section along Shalimar Bagh to Mokhe



Ground water Resource, Extraction, Contamination and other issues in Jalandhar West Block

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	177.40 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1464 mcm
	In-storage Aquifer-II (Specific Yield Concept)	2001 mcm
	In-storage Aquifer-II (Storativity Concept)	8.86 mcm
	In-storage Aquifer-III (Specific Yield Concept)	439 mcm
	In-storage Aquifer-II (Storativity Concept)	40.1 mcm
	Total Resources	4130.50 mcm
Ground Water Extraction (as per 2013)	Irrigation	314.50 mcm
	Domestic & Industrial	9.74 mcm

Future Demand for domestic & Industrial sector (2025) (as per 2013)	12.38 mcm
Stage of Groundwater Development	183 %
Chemical Quality of ground water	Ground water in the area is alkaline in nature pH values are from 8.10 to 8.28, EC value of the ground water are from 400 to 560 µS/cm at 25^0C. RSC values are varying from (-)2.60 is (-) 0.27 meq/L and the area is fit for irrigation..
Ground water Contamination Issues	Not Available (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: 91 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 2.78 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Jalandhar West Block (338.9 sq km)

Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 64.07 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean.*

The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop

Area coverage: *32% of the total rice area needs to change i.e.* 63.0 sq km

Anticipated volume of water to be saved: 63.0 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
177.40	314.50	324.20	200	63	63	143.14	183	35.50	32

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 34

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

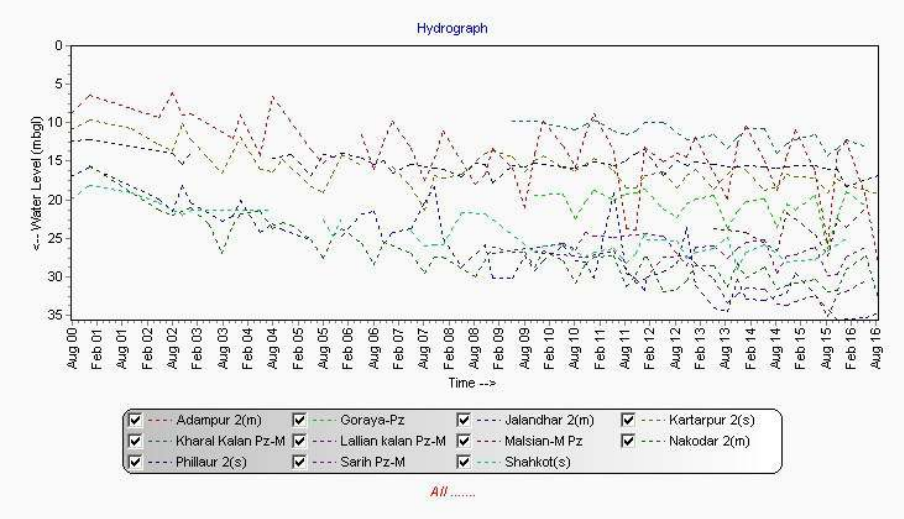
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

VI. Salient Information of Lohian Block

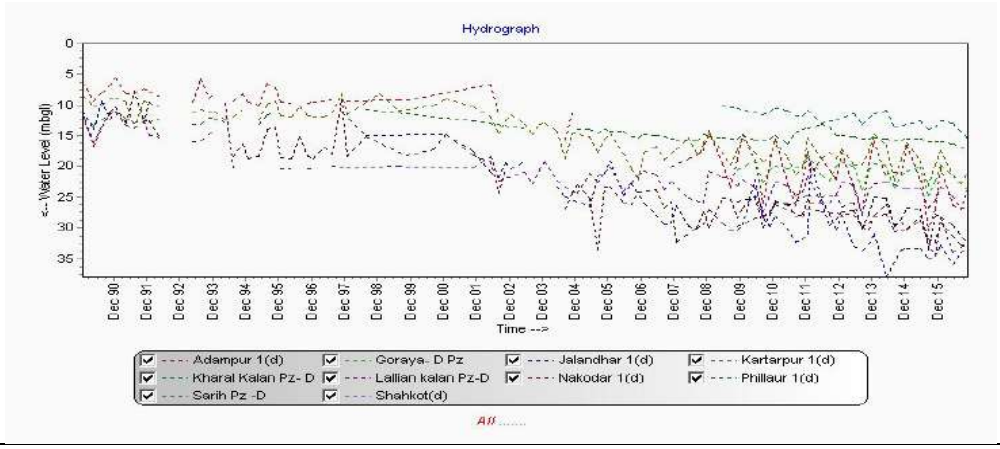
<table>
<tr><td>Block Area
(in Km^2)</td><td>280.30 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 0
Rural Population: 59846
Total population: 59846</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 454 mm
Non-monsoon Rainfall : 103 mm
Annual Average Rainfall: 557 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 332.71 sq km
Net sown area: 176.77 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 188%
<u>Area under</u>
Ground water Irrigation: 176.7 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 332.71 sq km
Net Irrigated area: 176.77 sq km
Number and types of abstraction structures: 6880, 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 205 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>13.13 – 96.0</td><td>83</td><td>65</td><td>1413.6</td></tr>
<tr><td>Aquifer-II</td><td>105.0 – 180.0</td><td>75</td><td>30</td><td>629</td></tr>
<tr><td>Aquifer-III</td><td>205.0 – 300.0</td><td>95</td><td>50</td><td>1031</td></tr>
</table>
Total Ground Water Resources available is 3073.8 mcm and total potential granular zones available are 145 m up to depth of 205 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 215.01 mcm Domestic and industrial water supply: 1.46 mcm *Future water demands* Irrigation development potential : (-)115.02 mcm Domestic and industrial water supply up to 2025 years : 1.82 mcm Water Scarcity Villages: 85
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 9.60 – 32.40 m bgl Post Monsoon: 10.75 – 33.15 m bgl Seasonal Fluctuation: (-)1.15 – (-)1.55 m/yr **Aquifer-II &III** No Monitoring Stations

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	0	0	**0**
WRED/PSTC/WSS	4	9	1	0	**14**
PRIVATE	0	3	1	0	**4**
TOTAL	**4**	**12**	**2**	**0**	**18**

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 (13.13 -96 m)	Quarter-nary Alluvial deposits	Unconfined to confined	65	NA	NA	12 % *(0.072)*	NA
Aquifer-II (105 - 180 m)		Semi confined to Confined	30				
Aquifer-III (205 - 300 m)		NA	50	1709	2300	NA	NA

* Well field proposed in adjacent block , NA : Not Available

Source: Groundwater Exploration Report, CGWB,2015

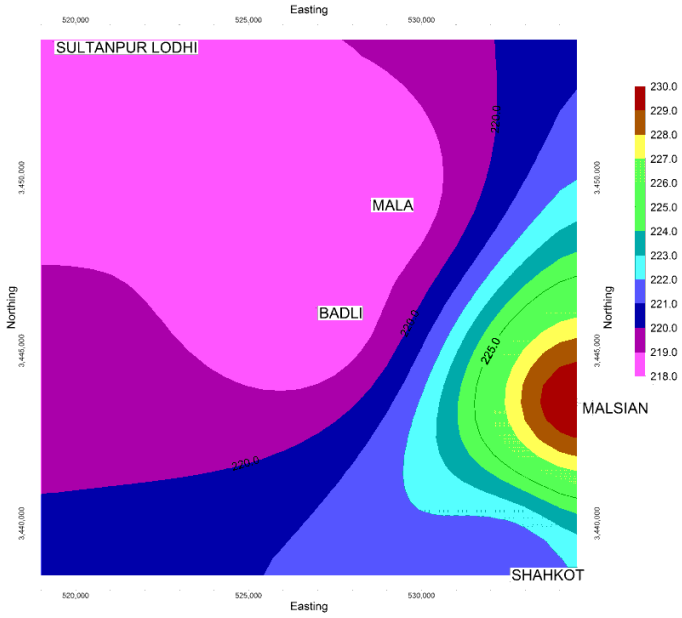
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

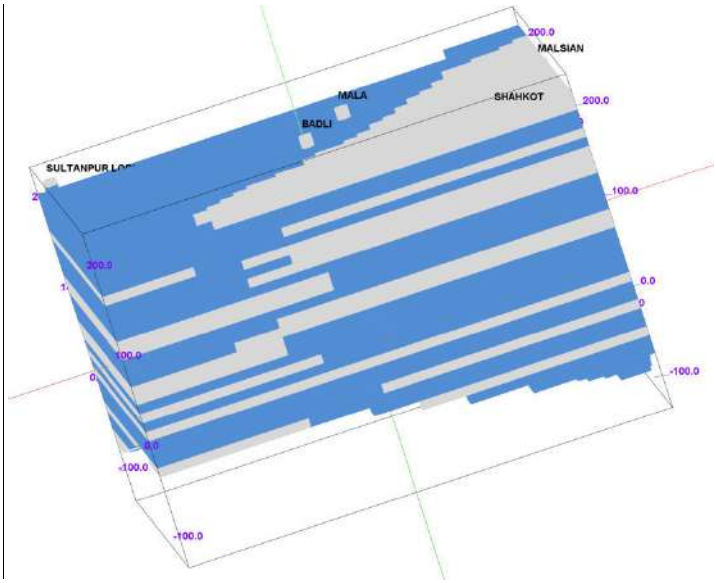
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED/PSTC/WSS	1	0	0	0	**1**
PRIVATE	0	1	0	0	**1**
TOTAL	**1**	**1**	**0**	**1**	**3**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

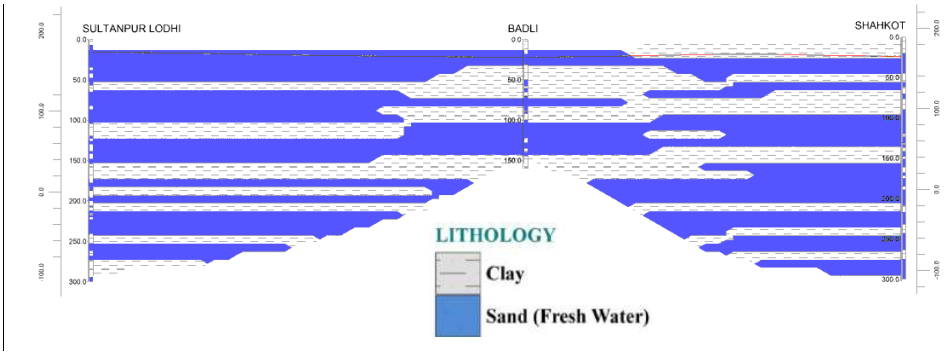
Elevation Map of Lohian Block



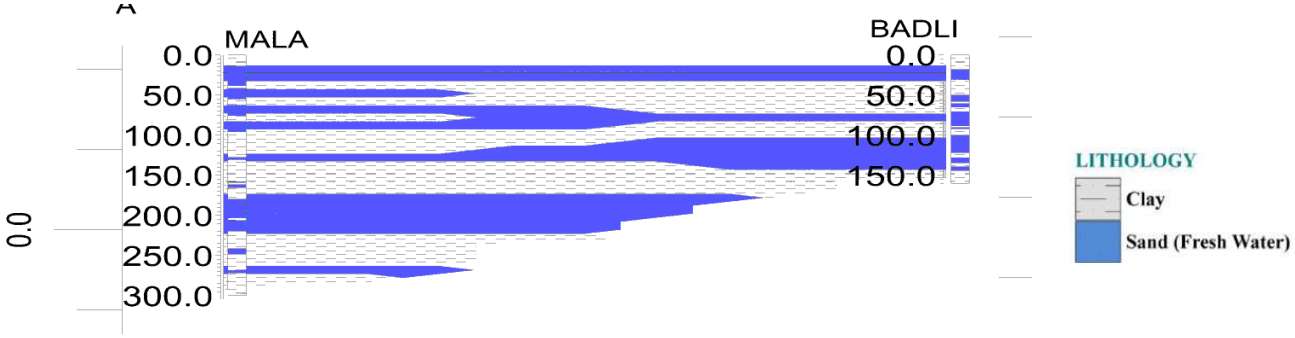
3-D Lithological model of Lohian Block



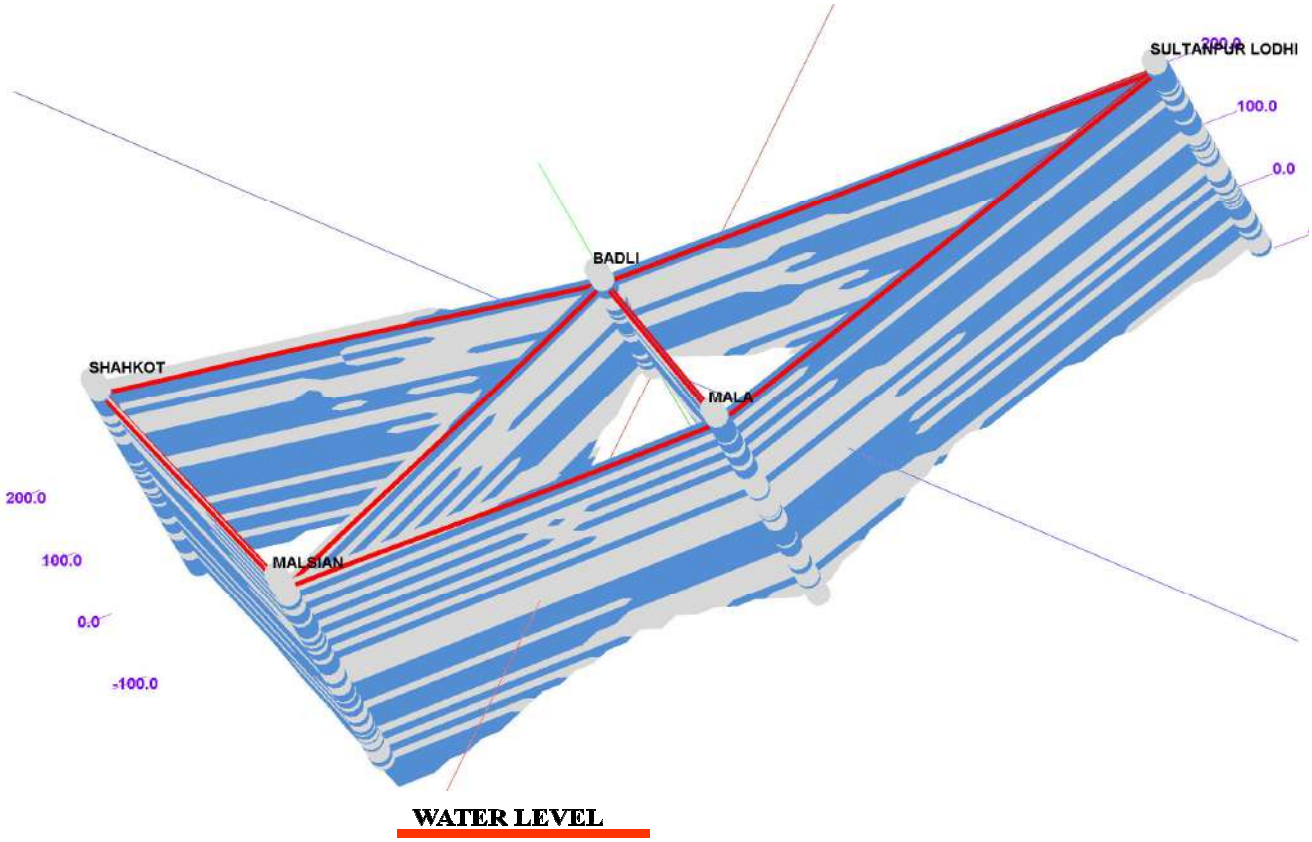
Lithological Cross section from Sultanpur to Shahkot

