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

Tarantaran District, Punjab

उत्तरी पश्चिम क्षेत्र, चंडीगढ़

North Western Region, Chandigarh

AQUIFER MAPPING

&

MANAGEMENT PLAN

TARNTARAN DISTRICT

PUNJAB

Central Ground Water Board
Ministry of Water Resources, River Development and Ganga Rejuvenation
Government of India
2018

CONTENTS

LIST OF FIGURES

LIST OF TABLES

AQUIFER MAPPING AND GROUND WATER MANAGEMENT IN HOSHIARPUR DISTRICT, PUNJAB
(2583 Sq.Km UNDERNAQUIFERUIM XII PLAN)

1.0 INTRODUCTION

The demand for the water has multiplied manifold with a rapid growth in population, agriculture /irrigation and industries. It has affected both the available surface and ground water resources. This has given acceleration to the ground water development. With the large scale development of ground water, it has become essential to monitor the behavior and to suggest measures to salvage the changed situation of the ground water system.

There has been a paradigm shift from "groundwater development" to "groundwater management" in the past two decades in the country. An accurate and comprehensive micro-level picture of ground water through aquifer mapping in different hydrogeological settings would enable robust groundwater management plans in an appropriate scale. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. This would help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India.

Central Ground Water Board (CGWB) implemented the Aquifer Mapping Programme in Punjab in four phases (**Fig. 1**) with the broad objective of preparing an Aquifer-wise management plan for the region. Various multi–disciplinary geo-scientific activities were undertaken in the study partly through in-house capacity of CGWB, DWRS, PSCTC and Private agencies for generation of additional micro-level hydrogeological data. This report primarily deals with Tarntaran district of Punjab State (**Fig. 1**), covered under Phase-I.

Tarn Taran district lies between 31^0 05', and 31^0 30' 05 north latitude and 74^0 30' and 75^0 15' 05"east longitudes. The area falls in Survey of India toposheetNos 44-I & 44-M. It has a geographical area of 2583 sq. km. It is bounded by Amritsar district in the north ,Kaputhala district in the east Pakistan in the west , and Ferozpur district in the south. The district headquarters is located at Tarn Taran. The total population of the district is 1120070 (census-2011) The district has decennial growth rate of 19.28 %. Density of population per square kilometre is 464. The area is well connected by roads and railways. National highways 1, 1a, and 15 pass through the area and connect the important towns falling in the tract. Major towns are

connected with broad gauge line of Northern Railways run through Khem Karan- Patti- Tarn Taran to Amritsar.

There are three tehsils namely Tarn Taran , Patti, and Khadur Sahib and five sub tehsils namely Jhabal, Chohla sahib, Khem Karan, Bhikiwind and Goindwal Sahib in the district.The district is divided into 8 development blocks namely Gandiwind, Bhikiwind, TarnTaran, Khadur Sahib, NausheraPannuan, Chohla Sahib, Patti, and Valtoha.

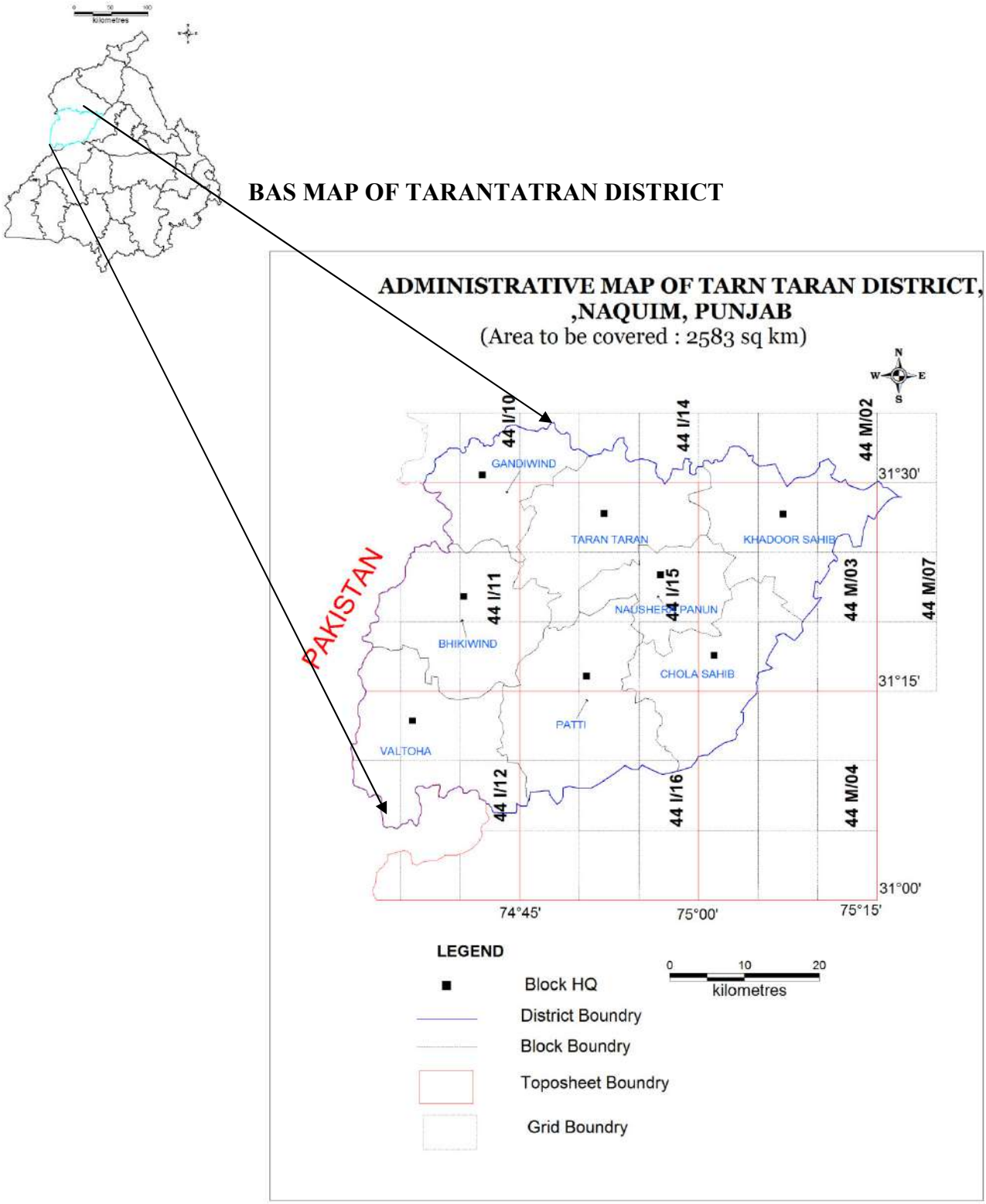


Fig:1 Base Map

2.0SOIL CHARACTERISTICS&LAND USE

Saline and alkaline soils occur in the district. Soils with salt content exceeding 0.2% are considered to be high salt soils and this concentration is injurious for plant growth. Soils whose

pH values exceed 9.0 have been classified as high alkali soils. The alkalinity render the soil impervious. The alkali soils present in the area has low fertility as compared to normal soils. The Soils of the district are categorized as tropical arid brown (weakly SOLONIZED), and arid brown soil (SOLONIZED).These soils are deficient in NPK.

2.1LAND USE, AGRICULTURE AND IRRIGATION

Tarn Taran is primarily an agricultural district. Agriculture constitutes the main source of economy, and most of the area fit for agriculture is being cultivated. The land utilization in the district is as follows:

1. Area under forests 5176 hac
2. Net area sown 217541 hac
3. Total cropped area 384541 hac

The main Rabi crops grown in the district are- wheat (185800 hect.), gram and barley,where askharif crops grown are- rice (166000 hect.), maize, bajra,sugar cane and cotton.

The district has a network of Upper Bari Doab canal which give rise to various branches such as Sabraon branch, Lowerkasur branch etc. These canals further feed their distributaries. The district has 100% irrigation facility, out of which 44.73% comes from ground water source. About 71% area of Patti block and 59% area of Tarn Taran Block is irrigated by canal water, and rest of the area of the district is irrigated with ground water.

3.0 CLIMATE

The climate of the district can be classified as tropical steppe,semi-arid and hot, which is mainly characterized by general dryness except for a short period during southwest monsoon season. There are four seasons in a year namely the cold season from November to March, hot season from April to June, south west monsoon season from the last week of June to the middle of September and the post monsoon season from September till the beginning of November. During cold season, a series of western disturbances affect the climate of the district. During the summer months i.e. From April to June, weather is very hot, dry and uncomfortable. The weather becomes humid and cloudy during July to September.

3.1 RAINFALL

The normal annual rainfall of the district is 545 mm, which is unevenly distributed over the area in 30days. The south-west monsoon which contributes 74%, sets in last week of June and withdraws in middle of September. July and August are the rainiest months. Rest 26% of annual rainfall occurs in the non-monsoon months in the wake of western disturbances and thunder storms.

Normal Annual Rainfall: 545 mm

Normal monsoon Rainfall: 405 mm

Temperature

Mean Maximum : 40.50C(May&June)

Mean Minimum : 4.50C(January)

Normal Rainy days : 30

4.0 GEOMORPHOLOGY

4.1 Physiography:

Physiographically the district represents alluvial plain. The topographic gradient is about 0.4m/km in the district. The district falls in Ravi sub basin, Beas Sub basin and Satluj sub basin of Indus Basin. The area of the district in Ravi sub basin in the northern part of the district is 1440 sq. Km. Whereas Beas sub basin in the central part of the district covers an area of 783 sq. Km. Satluj sub basin covers an area of 361 sq km in the eastern part of the district.

4.2 Drainage and Canal Network

The area is drained by Patti and NakashNadi besides several artificial drains. The area is however broadly drained by the river Sutlej and its distributaries from the southern boundary of the district.

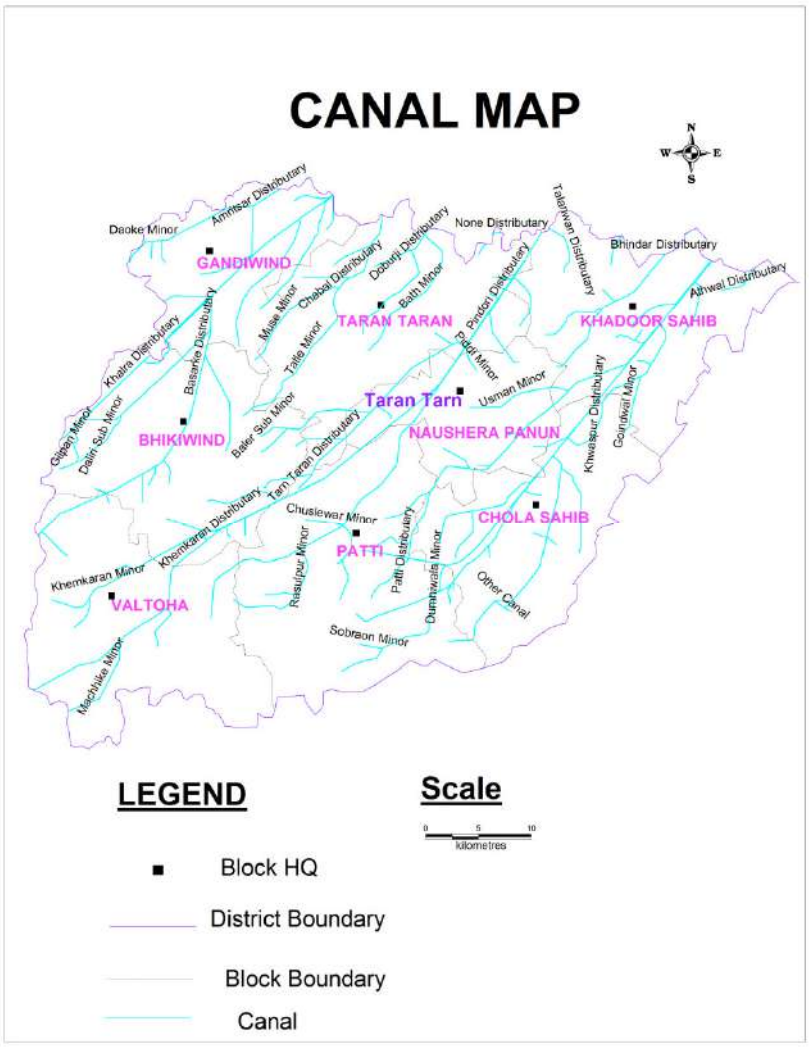


Fig 2:Canal map of Tarntarn District

5. DATA COLLECTION AND GENERATION

5.1 Tube well Logs

The Lithologs of Exploratory Well/ Observation well/ Piezometer/ productive wells of CGWB, and private agencies have been collected and those supported electrical logs have been validate for aquifer map preparation. The details are shown in table below,

Table 1:Data Availability of Exploration Wells of Tarn TaranDistrict

TARN TARAN DISTRICT

Sl.No	Source of data	Depth Range (m)			
		< 100	100-200	200-300	>300
1	CGWB	0	0	8	0
2	PRIVATE	0	51	0	0
Total		0	0	0	0

5.2 SPATIAL DATA DISTRIBUTION

The actual data of all the wells in the area are plotted on the map of 1:50000 scale with 5 min x 5 min grid (9km x 9km) and is shown in Fig: 2.The exploration data shows that majority of tube wells falls in the IIndAquifer. After data validation, only selected the deepest well in each quadrant is plotted on the map of 1.50000 scaleswith 5 min x 5 min grid (9km x 9km) and is shown in Fig: II. The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation.