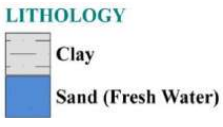


Lithological Cross section from Malla to Badli

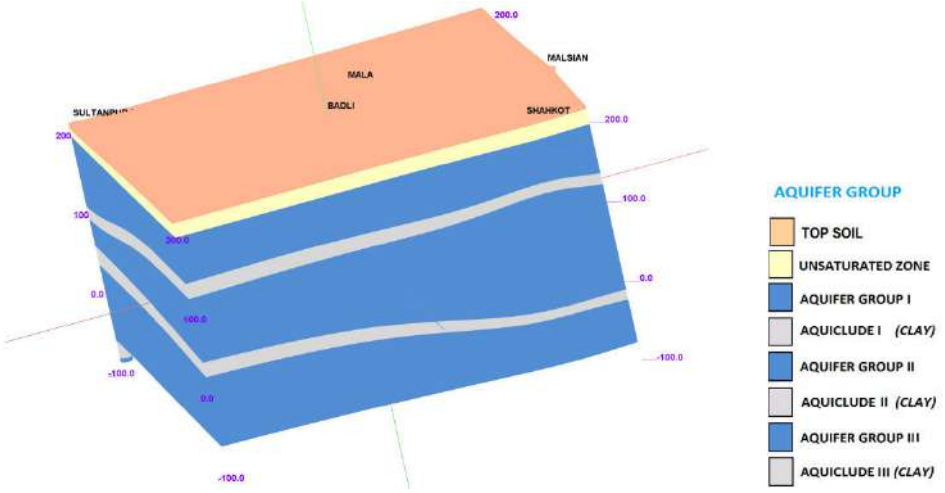


3-D Lithological Fence Diagram

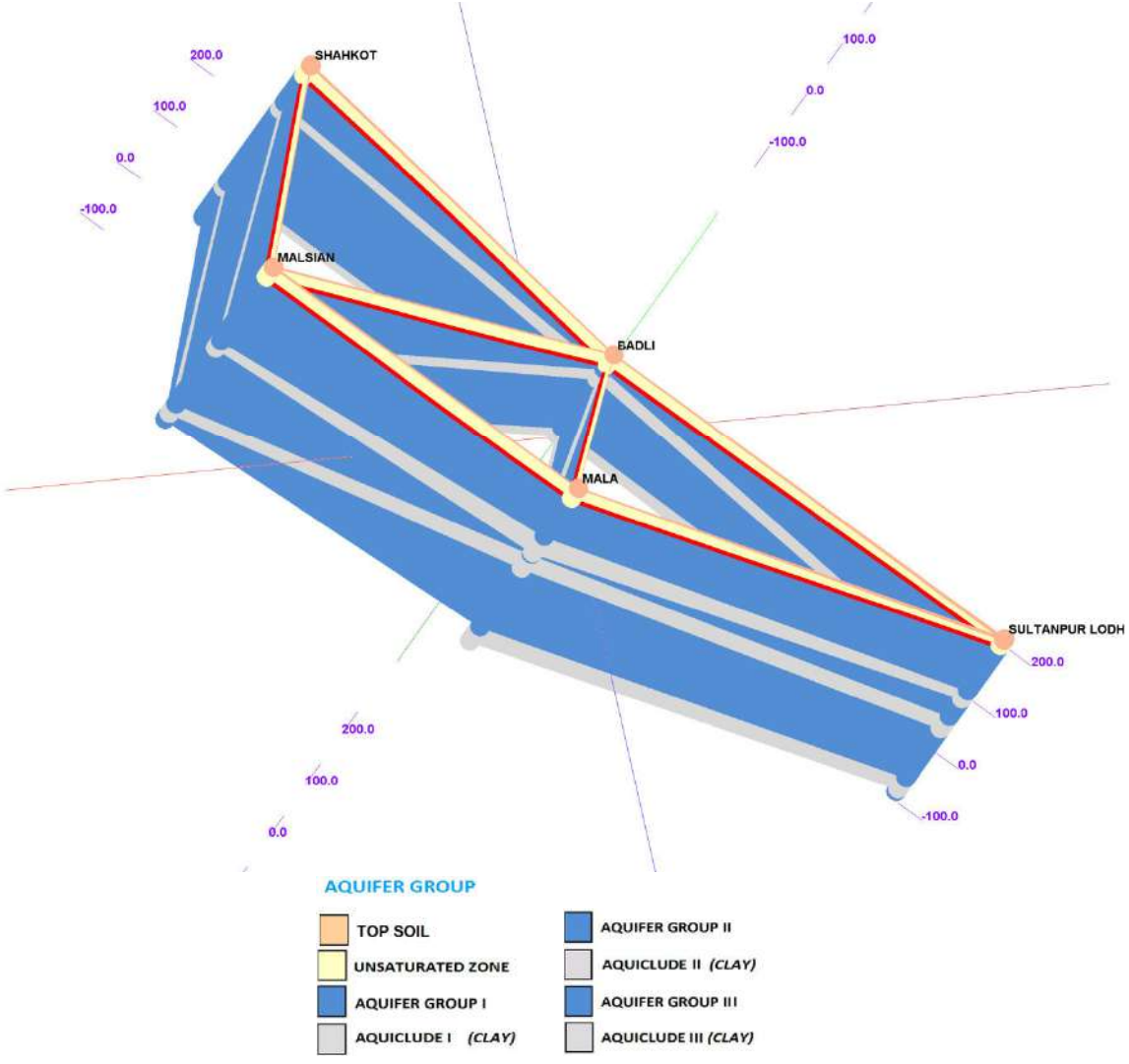




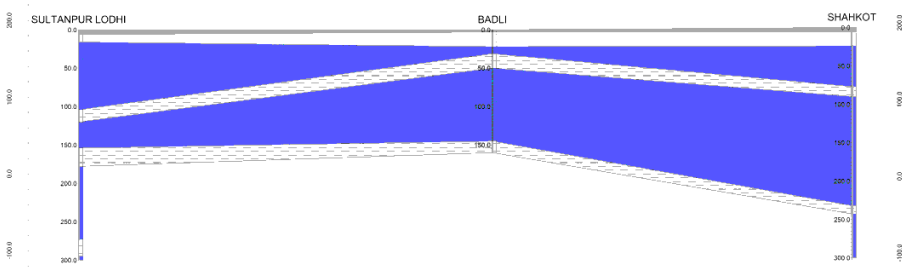
3-D Aquifer Disposition Model of Lohian Block



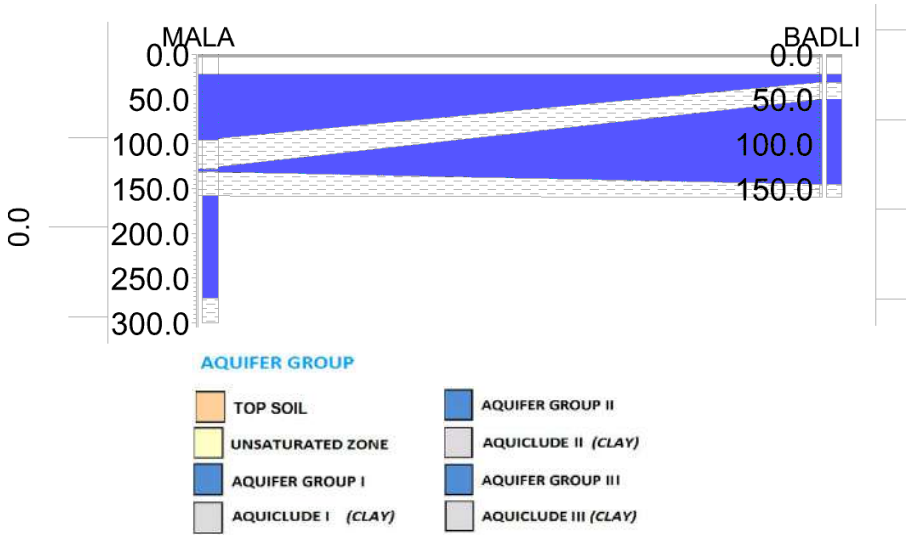
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along North West to South East



Aquifer Cross section along Malla to Badli



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	101.82 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1312 mcm
	In-storage Aquifer-II (Specific Yield Concept)	605 mcm
	In-storage Aquifer-II (Storativity Concept)	23.35 mcm
	In-storage Aquifer-III (Specific Yield Concept)	1009 mcm
	In-storage Aquifer-II (Storativity Concept)	22.30 mcm
	Total Resources	3073.80 mcm
Ground Water	Irrigation	215.01 mcm

Extraction (as per 2013)	Domestic & Industrial	1.46 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		1.82 mcm
Stage of Groundwater Development		213 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature, suitable for drinking and is fit for irrigation.
Ground water Contamination Issues		Not Available (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: 77 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 1.75 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Lohian Block (280.30 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 43.80 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean.*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *37% of the total rice area needs to change i.e.* 58.80 sq km
Anticipated volume of water to be saved: 58.8 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
101.82	215.01	216.47	161	58.8	58.8	156.25	213	35.50	37

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 17

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

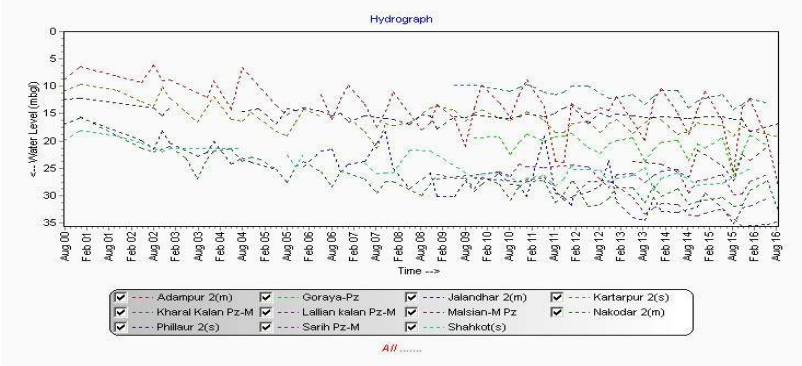
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

VII. Salient Information of Nakodar Block

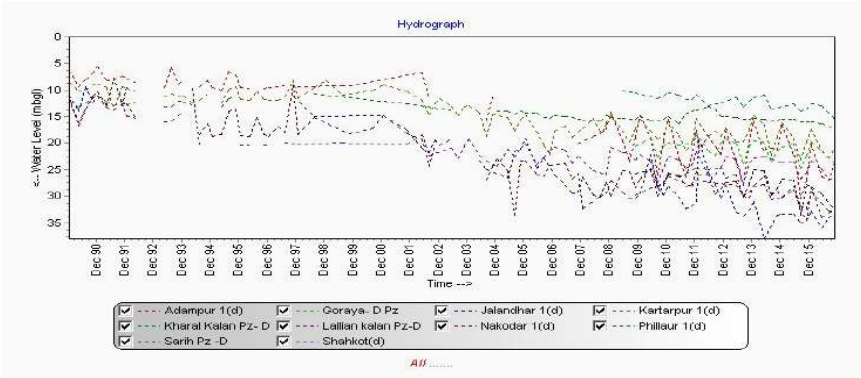
<table>
<tr><td>Block Area
(in Km^2)</td><td>353.30 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 0
Rural Population: 167014
Total population: 167014</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 484 mm
Non-monsoon Rainfall : 136 mm
Annual Average Rainfall: 620 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 424.14 sq km
Net sown area: 275.13 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 154%
<u>Area under</u>
Ground water Irrigation: 275.10 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 424.14 sq km
Net Irrigated area: 275.13 sq km
Number and types of abstraction structures: 13805, 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 205 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>26.64 – 160.0</td><td>133</td><td>64</td><td>1818.70</td></tr>
<tr><td>Aquifer-II</td><td>170.0 – 250.0</td><td>80</td><td>67</td><td>1714</td></tr>
<tr><td>Aquifer-III</td><td>276.0 – 300.0</td><td>24</td><td>18</td><td>453</td></tr>
</table>
Total Ground Water Resources available is 3985.40 mcm and total potential granular zones available are 149 m up to depth of 205 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 451.38 mcm Domestic and industrial water supply: 7.47 mcm *Future water demands* Irrigation development potential : (-)270.17 mcm Domestic and industrial water supply up to 2025 years : 9.44 mcm Water Scarcity Villages: 87
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 8.40 – 30.60 m bgl Post Monsoon: 6.85 – 34.28 m bgl Seasonal Fluctuation: 1.48 – (-)0.45 m/yr Mean (10 yrs) : (-)1.08 – (-)2.82 m/yr *Trends* Pre Monsoon: (-)0.33m/yr Post Monsoon: (-)0.53 m/yr **Aquifer-II &III** Pre Monsoon: 29.38 – 32.90 m bgl Post Monsoon: 31.20– 35.15 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	0	0	**0**
WRED/PSTC/WSS	4	9	1	0	**14**
PRIVATE	0	3	1	0	**4**
TOTAL	**4**	**12**	**2**	**0**	**18**

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 (26.64 -160 m)	Quarter-nary Alluvial deposits	Unconfined to confined	64	NA	NA	12 % *(0.072)*	NA
Aquifer-II (170 - 250 m)		Semi confined to Confined	67				
Aquifer-III (276 - 300 m)		NA	18	NA	NA	NA	NA

* Well field proposed in adjacent block , NA : Not Available

Source: Groundwater Exploration Report, CGWB,2015

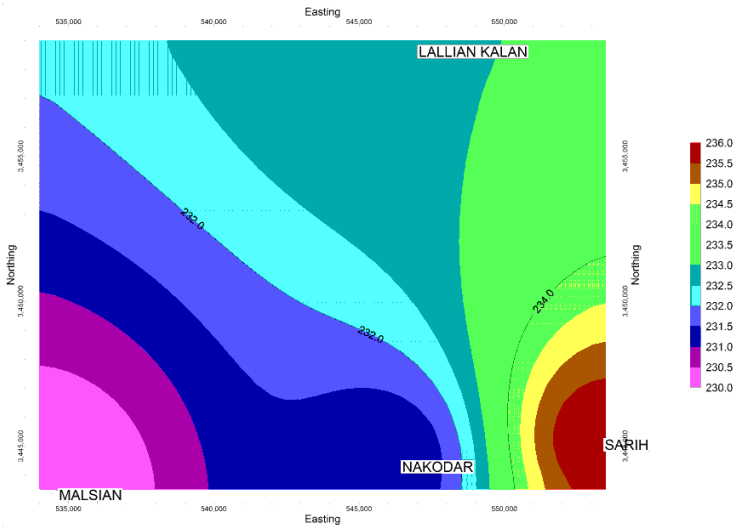
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

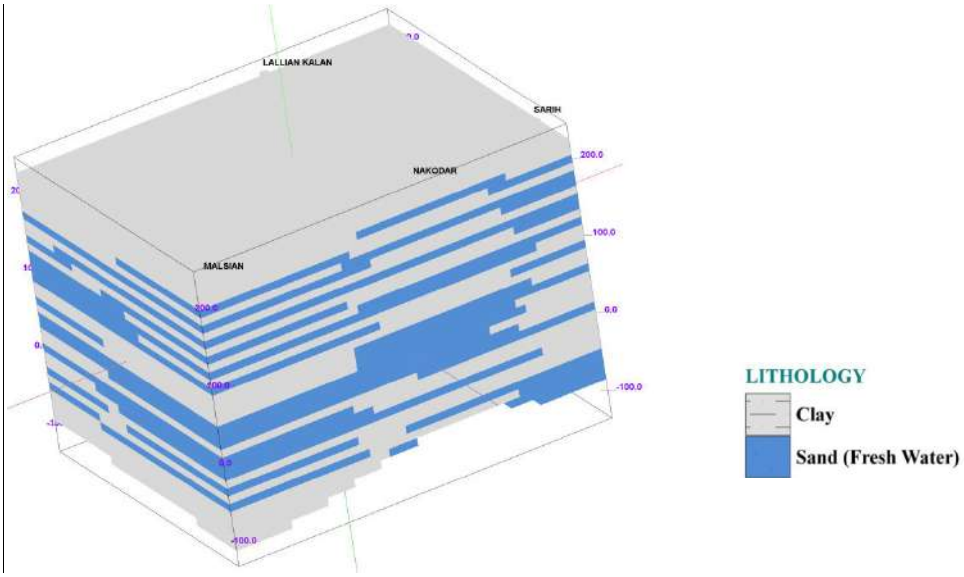
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	0	**0**
WRED/PSTC/WSS	0	5	1	0	**6**
PRIVATE	0	3	1	0	**4**
TOTAL	**0**	**8**	**2**	**0**	**10**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

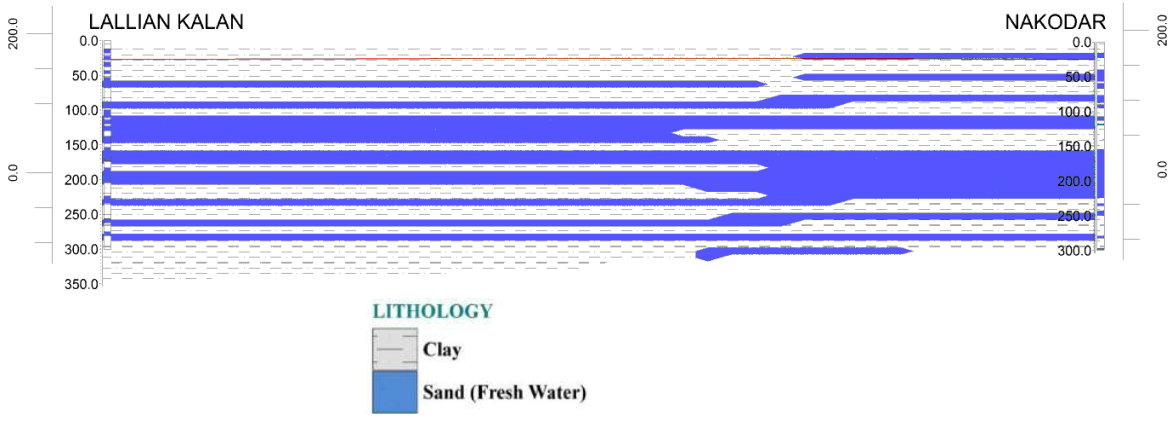
Elevation Map of Nakodar Block



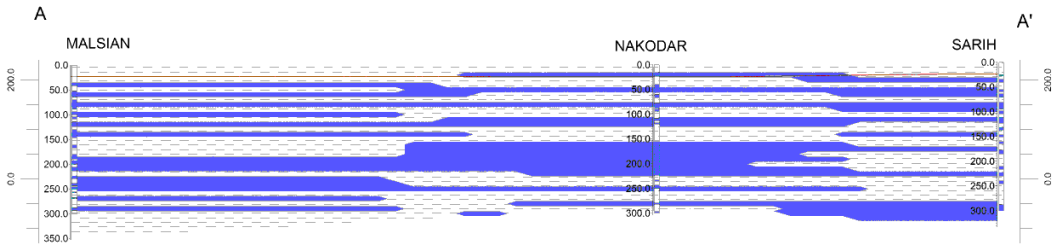
3-D Lithological model of Nakodar Block



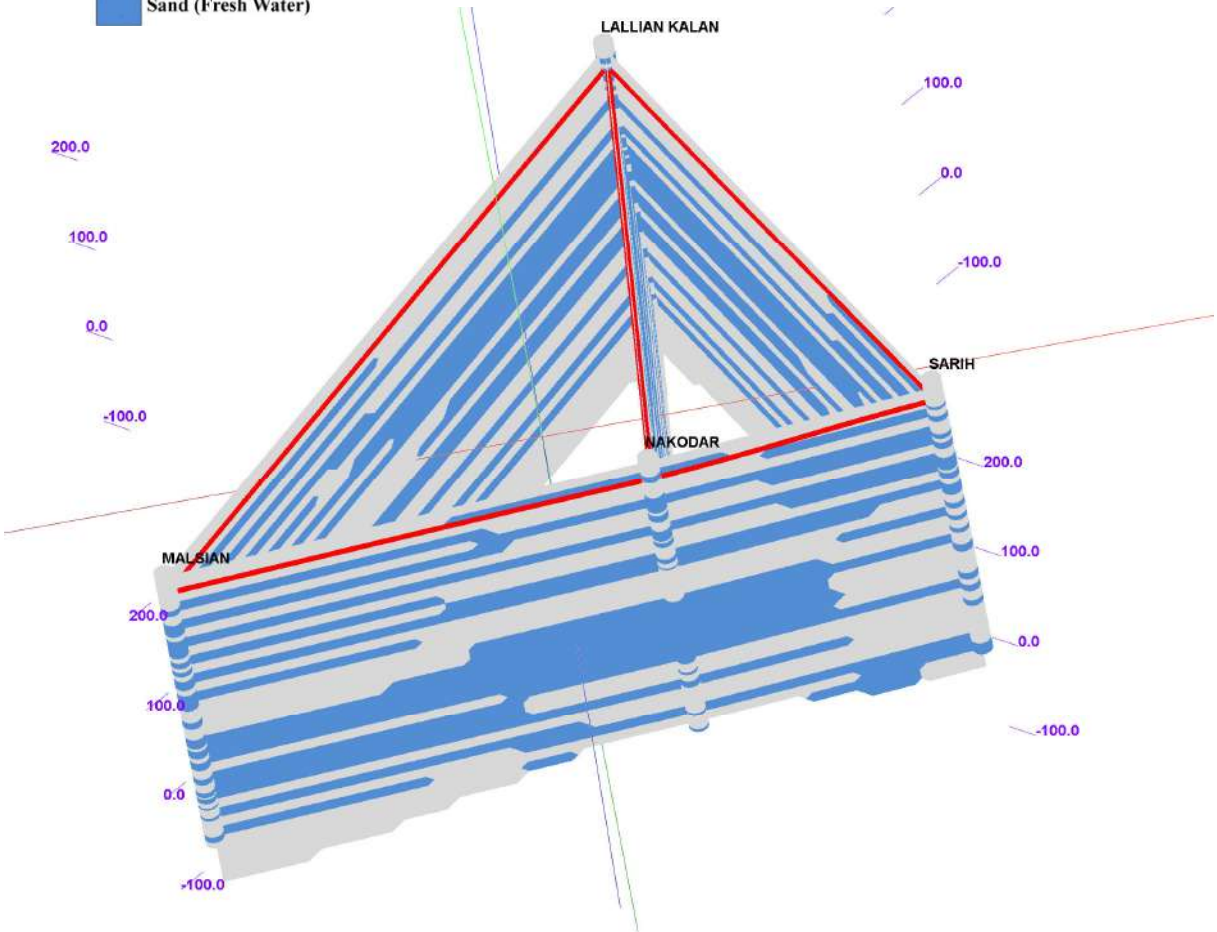
Lithological Cross section from Lallian kalan to Nakodar



Lithological Cross section from Malsian to Sarih

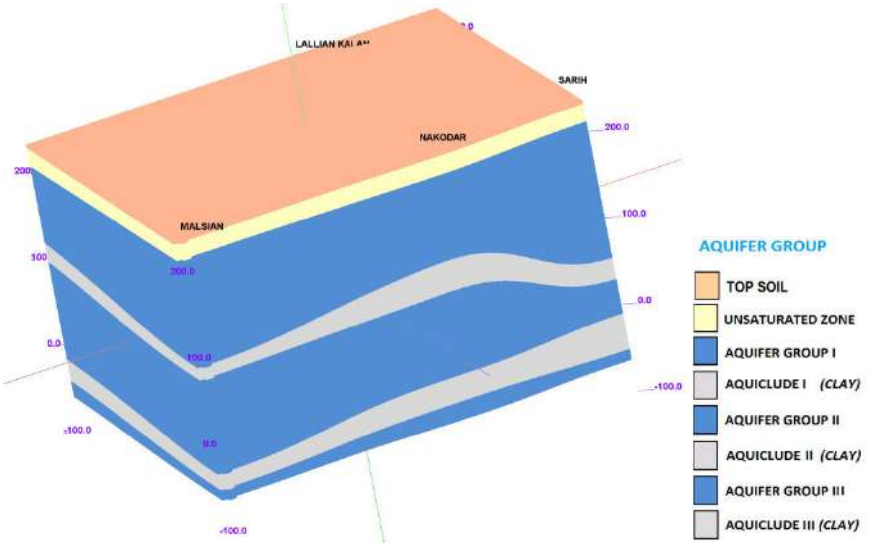


3-D Lithological Fence Diagram

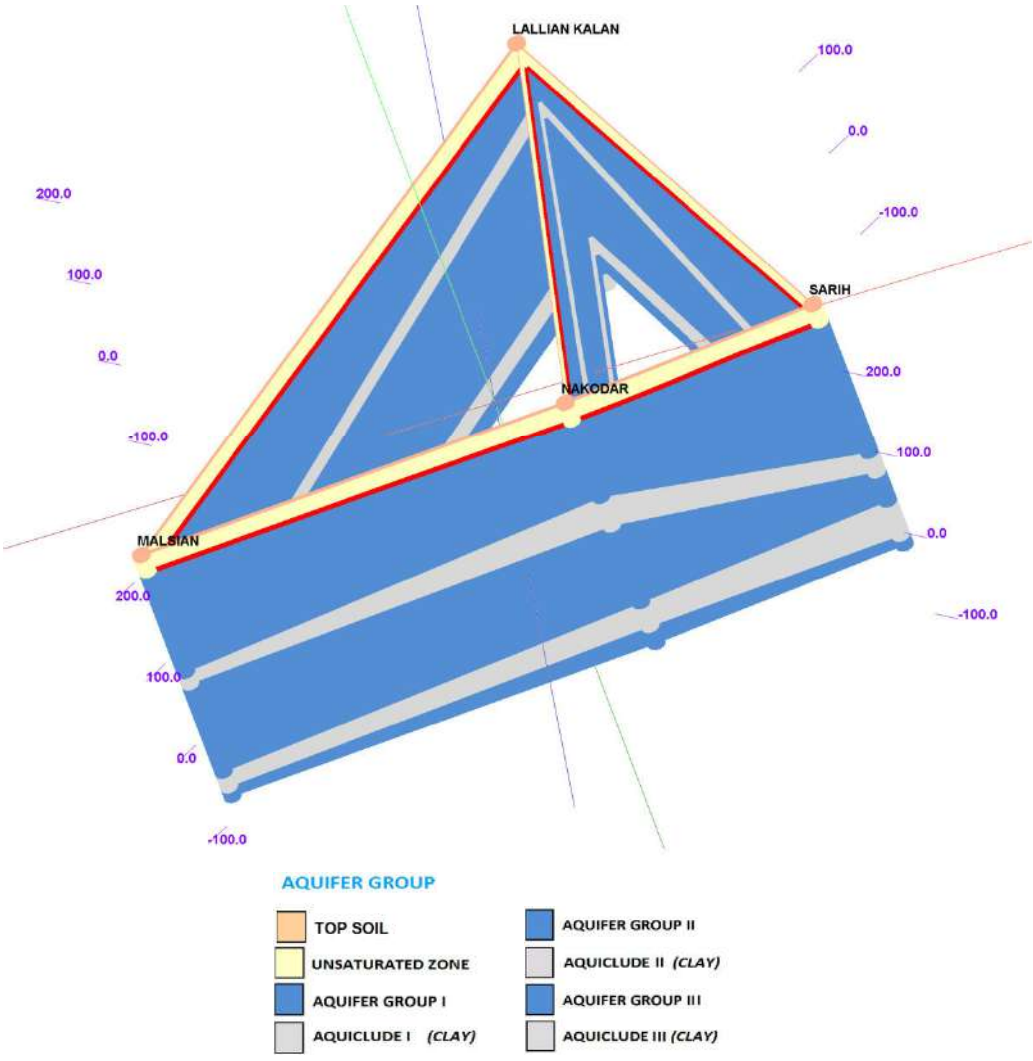


WATER LEVEL

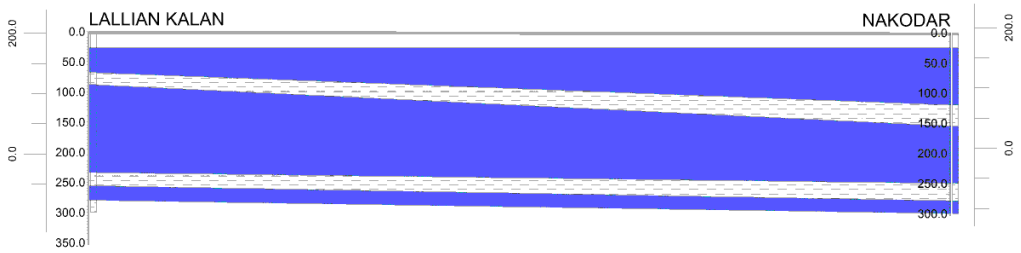
3-D Aquifer Disposition Model of Nakodar Block



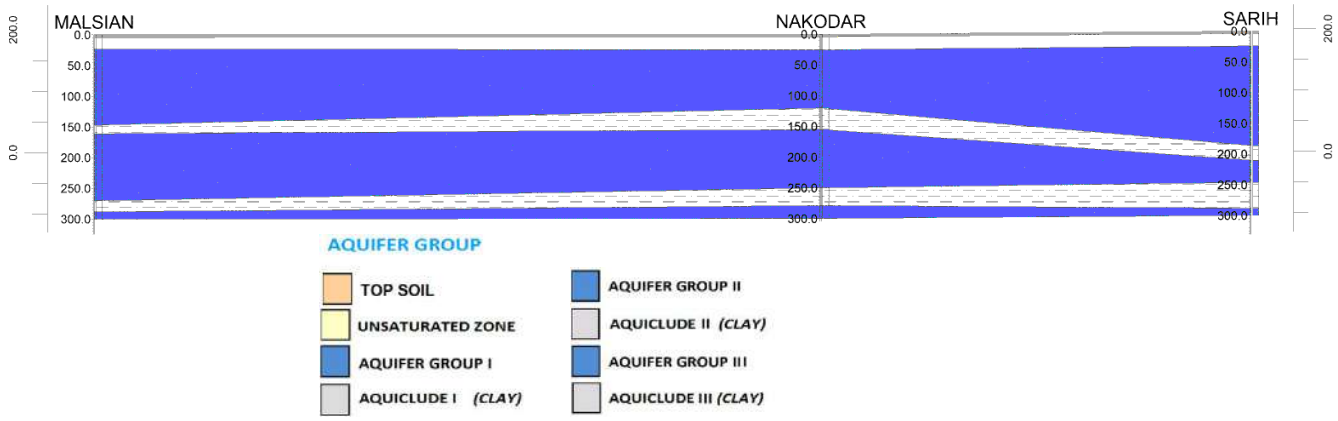
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Lallian kalan to Nakodar