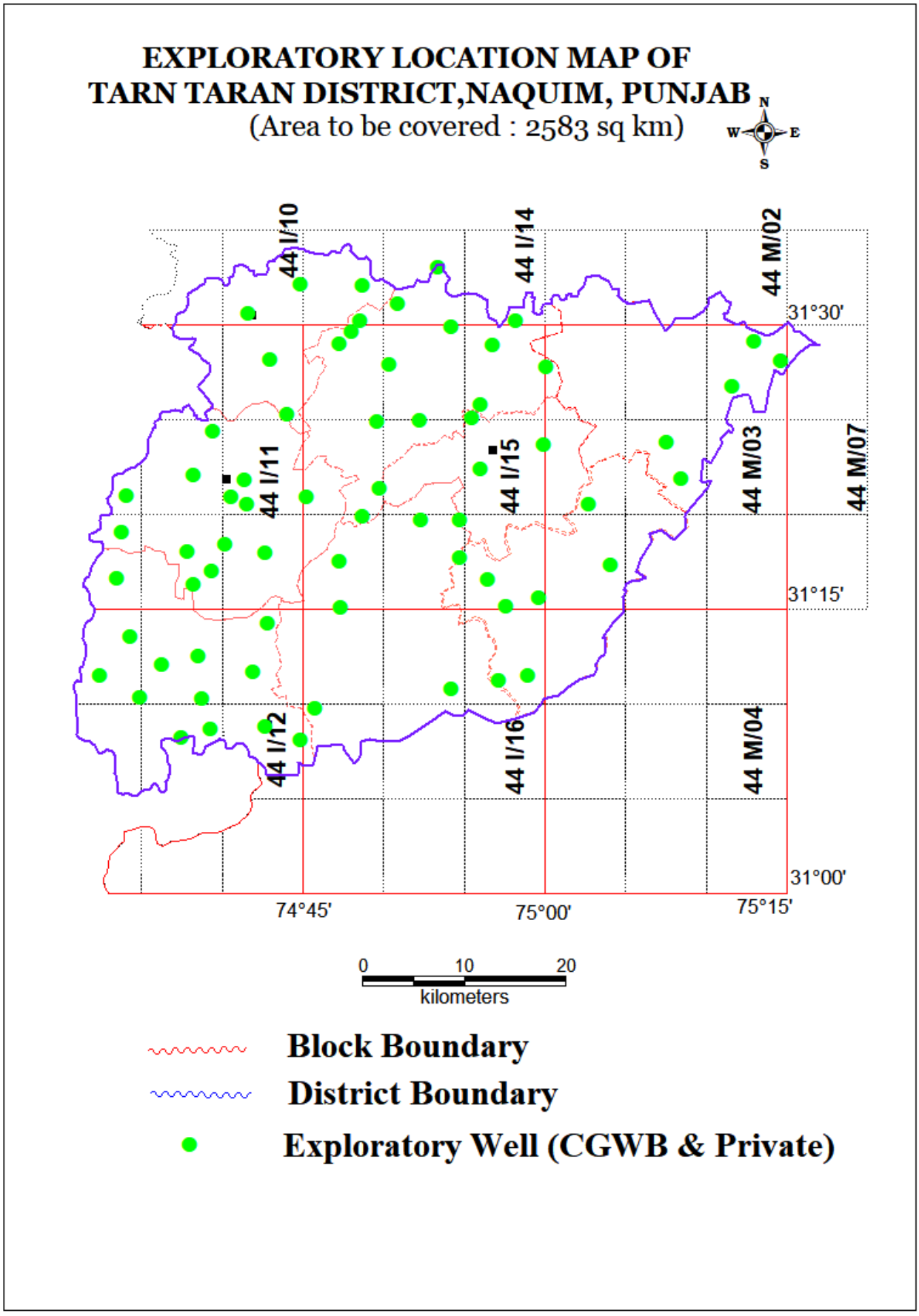


Fig:3 Exploratory Bore Hole Location

5.3 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have been validated for consideration to generate aquifer map. Thedeepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig 4.