Aquifer Cross section along Malsian to Sarih



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	190.66 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1628 mcm
	In-storage Aquifer-II (Specific Yield Concept)	1704 mcm
	In-storage Aquifer-II (Storativity Concept)	9.49 mcm
	In-storage Aquifer-III (Specific Yield Concept)	407 mcm
	In-storage Aquifer-II (Storativity Concept)	45.90 mcm
	Total Resources	3985.40 mcm
Ground Water Extraction (as per 2013)	Irrigation	451.38 mcm
	Domestic & Industrial	7.47mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		9.44 mcm
Stage of Groundwater Development		241 %

Chemical Quality of ground water	Ground water in the area is alkaline in nature pH values are from 8.10 to 8.28, EC value of the ground water are from 380 to 510 µS/cm at 25^0C. RSC values are varying from (-) 0.40 is 1.20 meq/L and the area is fit for irrigation..
Ground water Contamination Issues	**Iron (mg/l)** Nakodar (3.83)
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: 102 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 4.42 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Nakodar Block (353.3 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 91.96 mcm
Required Change in cropping pattern
Proposed change in cropping pattern: *Rice to Maize, Soyabean.*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *50% of the total rice area needs to change i.e.* 149.10 sq km
Anticipated volume of water to be saved: 149.10 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
190.7	451.38	458.85	302	149.10	149.10	302.28	241	78.60	50

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 34

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

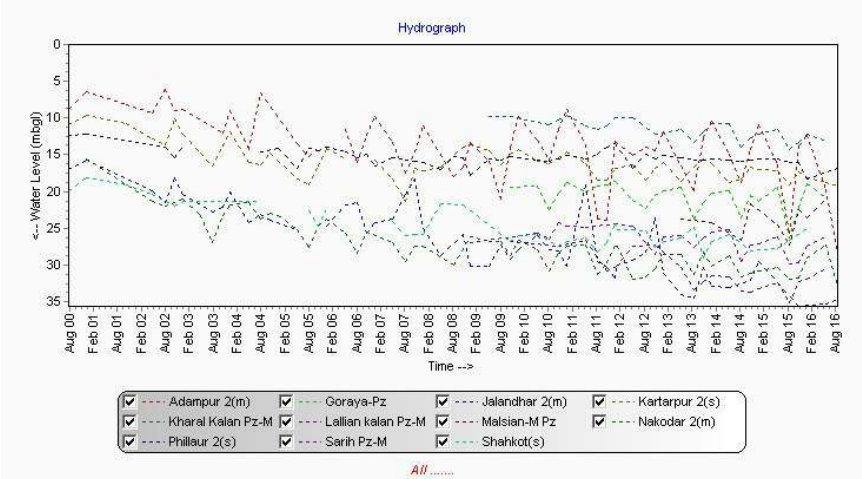
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

VIII. Salient Information of Nurmahal Block

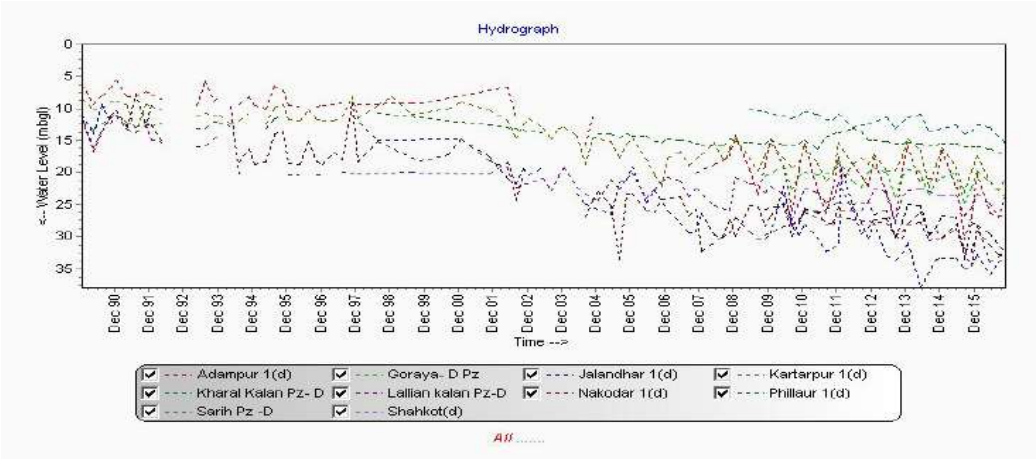
<table>
<tr><td>Block Area
(in Km^2)</td><td>319.80 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 0
Rural Population: 91655
Total population: 91655</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 504 mm
Non-monsoon Rainfall : 123 mm
Annual Average Rainfall: 627 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 396.18 sq km
Net sown area: 202.48 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 196%
<u>Area under</u>
Ground water Irrigation: 202.47 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 396.20 sq km
Net Irrigated area: 202.47 sq km
Number and types of abstraction structures: 7312, 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 205 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>18.92 – 143.0</td><td>124</td><td>62</td><td>1584.70</td></tr>
<tr><td>Aquifer-II</td><td>112.0 – 186.0</td><td>74</td><td>26</td><td>605</td></tr>
<tr><td>Aquifer-III</td><td>279.0 – 300.0</td><td>21</td><td>16</td><td>721</td></tr>
</table>
Total Ground Water Resources available is 2910.80 mcm and total potential granular zones available are 104 m up to depth of 205 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 288.73 mcm Domestic and industrial water supply: 1.96 mcm *Future water demands* Irrigation development potential : (-)134.13 mcm Domestic and industrial water supply up to 2025 years : 2.47 mcm Water Scarcity Villages: 71
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 19.50 – 27.90 m bgl Post Monsoon: 24.30 – 31.20 m bgl Seasonal Fluctuation: (-) 2.40 – (-)3.60 m/yr **Aquifer-II &III** Pre Monsoon: 21.00 – 27.92 m bgl Post Monsoon: 21.60 – 31.24 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	0	0	**0**
WRED/PSTC/WSS	4	9	1	0	**14**
PRIVATE	0	3	1	0	**4**
TOTAL	**4**	**12**	**2**	**0**	**18**

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 (18.92 -143 m)	Quarter-nary Alluvial deposits	Unconfined to confined	62	NA	NA	12 % *(0.072)*	NA
Aquifer-II (112 - 236 m)		Semi confined to Confined	26	480	1408		1.61×10^{-4}
Aquifer-III (279 - 300 m)		NA	16	614	1408		1.21×10^{-4}

* Well field proposed in adjacent block , NA : Not Available

Source: Groundwater Exploration Report, CGWB,2015

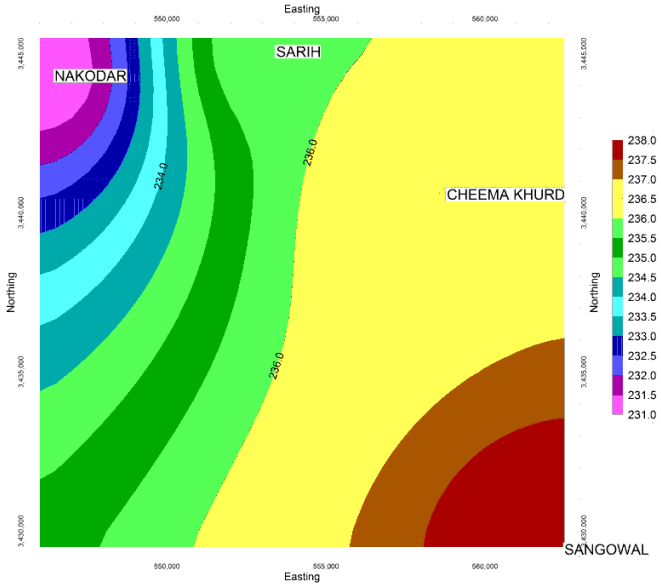
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

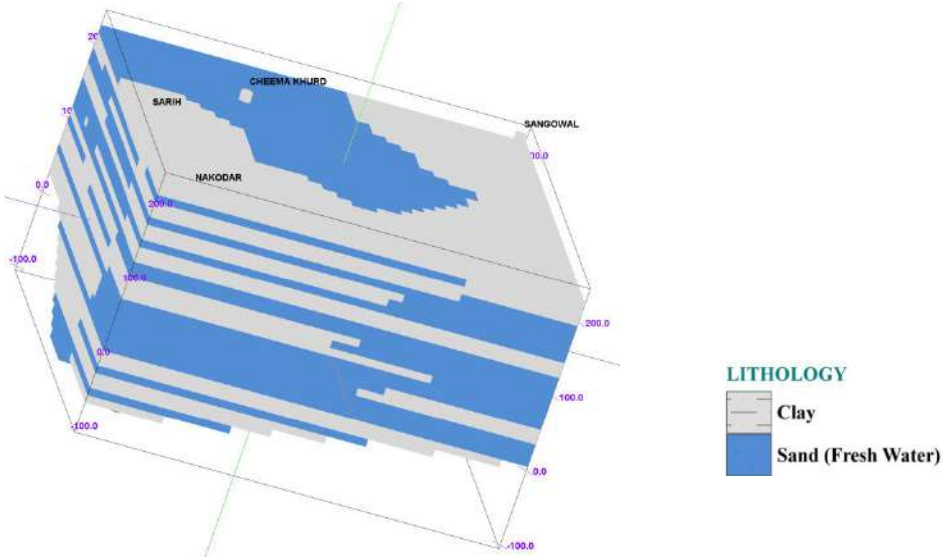
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	1	**1**
WRED/PSTC/WSS	1	0	0	0	**1**
PRIVATE	0	2	0	0	**2**
TOTAL	**1**	**2**	**0**	**1**	**4**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

Elevation Map of Nurmahal Block

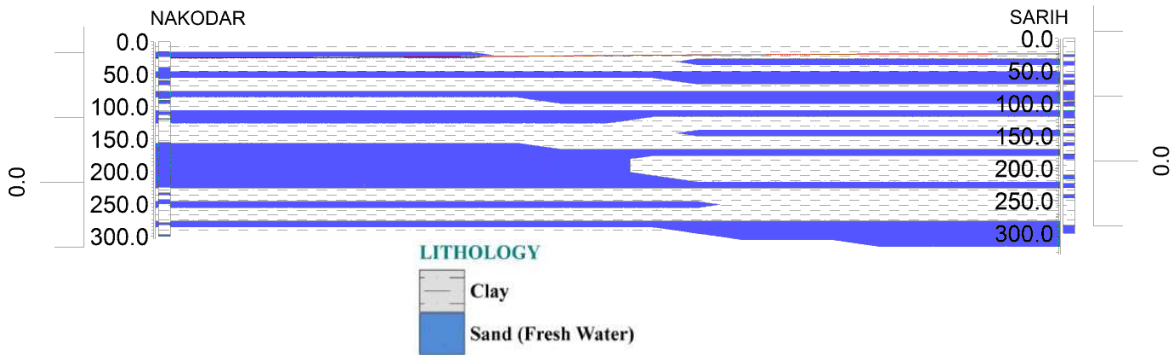


3-D Lithological model of Nurmahal Block

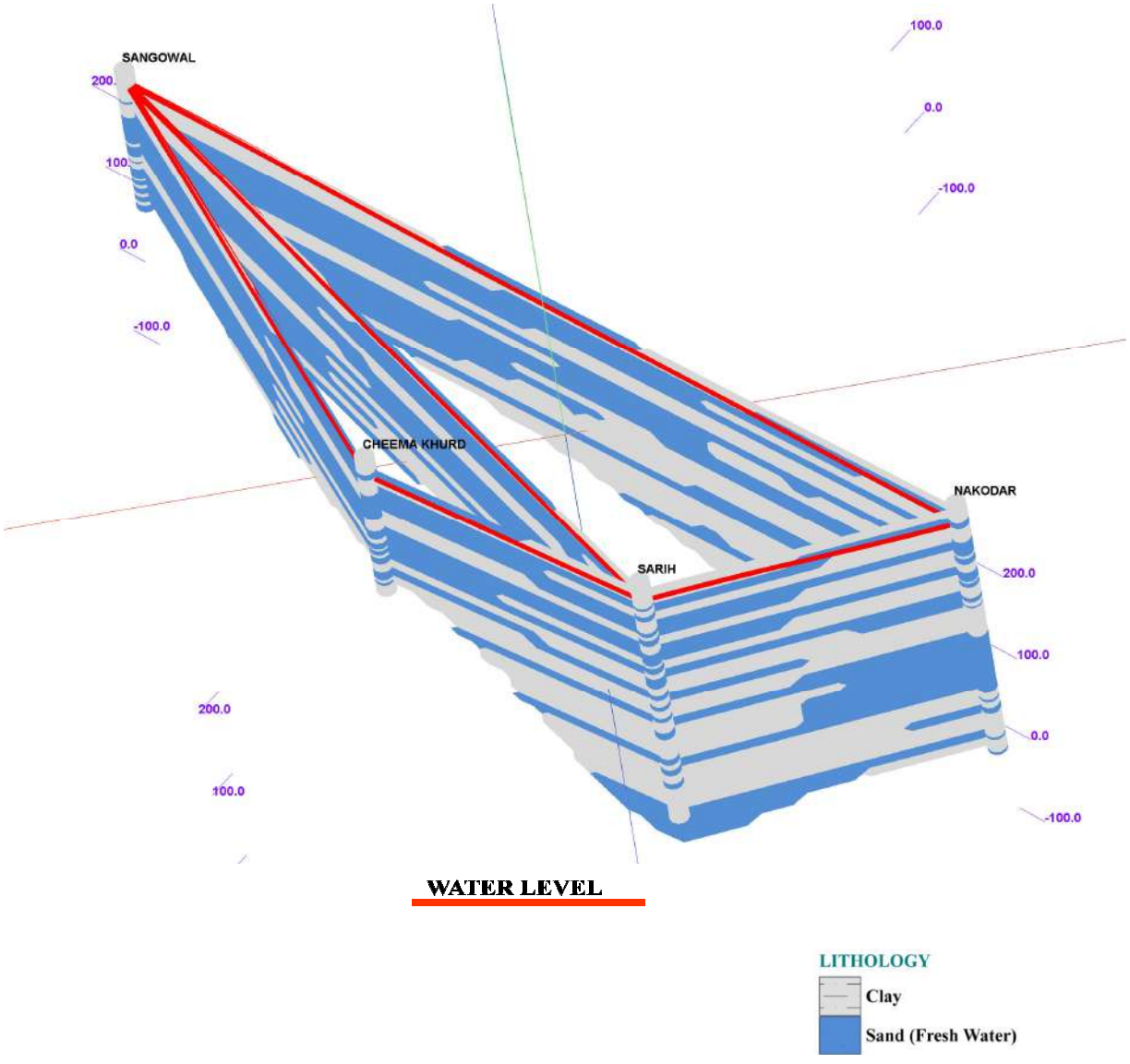


Lithological Cross section from Nakodar to Sangowal

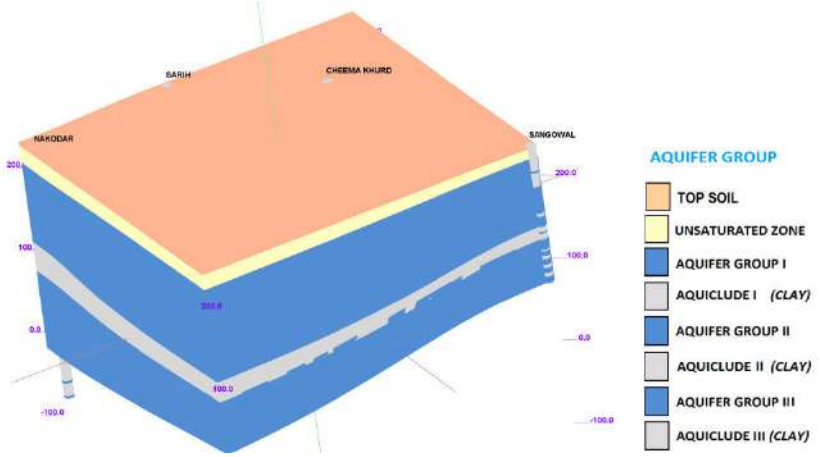
Lithological Cross section from Nakodar to Sarih