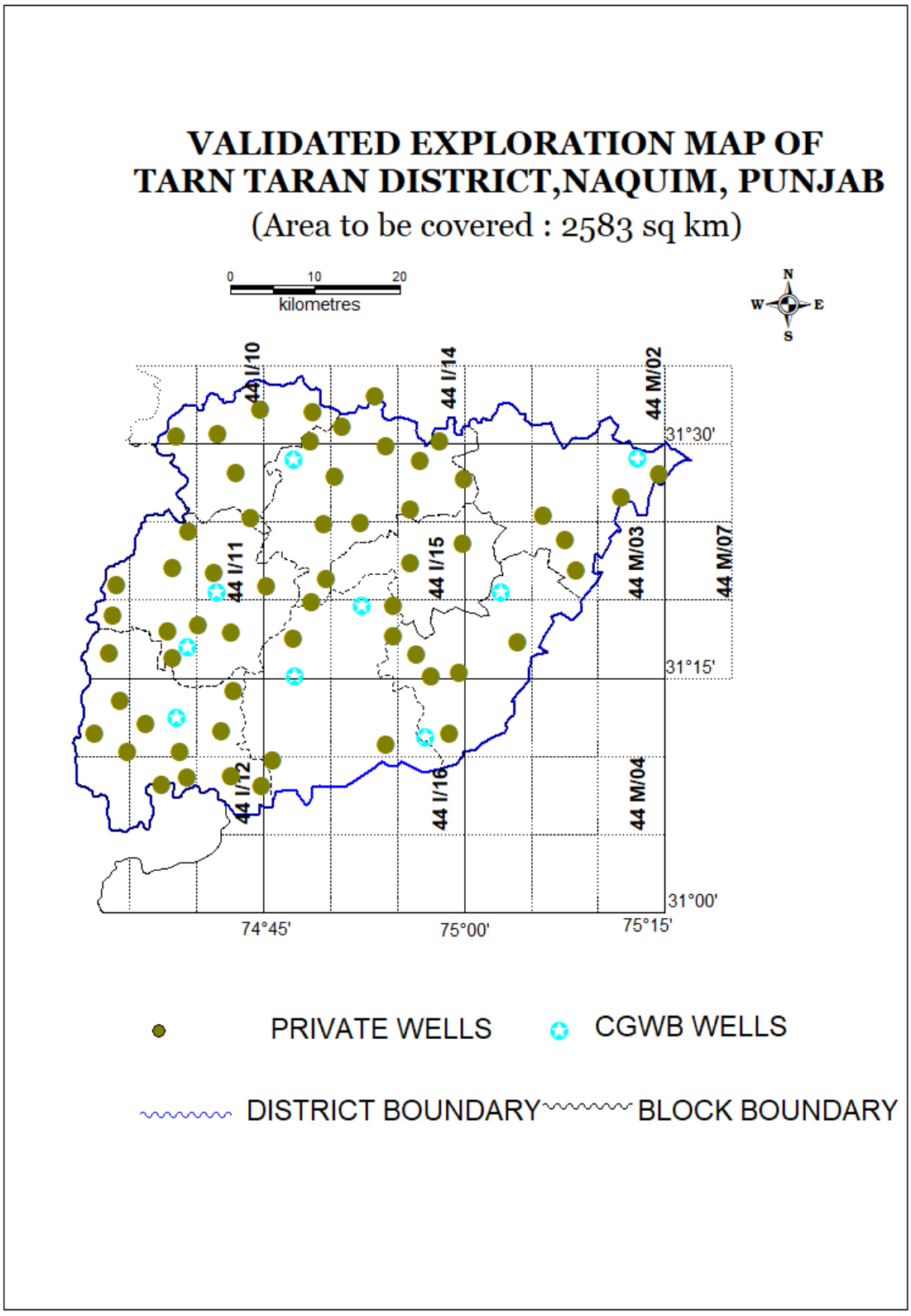


Fig:4Validated Exploration Data

Surface elevation map Fig 5 showsthat relief od district is from N E to SW and elevation range from 230 to 202. Differencebetween highestand ;lower elevation is 28m.

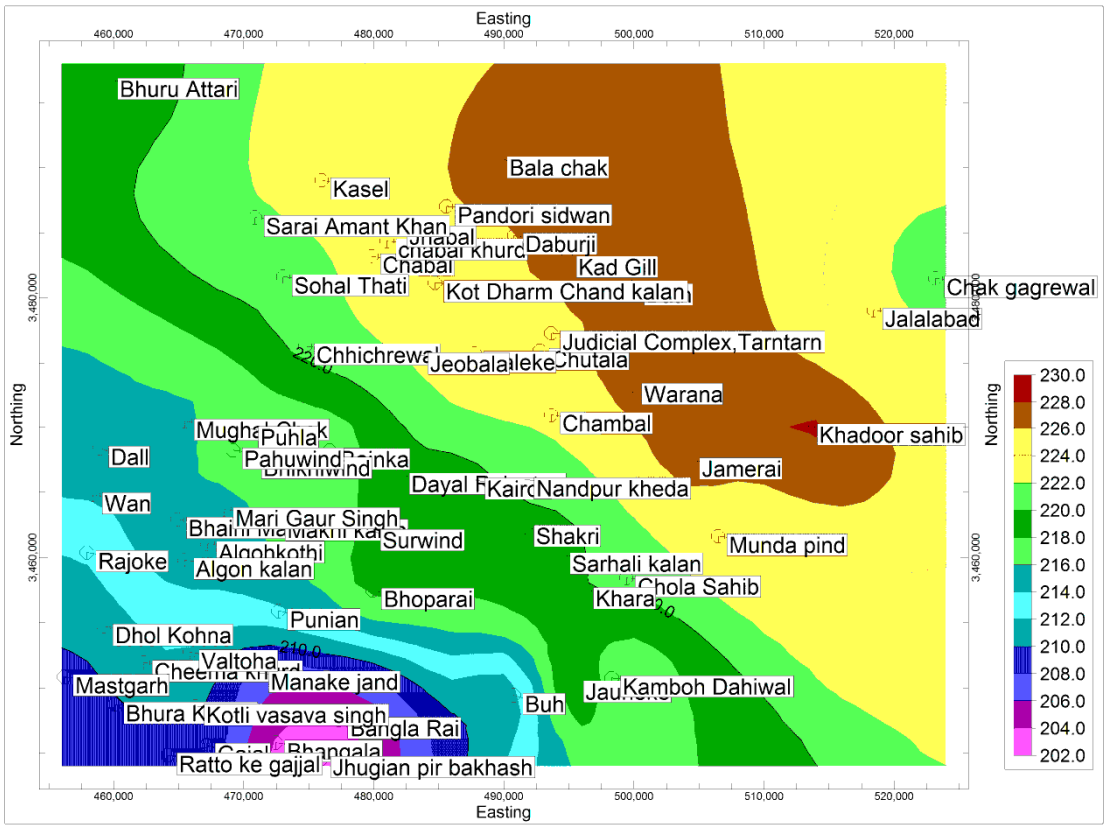


Fig 5: Elevation Contour Map-Tarntaran District

Table 2: Summaryof Optimised exploratory wells of TarnTaran District.

BLOCK	TOPOSHEET/QUADRANT	DEPTH RANGE (m)								ELEVATION (mamsl)	SOURCE OF DATA
		LOCATION	<100	LOCATION	100-200	LOCATION	200-300	LOCATION	>300		
NausheraPannuan	3B2 44I/ 15			Nandpurkheda	100					221	PRIVATE
Tarn taran	3B2 44I/ 14			Pandorisidwan	105					227	PRIVATE
Bhikhiwind	3C1 44I/ 11			Mari Gaur Singh	108					215	PRIVATE
Chohla sahib	3C1 44I/ 15			Sarhalikalan	109					219	PRIVATE
Valtoha	2C1 44I/ 12			Bhangala	112					201	PRIVATE
NausheraPannuan	2C2 44I/ 15			Chambal	112					222	PRIVATE
Tarn taran	1C1 44I/ 15			Kad Gill	113					227	PRIVATE
Gandiwind	1C1 44I/ 11			SohalThati	113					220	PRIVATE
Chohla sahib	3B3 44I/ 15			Shakri	114					219	PRIVATE
Tarn taran	3A1 44I/ 11			Wan	117					214	PRIVATE
Patti	1B 44I/ 16			Buh	118					207	PRIVATE
Valtoha	2B2 44I/ 12			Rattokegajjal	118					208	PRIVATE
Patti	2A 44I/ 16			Bangla Rai	119					203	PRIVATE
Tarn taran	1A 44M/ 03			Bath	119					229	PRIVATE

Tarn taran	3B1 44I/ 14			Balachak	122					228	PRIVATE
Bhikhiwind	3C2 44I/ 11			Makhikalan	125					217	PRIVATE
Tarn taran	1B1 44I/ 15			Daburji	126					226	PRIVATE
Valtoha	1A2 44I/ 12			Mastgarh	128					208	PRIVATE
Gandiwind	3C2 44I/ 10			SaraiAmant Khan	131					222	PRIVATE
Tarn taran	3A 44I/ 14			Jhabal	133					223	PRIVATE
Valtoha	1C2 44I/ 12			Manakejand	133					205	PRIVATE
Tarn taran	1B2 44I/ 15			KotDharm Chand kalan	137					225	PRIVATE
Valtoha	1C1 44I/ 12			Punian	142					215	PRIVATE
NausheraPannuan	2C1 44I/ 15			Warana	144					228	PRIVATE
Chohla sahib	3C2 44I/ 15			Chola Sahib	145					220	PRIVATE
Bhikhiwind	2A 44I/ 11			Dall	145					216	PRIVATE
Chohla sahib	3C3 44I/ 15			Khara	147					221	PRIVATE
Khadur sahib	1C1 44M/ 03			Chakgagrewal	148					220	PRIVATE
Valtoha	1B3 44I/ 12			Kotlivasavasingh	148					211	PRIVATE
NausheraPannuan	1C3 44I/ 15			Chutala	152					227	PRIVATE
Chohla sahib	3A 44M/ 03			Mundapind	153					224	PRIVATE
Bhikhiwind	3B1 44I/ 11			Bhaini Massa singh	155					217	PRIVAT

											E
Tarn taran	1C2 44I/ 15			Judicial Complex,Tarntarn	158					225	PRIVATE
Khadur sahib	2B 44M/ 03			Khadoor sahib	158					229	PRIVATE
Valtoha	2C2 44I/ 12			Jhugianpirbakhash	162					201	PRIVATE
Valtoha	3A2 44I/ 11			Rajoke	162					211	PRIVATE
Tarn taran	3A1 44I/ 15			DayalRajputan	166					220	PRIVATE
Tarn taran	2A1 44I/ 15			Jeobala	170					222	PRIVATE
Bhikhiwind	2C2 44I/ 11			Pahuwind	171					217	PRIVATE
Chohla sahib	1C1 44I/ 16			KambohDahiwal	178					213	PRIVATE
Gandiwind	3B 44I/ 10			BhuruAttari	182					218	PRIVATE
Gandiwind	3C1 44I/ 10			Kasel	182					223	PRIVATE
Tarn taran	1A1 44I/ 15			chabalkhurd	187					224	PRIVATE
Tarn taran	2B 44I/ 15			Daleke	187					224	PRIVATE
Valtoha	1A3 44I/ 12			BhuraKhona	195					209	PRIVATE
Bhikhiwind	2B 44I/ 11			Mughal Chak	195					215	PRIVATE
Valtoha	1B2 44I/ 12			Cheemakhurd	197					212	PRIVATE
Gandiwind	1C2 44I/ 11			Chhichrewal	197					221	PRIVATE
Patti	3A2 44I/ 15			Surwind	197					218	PRIVATE

Bhikhiwind	3B3 44I/ 11					Algonkalan	200			215	PRIVATE
Valtoha	1A1 44I/ 12					DholKohna	205			211	PRIVATE
Bhikhiwind	2A2 44I/ 15					Bainka	209			216	PRIVATE
Bhikhiwind	2C1 44I/ 11					Puhla	233			217	PRIVATE
Valtoha	2B1 44I/ 12					Gajal	247			210	PRIVATE
Bhikhiwind	3B2 44I/ 11							Algohkothi	300	214	CGWB
Bhikhiwind	2C3 44I/ 11							Bhikhiwind	300	217	CGWB
Patti	3A3 44I/ 15							Bhoparai	300	220	CGWB
Tarn taran	1A2 44I/ 15							Chabal	300	223	CGWB
Khadur sahib	1C2 44M/ 03							Jalalabad	300	223	PSTC
Chohla sahib	2A 44M/ 03							Jamerai	300	229	CGWB
Chohla sahib	1C2 44I/ 16							Jauneke	300	225	CGWB
Patti	3B1 44I/ 15							Kairon	300	219	CGWB
Valtoha	1B1 44I/ 12							Valtoha	300	213	CGWB

6. HYDROGEOLOGY

6.1 PREVIOUS WORK

The geological formations in the Tarn Taran district are of recent deposits known collectively as the Indo-Gangetic alluvium quaternary age, which consists of alluvial sand, clay and silt, beds of gravels and very coarse sand are rarely seen. Exploratory drilling at 14 places was carried out in the district. Out of these, six exploratory wells and two slim holes were drilled to ascertain sub-surface geology. Of these the exploratory well at Voltaha was abandoned due to very fine-grained aquifer material. The basement was not encountered even at deepest borehole was not encountered even at this site, the thickness of alluvium is assumed to be more than 500m. The yield of the six successful exploratory wells ranges between 484 to 4510 lpm for drawdown between 4.75 to 13.5 m. The hydraulic conductivity varies from 24 to 121 m/day. The value of storage coefficient varies between 2.08 x 10^{-2} to 8.04x 10^{-3}.Depth to water level in the district ranges from 10.08 to 19.68 m below ground level (bgl) during premonsoon period and between 10.56 to 20.10 m bgl during postmonsoon period.Water table slopes mainly from north -east to south- west indicating the flow direction in the district. Ground water in the district occurs under water table, Semi confined to confined conditions. The deeper aquifer is under semi-confined condition and composed of fine sand and is silty in nature. Major aquifer map of Tarntaran district dominated by older alluvium and younger alluvium. Major aquifer depicted in map Fig 6.