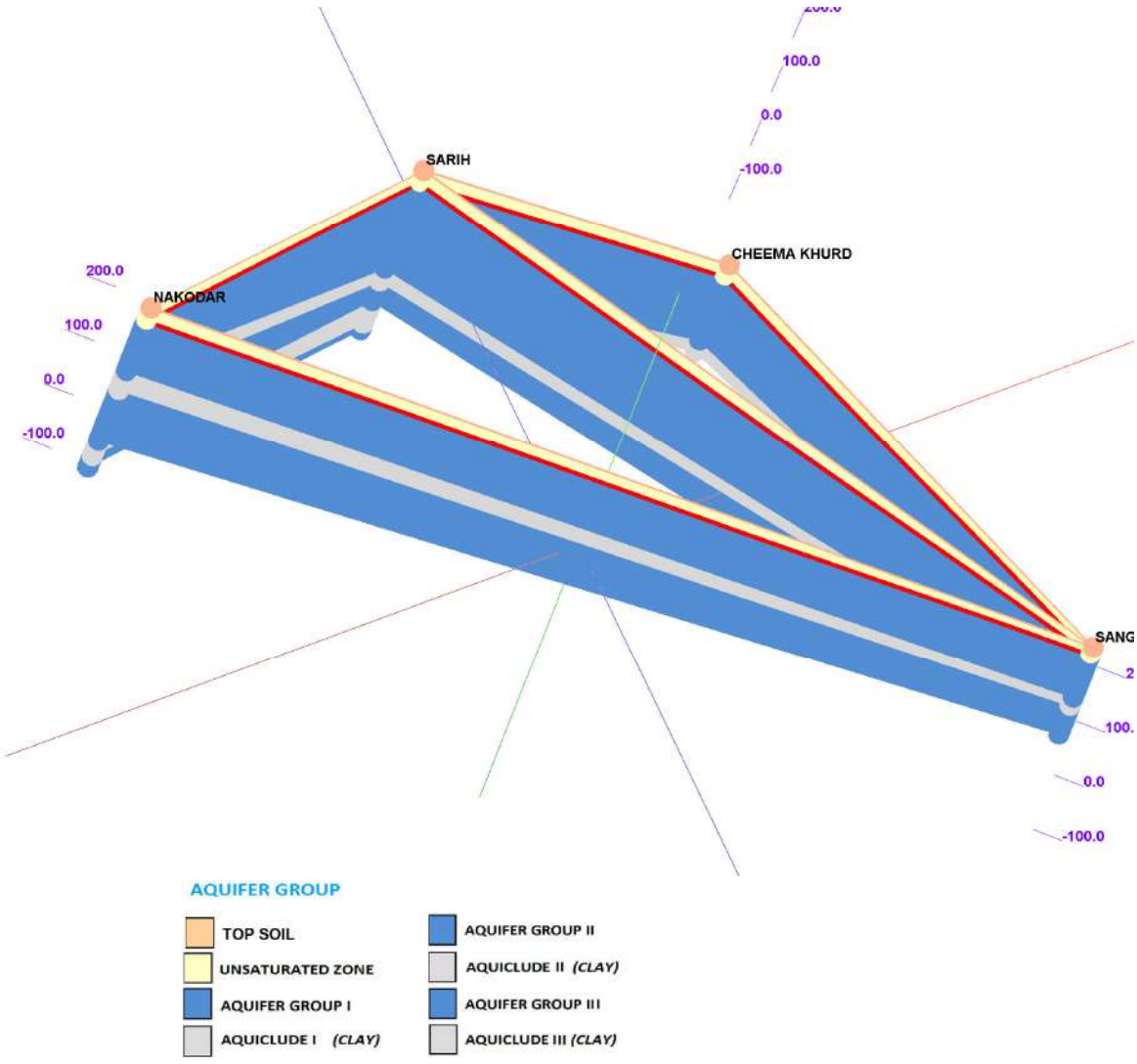
3-D Lithological Fence Diagram



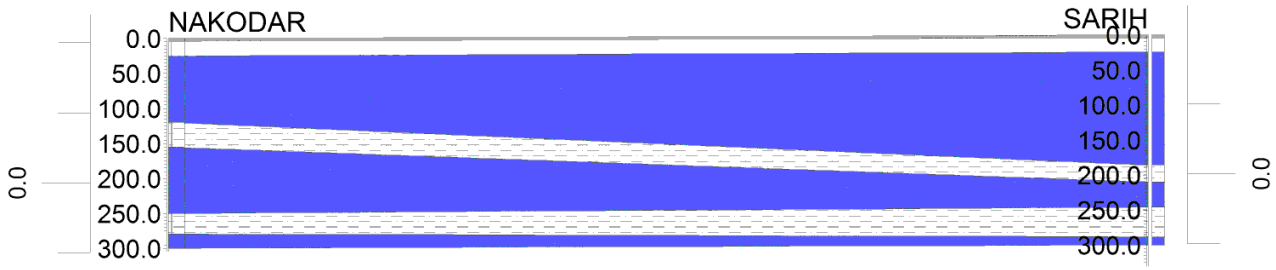
3-D Aquifer Disposition Model of Nurmahal Block



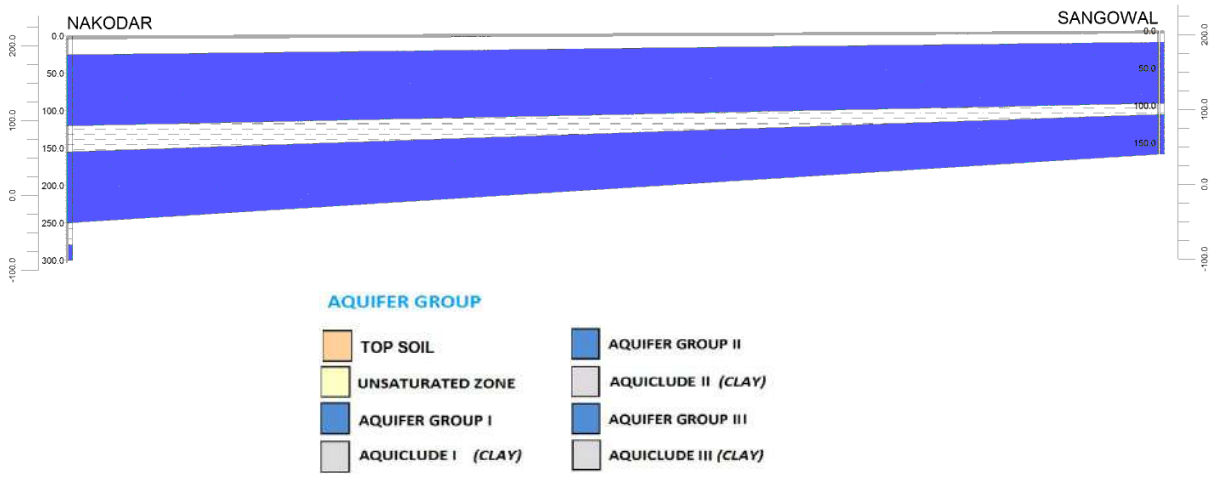
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Nakodar to Sarih



Aquifer Cross section along Nakodar to Sangowal



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	157.07 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1428 mcm
	In-storage Aquifer-II (Specific Yield Concept)	599 mcm
	In-storage Aquifer-II (Storativity Concept)	5.57 mcm
	In-storage Aquifer-III (Specific Yield Concept)	691 mcm
	In-storage Aquifer-II (Storativity Concept)	30.3 mcm
	Total Resources	2910.8 mcm
Ground Water Extraction (as per 2013)	Irrigation	288.73 mcm
	Domestic & Industrial	1.96mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		2.47 mcm

Stage of Groundwater Development	185 %
Chemical Quality of ground water	Ground water in the area is alkaline in nature pH values is 8.38, EC value of the ground water is 300 µS/cm at 25^0C. RSC values is (-)0.16 meq/L and the area is fit for irrigation..
Ground water Contamination Issues	**Fluoride (mg/l)** Sarih (1.2)
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: 81 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 2.63 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Nurmahal Block (319.80 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 58.82 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean.*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *32% of the total rice area needs to change i.e.* 58.30 sq km
Anticipated volume of water to be saved: 58.30 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
157.10	288.73	290.69	185	58.30	58.30	230.43	185	37.10	32

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 25

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

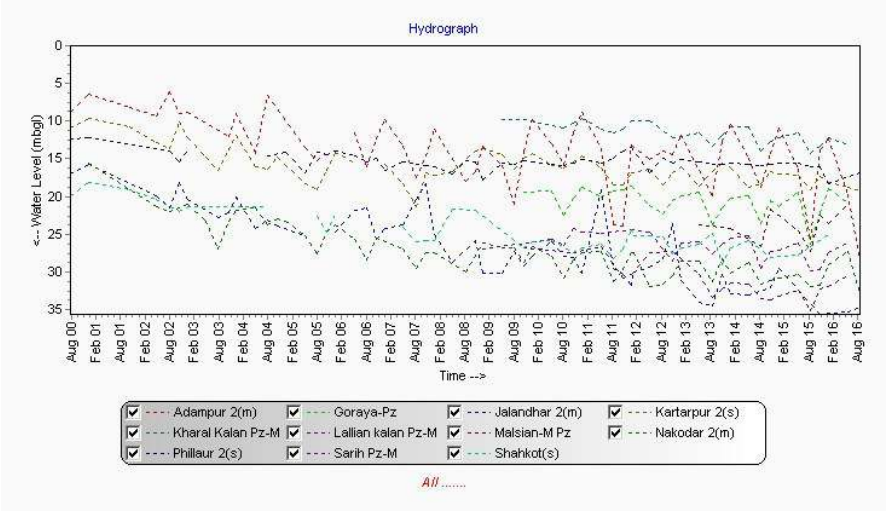
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

IX. Salient Information of Phillaur Block

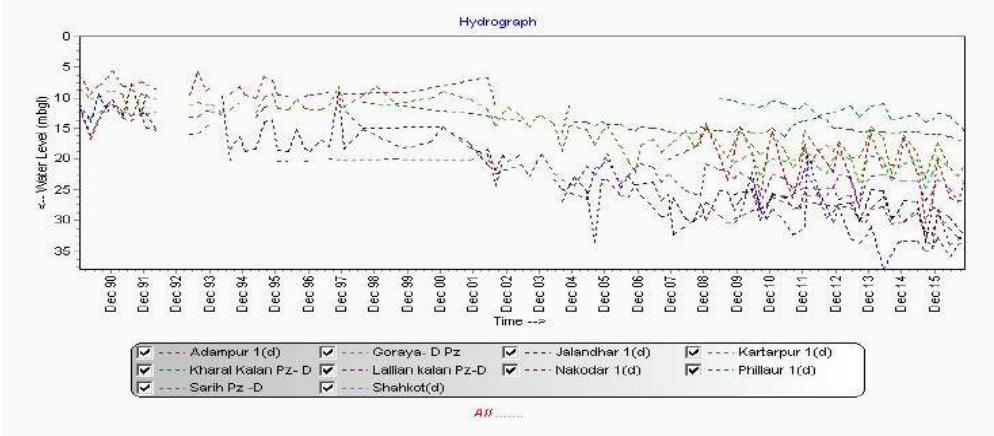
<table>
<tr><td>Block Area
(in Km^2)</td><td>270.3 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 6258
Rural Population: 137450
Total population: 143708</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 489 mm
Non-monsoon Rainfall : 139 mm
Annual Average Rainfall: 628 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 525.53 sq km
Net sown area: 293.12 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 179%
<u>Area under</u>
Ground water Irrigation: 293.12 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 525.70 sq km
Net Irrigated area: 283.12 sq km
Number and types of abstraction structures: 8812, 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 205 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>14.62 – 160.0</td><td>145</td><td>87</td><td>1869.40</td></tr>
<tr><td>Aquifer-II</td><td>108.0 – 250.0</td><td>142</td><td>82</td><td>1633</td></tr>
<tr><td>Aquifer-III</td><td>262.0 – 300.0</td><td>38</td><td>25</td><td>519</td></tr>
</table>
Total Ground Water Resources available is 4022.2 mcm and total potential granular zones available are 194 m up to depth of 205 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 306.22 mcm Domestic and industrial water supply: 12.59 mcm *Future water demands* Irrigation development potential : (-)145.86 mcm Domestic and industrial water supply up to 2025 years : 15.84 mcm Water Scarcity Villages: 100
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 16.65 – 21.20 m bgl Post Monsoon: 16.05 – 24.20 m bgl Seasonal Fluctuation: (-)1.60 – (-)3.60 m/yr **Aquifer-II &III** Pre Monsoon: 16.90 – 23.01 m bgl Post Monsoon: 16.95 – 24.21 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	0	0	**0**
WRED/PSTC/WSS	4	9	1	0	**14**
PRIVATE	0	3	1	0	**4**
TOTAL	**4**	**12**	**2**	**0**	**18**

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 (14.62 -160 m)	Quarter-nary Alluvial deposits	Unconfined to confined	87	5750	5670	12 % *(0.072)*	6.0 x 10^{-3}
Aquifer-II (108 - 250 m)		Semi confined to Confined	82				
Aquifer-III (262 - 300 m)		NA	25	NA	NA	NA	NA

* Well field proposed in this block , (Site : Massani) NA : Not Available

Source: Groundwater Exploration Report, CGWB,2015

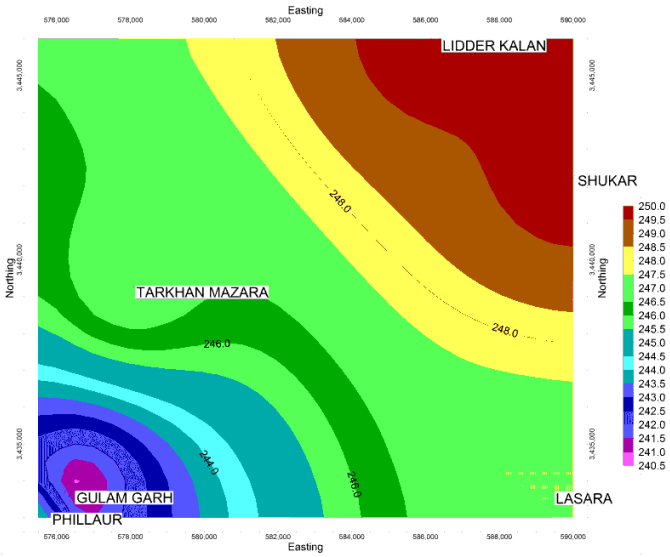
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