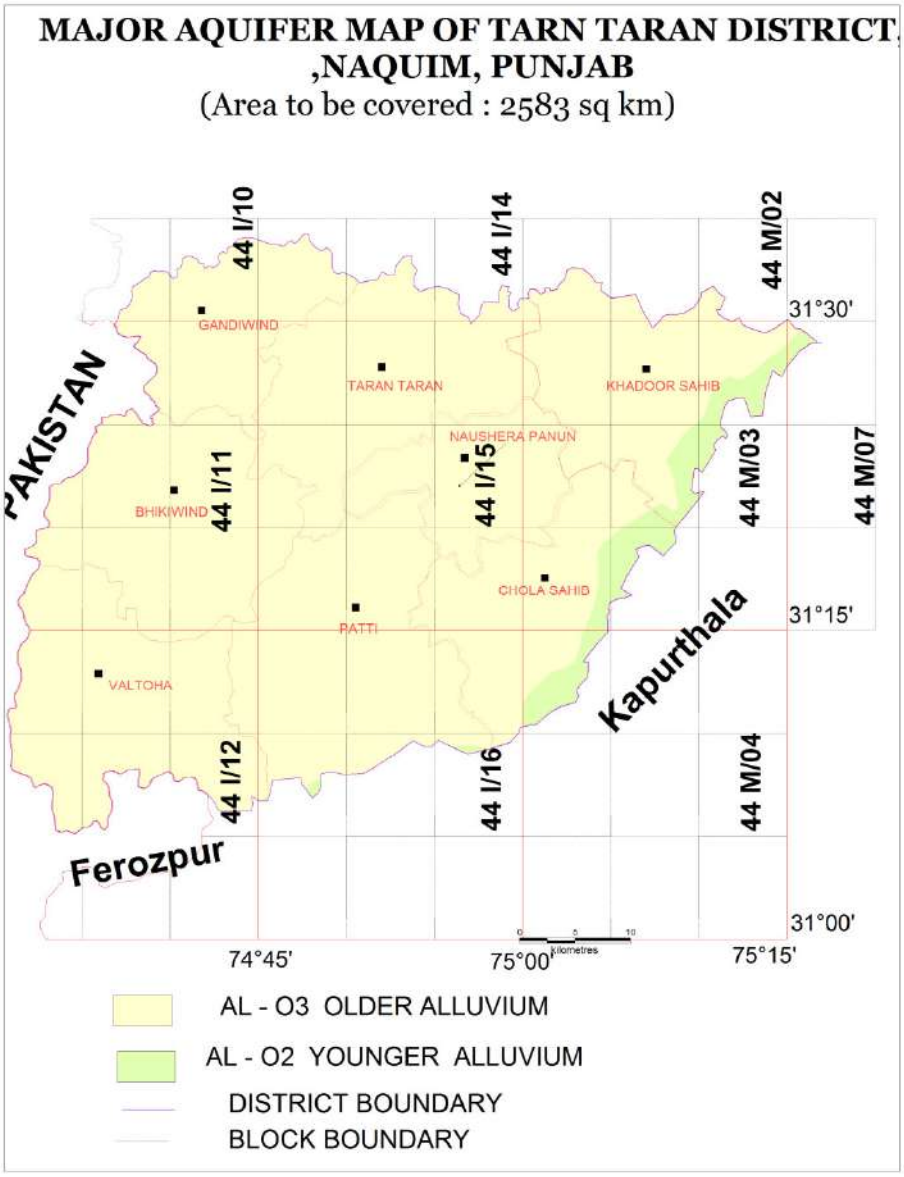
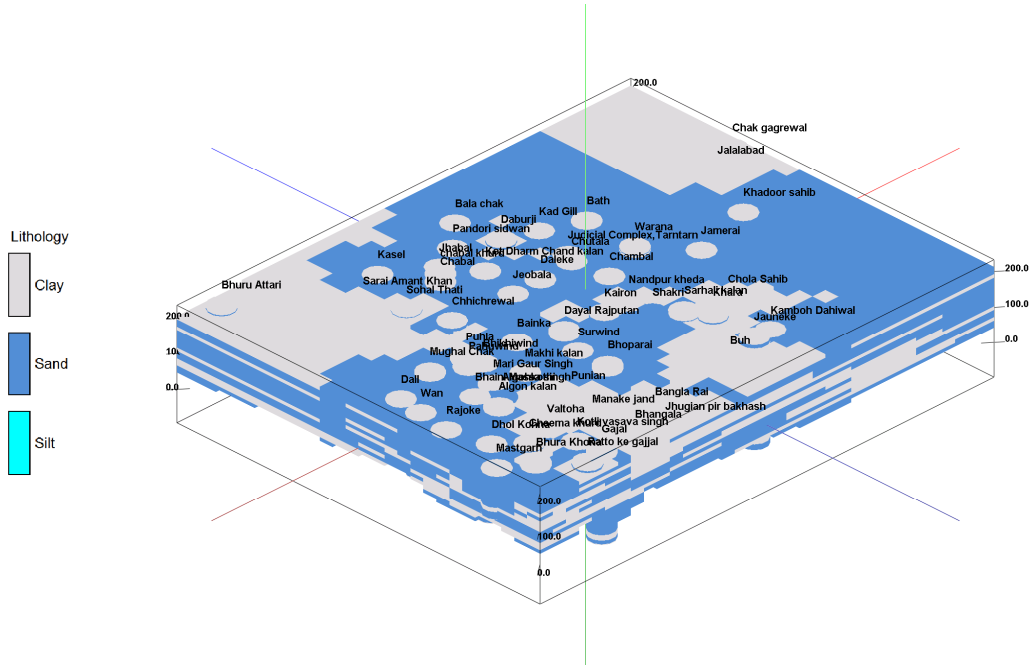


Fig:6 Major Aquifer of Tarntaran District

6.2 Present NAQUIFERUIM study

To understand the sub surface lithology and its disposition, the lithological data of the optimized wells drilled by CGWB, PHED and Private Agencies is plotted using the RockWorks15 software and a lithological model has been prepared and is shown in fig. The 2D lithology map and 3D lithological fence diagram has been prepared using the lithology model and are shown in fig 7 .

Fig 7: 3-Dimension Lithological Model of Tarntarn District



To present a three dimensional regional picture of the sub-surface conditions in the districts a fence diagram was prepared by synthesizing the various sub-surface sections. The fence diagram thus drawn reveals broad picture of disposition, inter relationship of granular zones, nature, geometry and extension of aquifers of the entire district. The aquifer group embodies a number of granular layers alternating with thick or thin clay lenses. Lithologs and fence location map showingof exploration wells and various block diagrams based on Lithology and Aquifer Group .