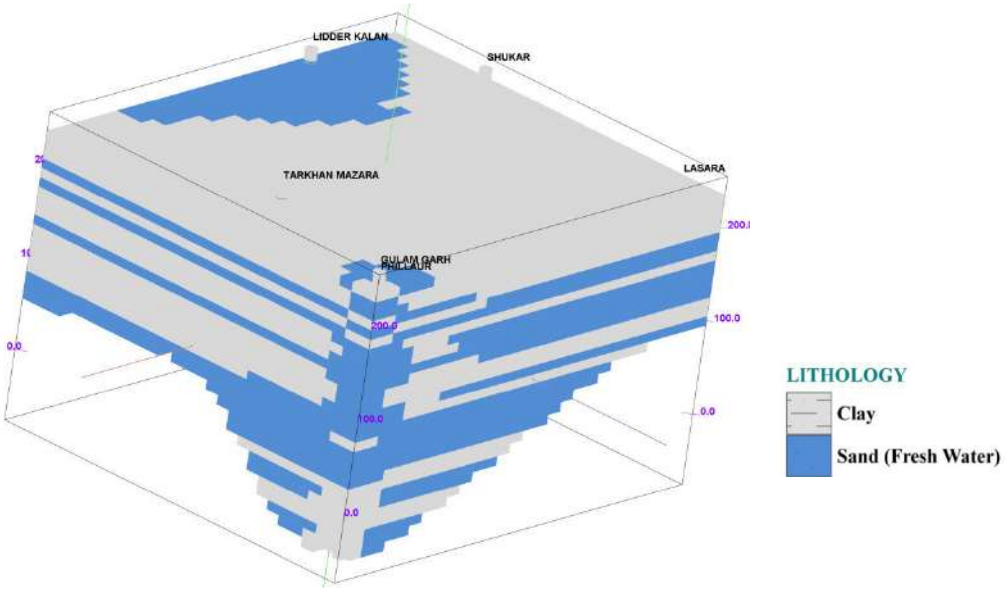
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	2	**2**
WRED/PSTC/WSS	0	0	0	0	**0**
PRIVATE	0	2	0	0	**2**
TOTAL	**0**	**2**	**0**	**2**	**4**

The data is validated by selecting the deepest well in each quadrant (elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

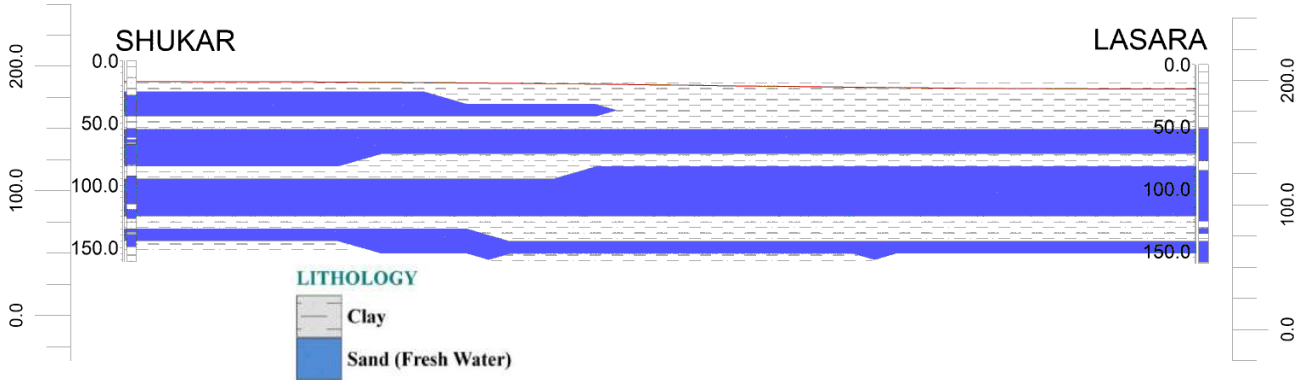
Elevation Map of Phillaur Block



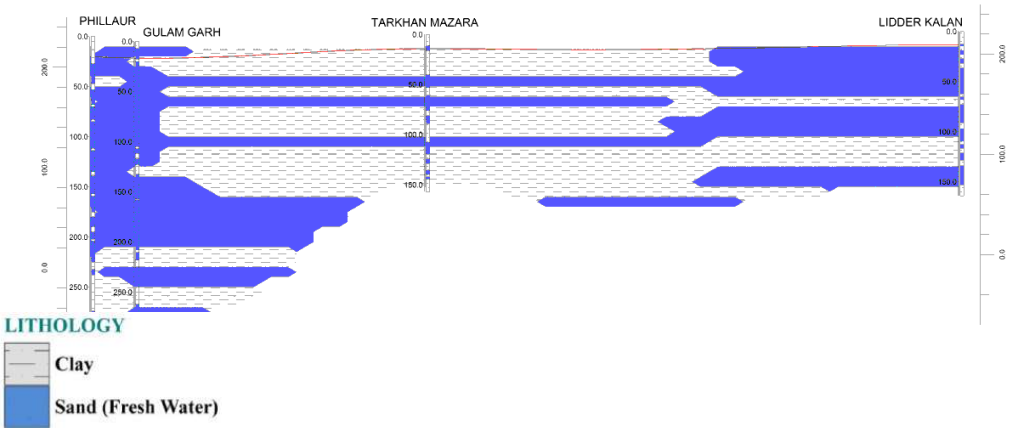
3-D Lithological model of Phillaur Block



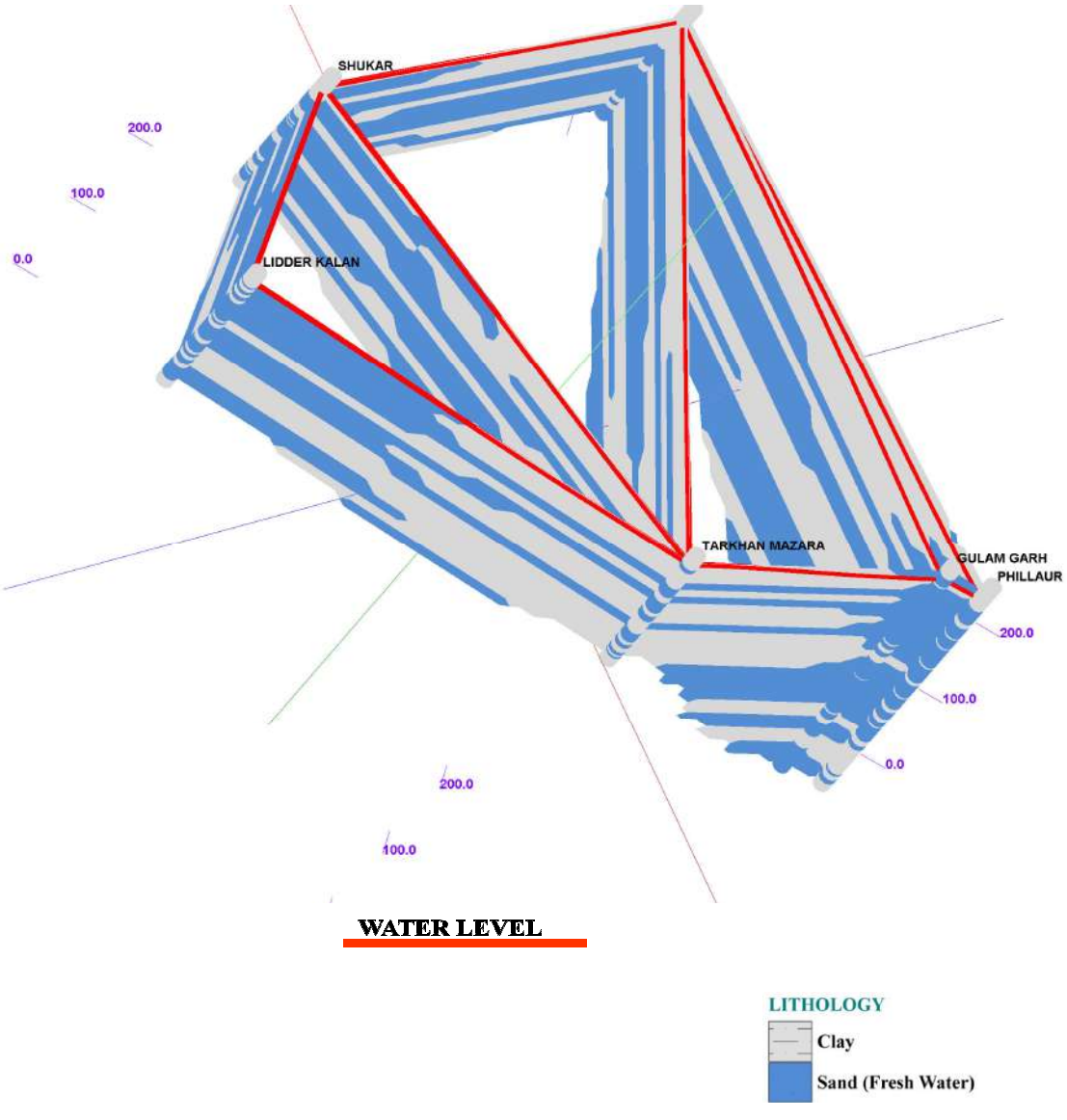
Lithological Cross section from Shukar to Lasara



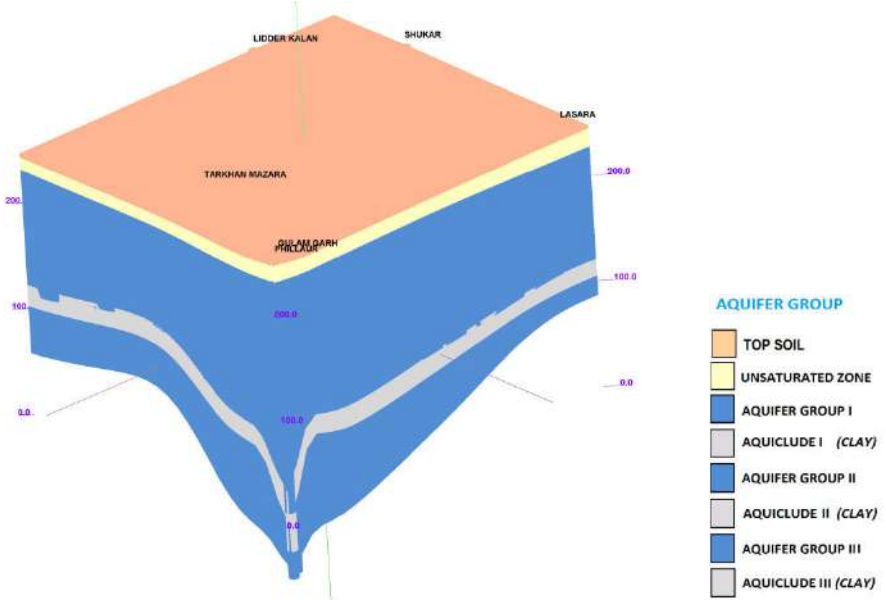
Lithological Cross section from Phillaur to Lidder kalan



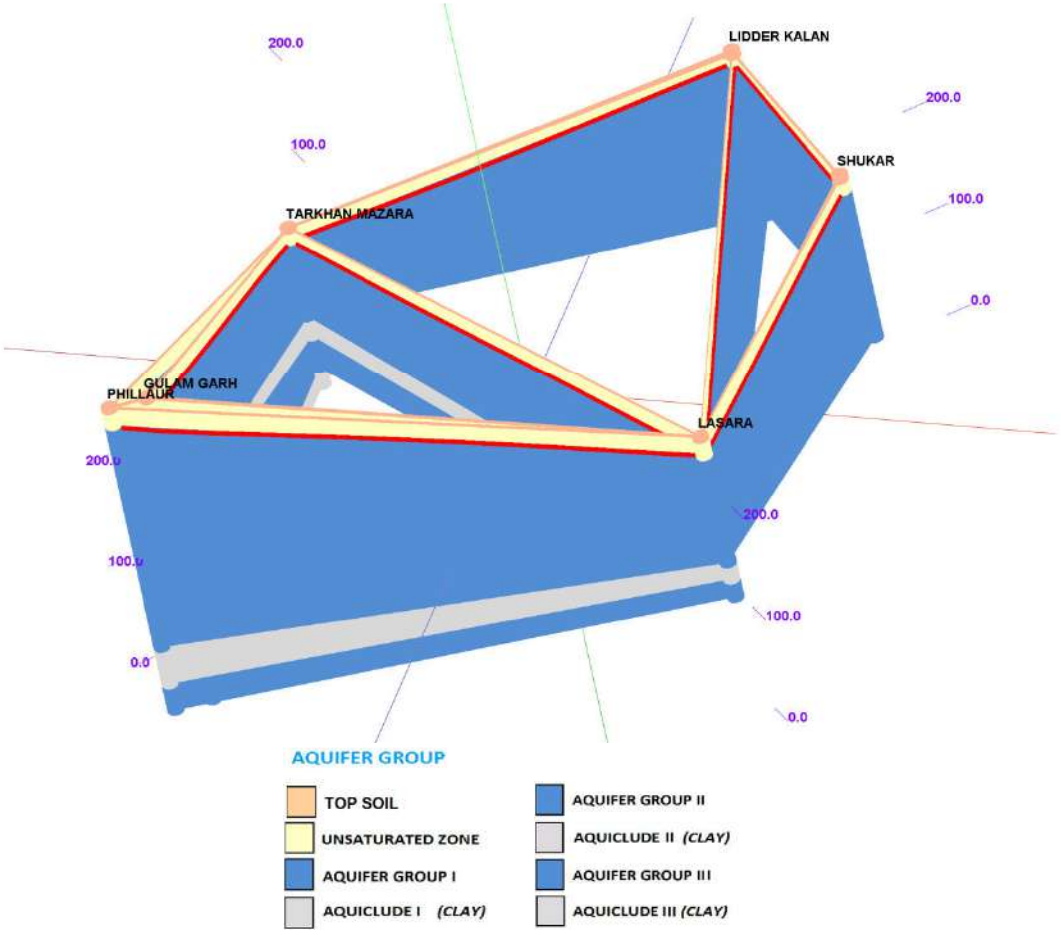
3-D Lithological Fence Diagram



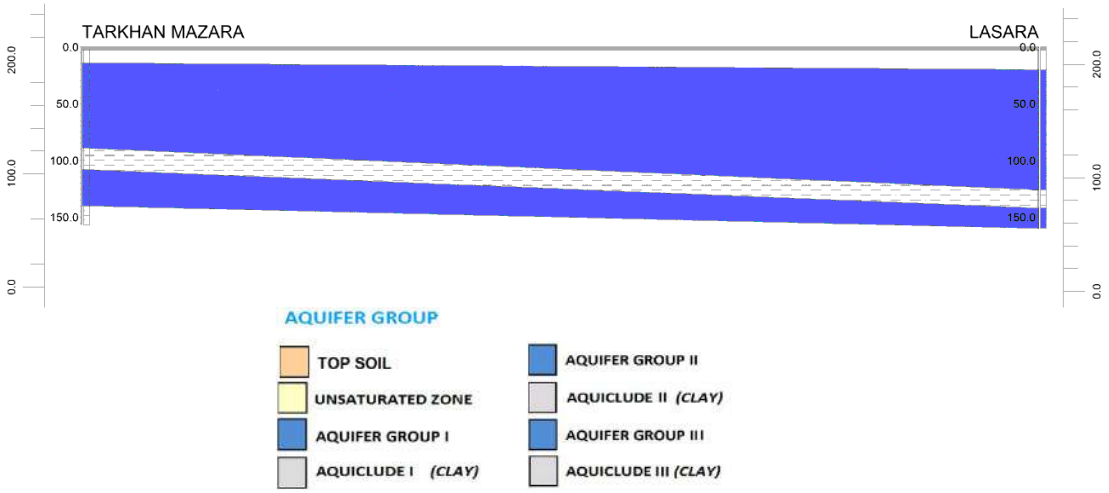
3-D Aquifer Disposition Model of Phillaur Block



3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Tarkhan mazara to Lasara



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	176.20 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1693 mcm
	In-storage Aquifer-II (Specific Yield Concept)	1596 mcm
	In-storage Aquifer-II (Storativity Concept)	37.63mcm
	In-storage Aquifer-III (Specific Yield Concept)	487 mcm
	In-storage Aquifer-II (Storativity Concept)	32.8 mcm
	Total Resources	4022.20 mcm
Ground Water Extraction (as per 2013)	Irrigation	306.22 mcm
	Domestic & Industrial	12.59 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		15.84 mcm
Stage of Groundwater Development		181 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature pH value is 8.59. EC value of the ground water is 700 µS/cm at 25^0C. RSC value is 0.97 meq/L and the area is fit for irrigation.

Ground water Contamination Issues	**Nitrate(mg/l)** Phillaur (55) **Fluoride(mg/l)** Phillaur (1.0)
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: 66 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 1.92 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Phillaur Block (270.30 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 62.39 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean.*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *31% of the total rice area needs to change i.e.* 61 sq km
Anticipated volume of water to be saved: 61 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
176.20	306.22	318.81	201	61.0	61.0	245.22	181	34.80	31

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 39

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

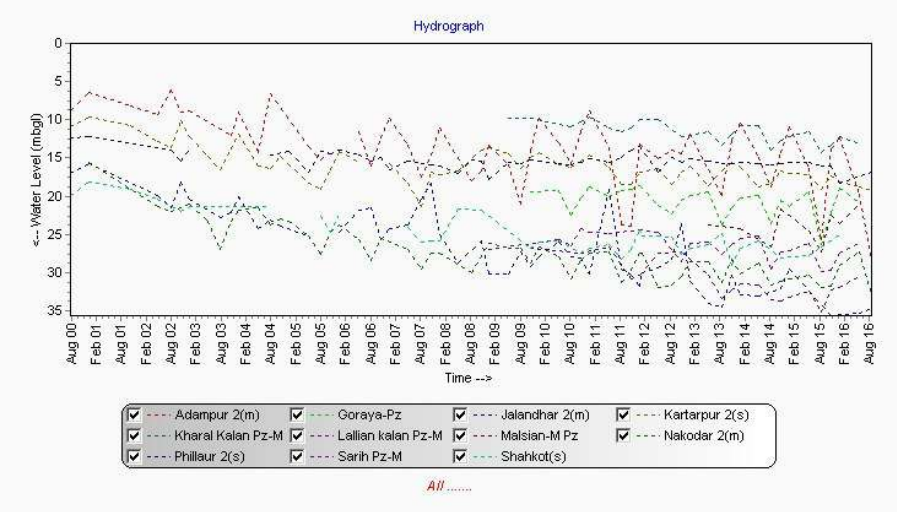
Other than that by 15 days ponding followed by 2 days of drying can lead to 25% saving of water in paddy crop.

X. Salient Information of Shahkot Block

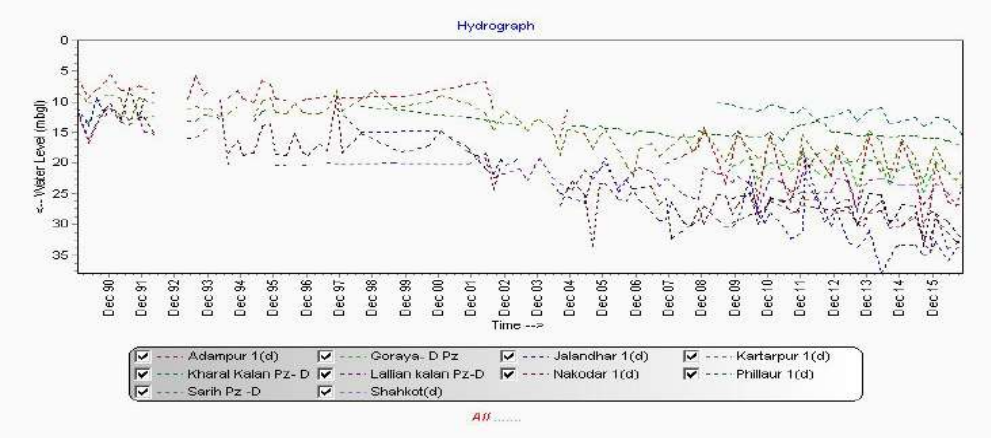
<table>
<tr><td>Block Area
(in Km^2)</td><td>240.7 sq km</td></tr>
<tr><td>District/ State</td><td>Jalandhar, Punjab</td></tr>
<tr><td>Population</td><td>Urban Population: 0
Rural Population: 85942
Total population: 85942</td></tr>
<tr><td>Rainfall</td><td>Normal Monsoon: 468 mm
Non-monsoon Rainfall : 106 mm
Annual Average Rainfall: 574 mm</td></tr>
<tr><td>Agriculture and Irrigation</td><td>Principal crops: Rice, Wheat, Sugar cane, and Maize
Other crops: Vegetables and Fodder
Gross cropped area: 373.89 sq km
Net sown area: 203.31 sq km
Irrigation practices: Tube well Irrigation
Cropping intensity: 184%
<u>Area under</u>
Ground water Irrigation: 203.31 sq km
Surface water irrigation: 0 sq km
Gross Irrigated area: 374.11 sq km
Net Irrigated area: 203.31 sq km
Number and types of abstraction structures: 7136, 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 205 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>26.91 – 147.0</td><td>120</td><td>75</td><td>1381.10</td></tr>
<tr><td>Aquifer-II</td><td>90.0 – 270.0</td><td>180</td><td>70</td><td>1220</td></tr>
<tr><td>Aquifer-III</td><td>243.0 – 300.0</td><td>57</td><td>27</td><td>495</td></tr>
</table>
Total Ground Water Resources available is 3096.10 mcm and total potential granular zones available are 172 m up to depth of 205 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	*Existing Gross Ground water Draft as on 2013* Irrigation: 194.75 mcm Domestic and industrial water supply: 5.58 mcm *Future water demands* Irrigation development potential : (-)120.49 mcm Domestic and industrial water supply up to 2025 years : 7.09 mcm Water Scarcity Villages: 82
Water level behavior	*Aquifer wise water level* **Aquifer-I** Pre Monsoon: 16.10 – 32.10 m bgl Post Monsoon: 19.10 – 33.60 m bgl Seasonal Fluctuation: 1.48 – (-)0.45 m/yr **Aquifer-II &III** Pre Monsoon: 19.30 – 34.30 m bgl Post Monsoon: 20.10 – 33.90 m bgl

Long Term Hydrograph Showing Shallow Aquifer Water Table Declining Trend



Long Term Hydrograph Showing Deeper Aquifer Water Table Declining Trend



Aquifer Disposition

Number of aquifers	1
Principal aquifer	Alluvium
Major Aquifer	Older Alluvium
Aquifer Disposition	Multiple Aquifer System (Two 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	0	0	**0**
WRED/PSTC/WSS	4	9	1	0	**14**
PRIVATE	0	3	1	0	**4**
TOTAL	**4**	**12**	**2**	**0**	**18**

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 (26.91 -147 m)	Quarter-nary Alluvial deposits	Unconfined to confined	75	NA	NA	12 % *(0.072)*	NA
Aquifer-II (90 - 270 m)		Semi confined to Confined	70				
Aquifer-III (243 - 300 m)		NA	27	NA	NA	NA	NA

* Well field proposed in this block (Site : Billi Chaharmi) , NA : Not Available

Source: Groundwater Exploration Report, CGWB,2015

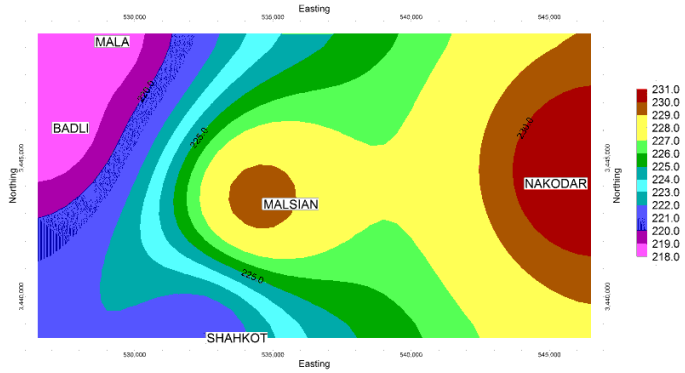
The Aquifer comprises of fresh and saline water and the major aquifer material is sand. The aquiclude and aquitard comprises of clay, clay with silt.

Exploratory Data Validated

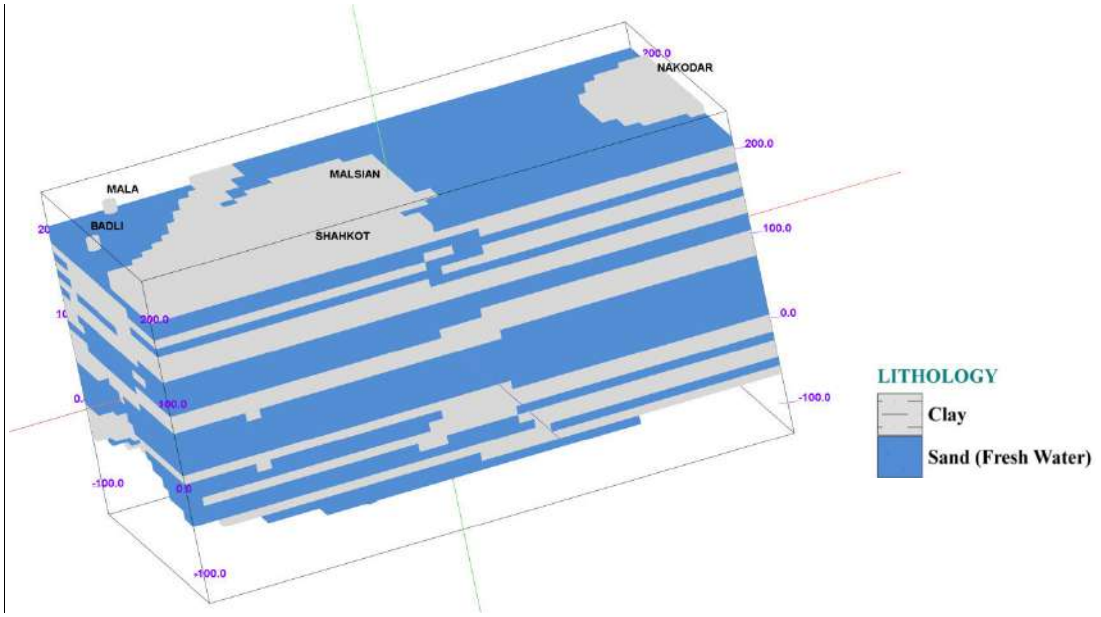
Source of Data	No. of exploration wells as per depth range (m)				Total
	<100	100-200	200-300	>300	
CGWB	0	0	0	2	**2**
WRED/PSTC/WSS	0	0	0	0	**0**
PRIVATE	0	2	0	0	**2**
TOTAL	**0**	**2**	**0**	**2**	**4**

The data is validated by selecting the deepest well in each quadrant(elevation map) and used for preparation of 3-D Litho models, 2-D Geological Cross Sections, Fence Diagrams and Aquifer Maps.