Fig 8 Fence selection Map

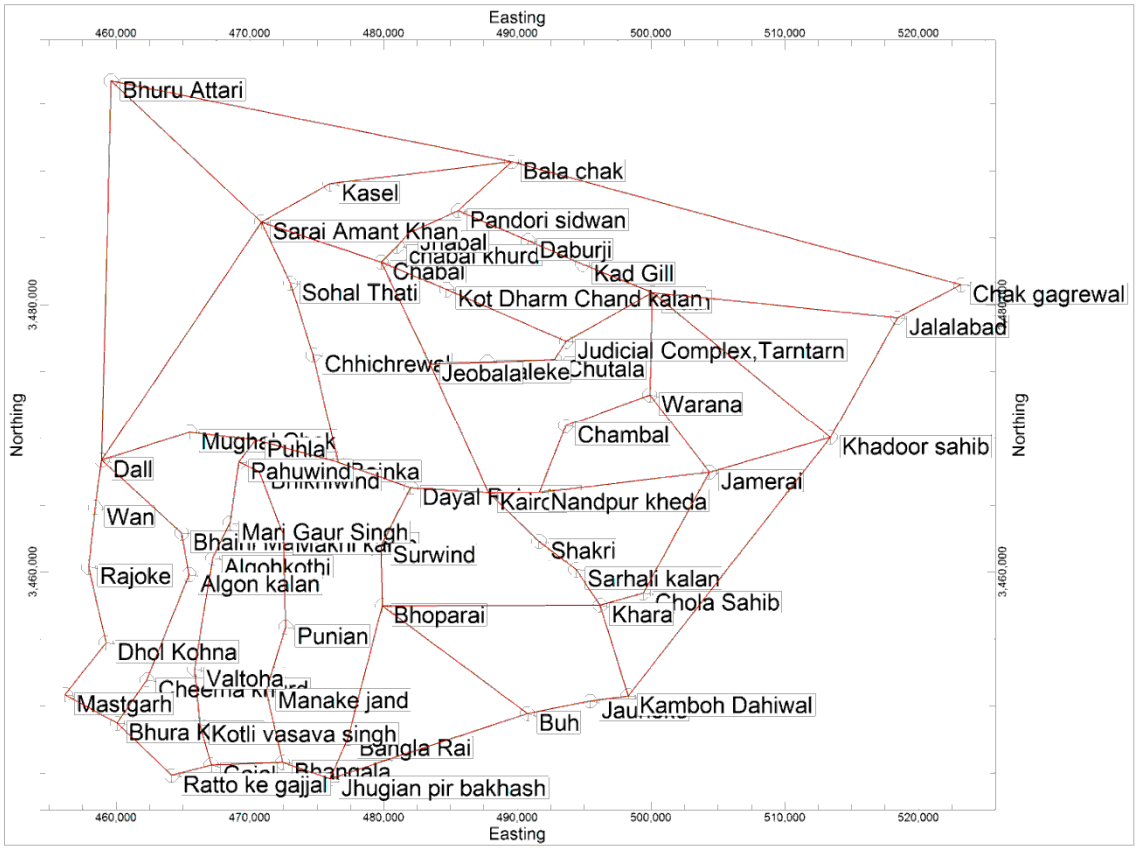


Fig 9: 3 Dimension Lithological Fence of Tarnatarn District

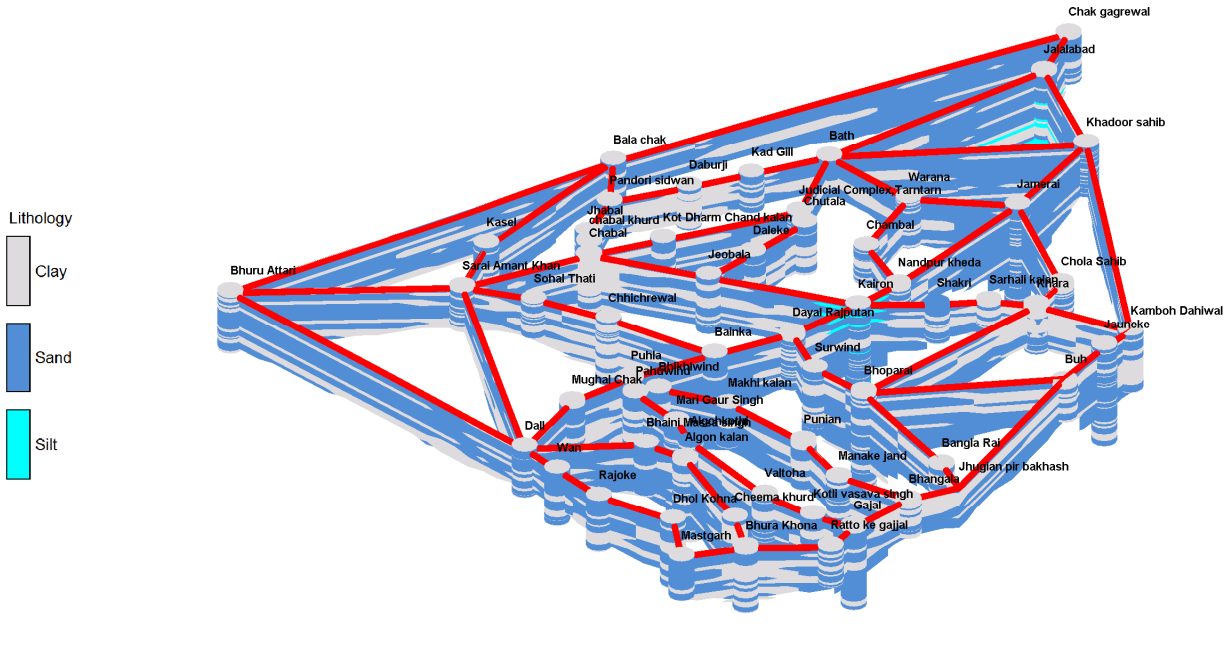
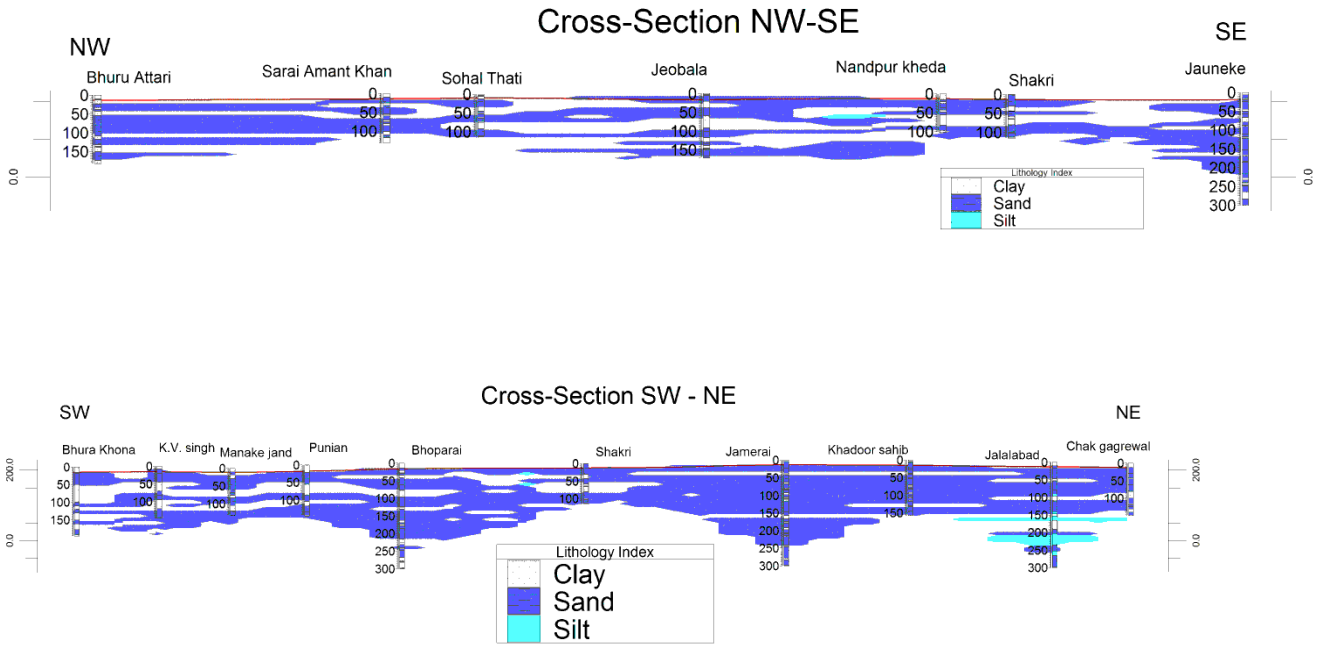


Fig 10: LithoCross sections of Tarn TaranDistrict



6.3 Aquifer Geometry (3-Dimensional)

A fence diagram was drawn to study the three dimensional regional picture of the sub-surface conditions in Tarn Tarandistrict area by synthesizing the various sub-surface sections. The fence diagram thus drawn reveals broad picture of disposition, inter relationship of granular zones, nature, geometry and extension of aquifers of the entire district (Fig. 5.3.6a &5.3.6b). 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 first water table aquifer extends all over the district composed of less coarse sediments as compared to other groups. This aquifer is overlain by a thin clay layer of about 0.5 to 2.5 m. thickness and is also underlain by clayey group of about 3 to 6 m. thick.