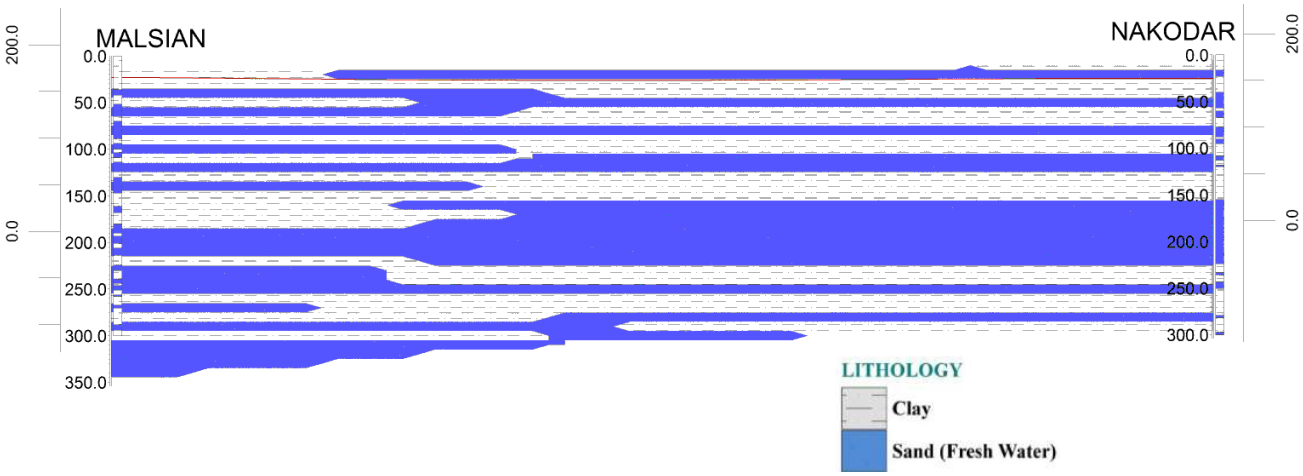
Elevation Map of Shahkot Block



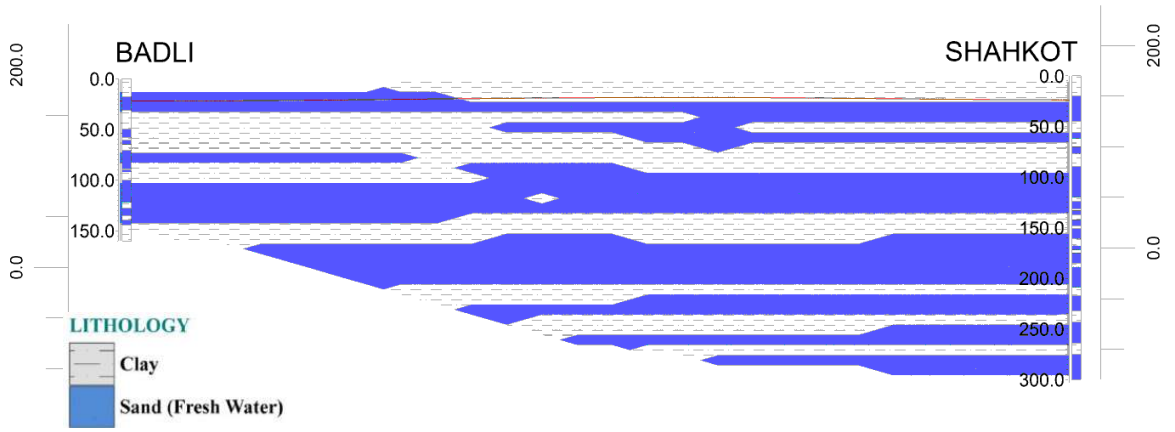
3-D Lithological model of Shahkot Block



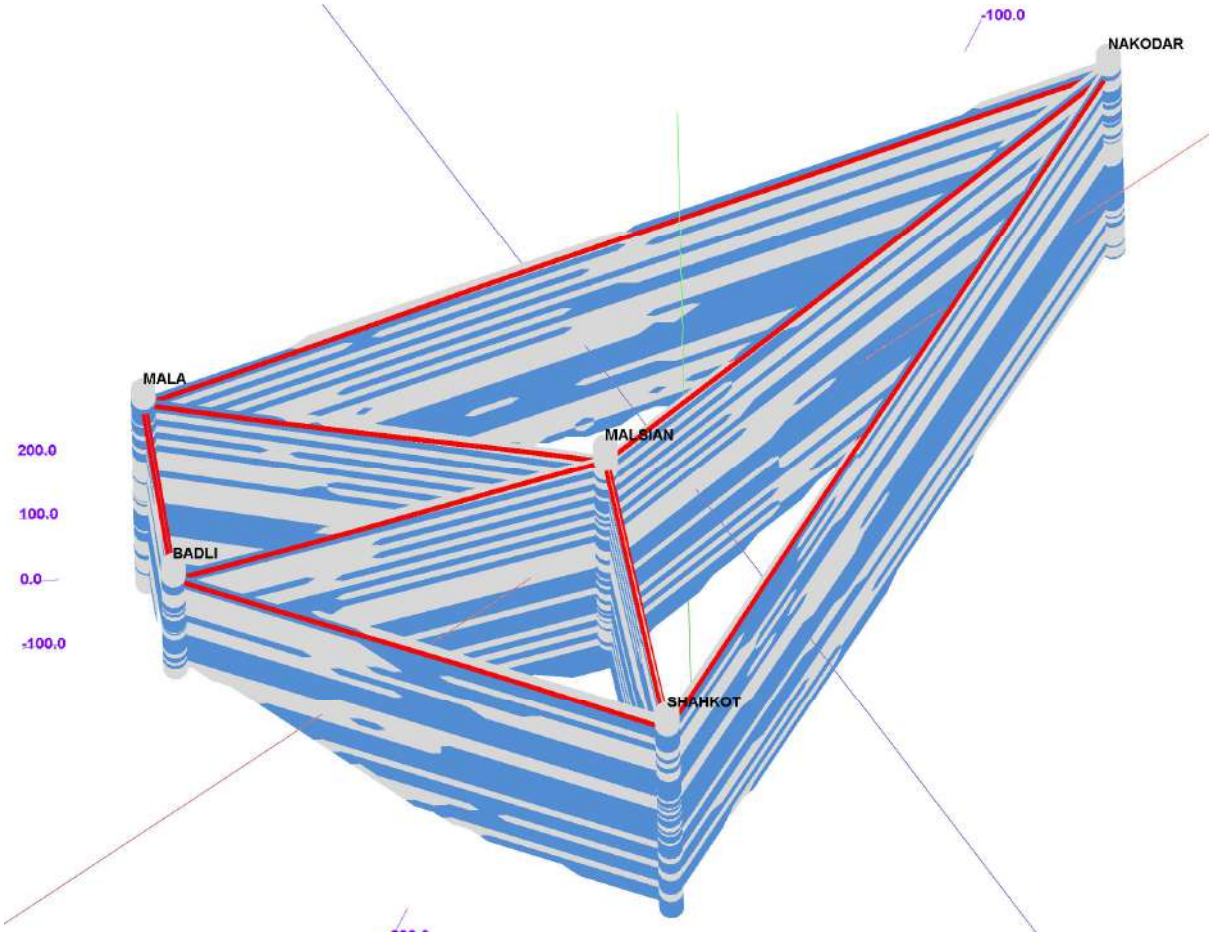
Lithological Cross section from Malsian to Nakodar



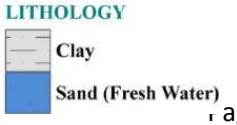
Lithological Cross section from Badli to Shahkot



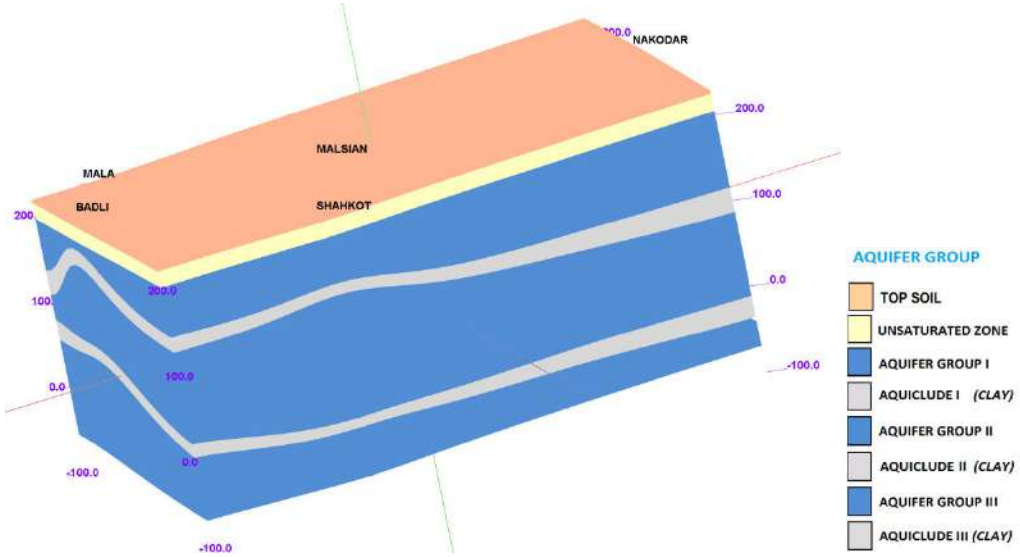
3-D Lithological Fence Diagram



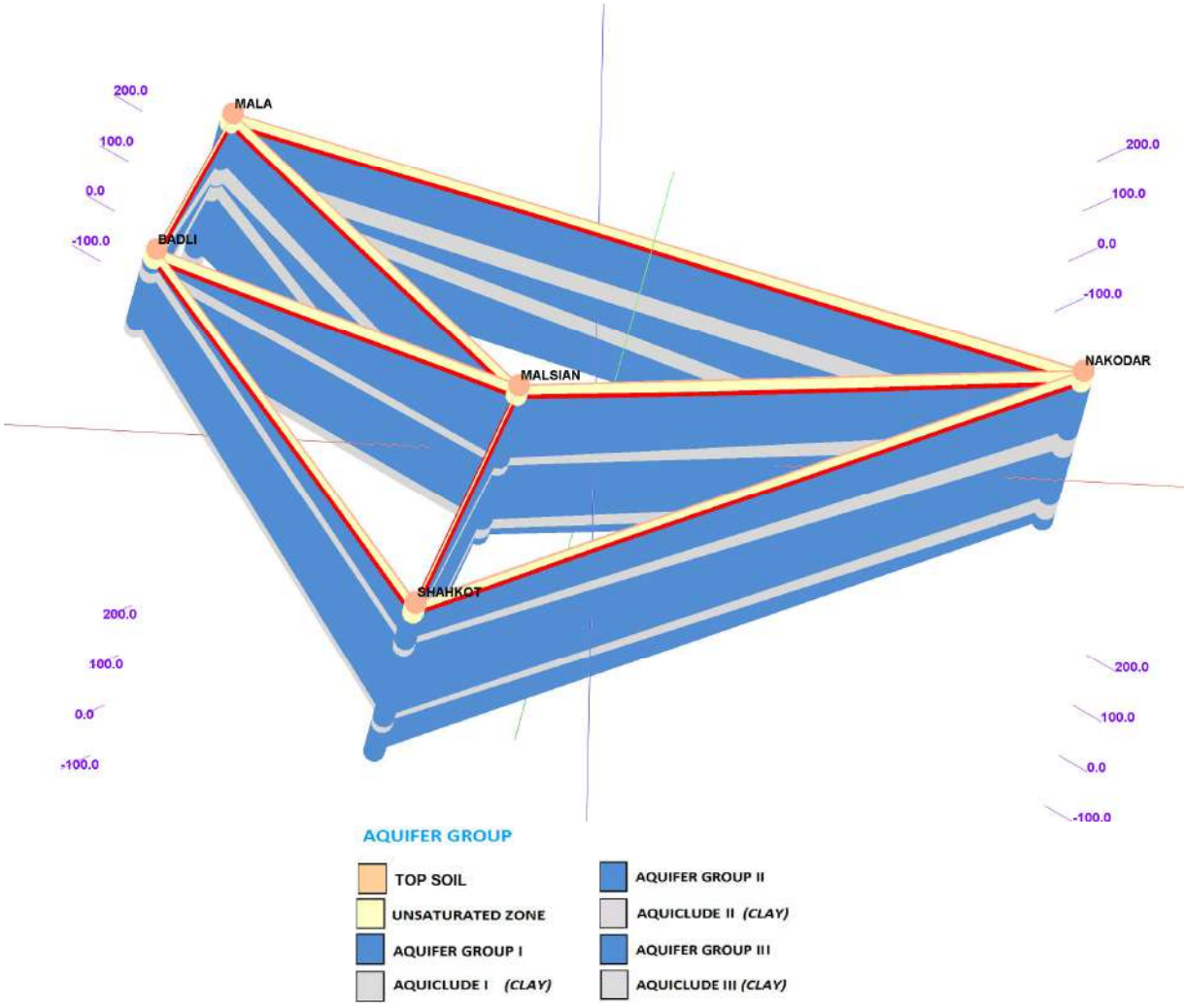
WATER LEVEL



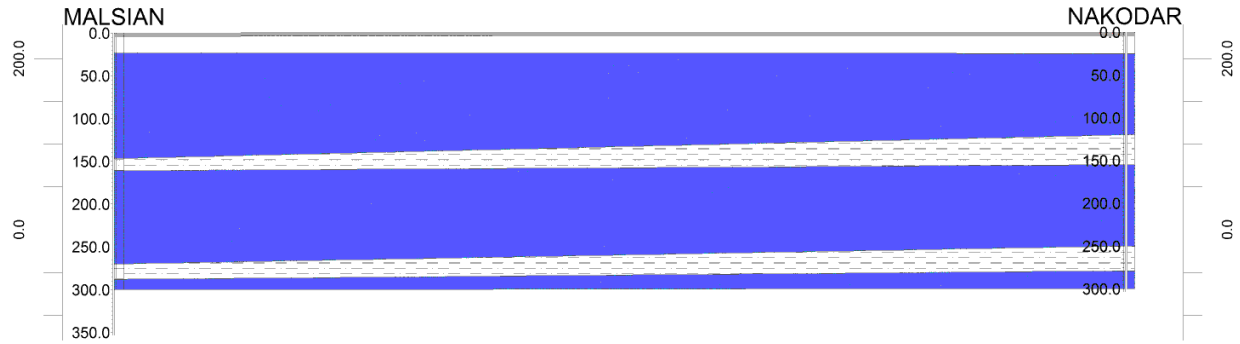
3-D Aquifer Disposition Model of Shahkot Block



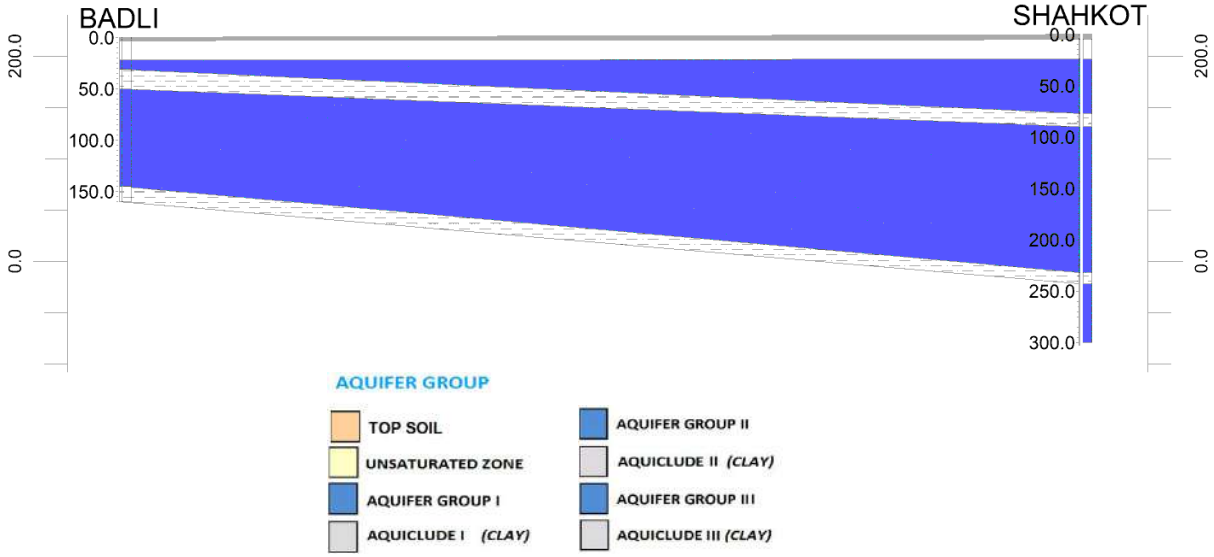
3-D Aquifer Disposition Fence Diagram



Aquifer Cross section along Malsian to Nakodar



Aquifer Cross section along Badli to Shahkot



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

Ground Water Resources upto the depth of 300m	Dynamic Fresh water resources (Aquifer-I)	81.36 mcm
	In-storage Aquifer-I (Specific Yield Concept)	1300 mcm
	In-storage Aquifer-II (Specific Yield Concept)	1213 mcm
	In-storage Aquifer-II (Storativity Concept)	6.99 mcm
	In-storage Aquifer-III (Specific Yield Concept)	468 mcm
	In-storage Aquifer-II (Storativity Concept)	26.90 mcm
	Total Resources	3096.10 mcm

Ground Water Extraction (as per 2013)	Irrigation	194.75 mcm
	Domestic & Industrial	5.58 mcm
Future Demand for domestic & Industrial sector (2025) (as per 2013)		7.09 mcm
Stage of Groundwater Development		246 %
Chemical Quality of ground water		Ground water in the area is alkaline in nature pH value is 8.38, EC value of the ground water is 555 µS/cm at 25^0C. RSC values are varying from 2.99 meq/L and the area is fit for irrigation..
Ground water Contamination Issues		Not Available (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: 66 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 2.14 mcm volume of water*

Demand side interventions

Advanced Irrigation Practices

Area proposed to be covered: Entire Shahkot Block (240.7 sq km)
Volume of Water expected to be conserved under advanced irrigation practices such as lining of underground pipelines (Kutcha channel) etc.: 62.39 mcm

Required Change in cropping pattern

Proposed change in cropping pattern: *Rice to Maize, Soyabean.*
The overexploitation can be managed at sustainable level (100%) by changing the Paddy crop
Area coverage: *40% of the total rice area needs to change i.e.* 66.80 sq km
Anticipated volume of water to be saved: 66.80 mcm

Net Annual Ground Water Availability 2013 (mcm)	*Total Irrigation Draft (present) (mcm)*	*Gross Draft all uses (present) (mcm)*	*Paddy area (Sq km)*	*Required Area to be Change from Paddy to Maize/ soya bean (Sq km)*	*Amount of Water Saved (mcm)*	*Gross draft after saving of water (mcm)*	*Present Stage of development (%)*	*Reduction in Stage of development after Maize/ soya bean (%)*	*Crop Diversified area (%)*
81.36	194.75	200.33	167	66.80	66.80	127.95	246	82.10	40

Alternate Water sources

Surface water sources: *Tanks, Ponds*

No.of Water tanks: 20

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.