The thickness of water table aquifers varies from 20 to 40m and it extends maximum down to 50m. The granular material mainly consists of fine to medium sand. In the south-western part of the district there are 6-8 granular zones separated by clay beds. The thickness of granular material ranges between 15 to 85m and the aquifers are composed of fine to medium sand. The thickness of these clay beds varies from 10 to 45m. The clay beds are laterally and vertically extensive in nature and contain some kankar also. In the extreme SW part the thickness of clay beds is maximum. The water table aquifer extends down to 10-30m depth. There is general trend of decrease in percentage of granular material from NE to SW. The percentage ranges from 66% in north – eastern part (Jandiala Guru) to 89% near Boparai in south – western part. Higher percentage of sand in the district may be due to proximity to source area. Aquifer Group thickness and depth ranges minimum and maximum are shown in Striplogs showing Lithology and block diagrams based on Lithology and Aquifer Group are shown in Fig.11.

Table:3 Aquifer group depth and thickness range of Tarntaran District

Aquifer Group	Depth Range (mbgl)		Thickness (m)	
	From	To	Min	Max
Aquifer I	15	138	46	123
Aquifer II	55	285	35	218
Aquifer III	191	300	85	109

Fig.11 3Dimesion Aquifer Model-Tarntaran District

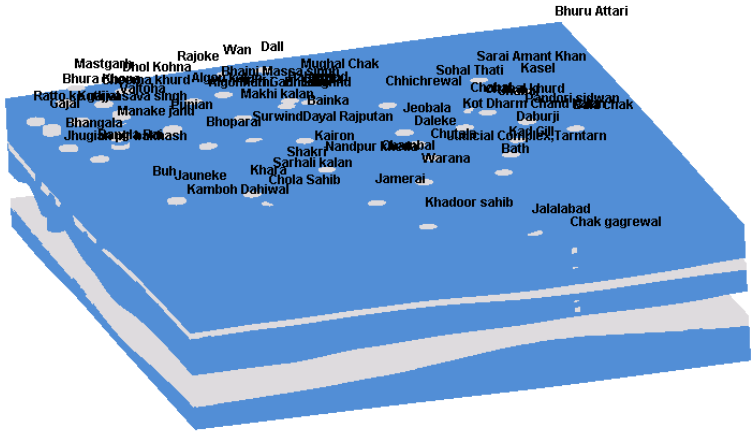
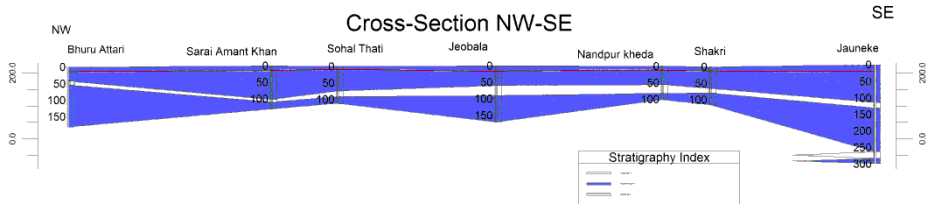
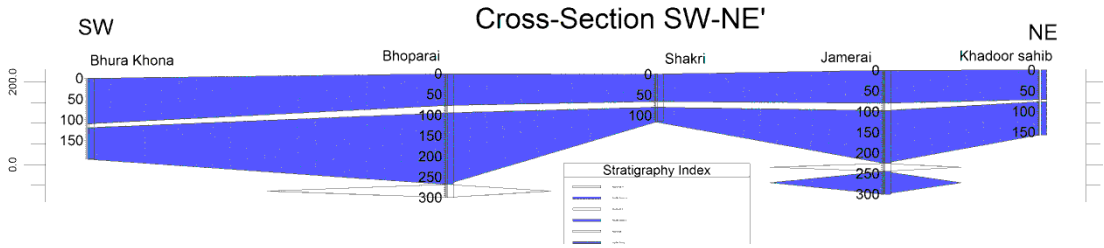


Fig.12:Aquifer Section (2D) map of Tarn Taran District





7. 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 up to 300m depth. The assessment of Dynamic and in storage Ground Water Resources of the study area have been carried out jointly by CGWB, Water Resources & Environment Directorate, Department of Irrigation, on the basis of Groundwater Estimation Committee (GEC) (1997) methodology based on data available and as per the revised methodology for the year 2013.

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 fresh 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 Water Resources & Environment Directorate, Department of Agriculture, and Punjab Water Resource Management & Development Corporation, Punjab

7.1 Unconfined aquifers

Dynamic Resources

As per Groundwater Resources Estimation 2013, the ground water development in all blocks has exceeded the available recharge, thus all blocks**Bhikhiwind,Chola Sahib, Gandiwind, Khaduar Sahib, NaushehraPanuan Patti , Tarntaran, and Valtoha**have been categorized as **over exploited**. Stage of ground water development in the Tarntaran district has been assessed to be **133%**.

Table 4: Dynamic Ground Water Resource & Development Potential (as on 31.03.2013):

S. No.	Assessment Unit/Distict	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	Provision for domestic, and industrial requirement supply to 2025 years	Net Annual Ground Water Availability for future irrigation development	Stage of Ground Water Development 7/4*100 (%)
1	2	3	4	5	6	7	8	9
1	**BHIKHIWIND**	17673	21864	274	22138	405	-4596	**125**
2	**CHOLA SAHIB**	16175	18586	265	18851	393	-2803	**117**
3	**GANDIWIND**	26771	28507	166	28673	245	-1982	**107**
4	**KHADUR SAHIB**	17541	25604	302	25905	447	-8509	**148**
5	**NAUSHEHRA PANUAN**	9975	16210	209	16419	310	-6545	**165**
6	**PATTI**	16085	25377	494	25870	727	-10019	**161**
7	**TARN TARAN**	22192	27726	600	28326	879	-6413	**128**
8	**VALTOHA**	14608	21792	222	22014	330	-7514	**151**
	TOTAL	**141020**	**185665**	**2531**	**188196**	**3736**	**-48381**	**133**

Instorage Ground Water Resources

As per revised guidelines recommended by the Central Level Expert Group on ground water 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

7.2 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 11. However, since ground water withdrawals from confined aquifer are known to have serious environmental degradation effects, the preliminary assessment of ground water resources in confinedaquifer is restricted to the estimation of ground water storage under pressure conditions only but here the storage under de-saturation is also computed.

Storativity Concept:

ii)	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

Specific Yield Concept:

ii)	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 modelling approach.

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

Fig 13: Concept for Resource Estimation in Unconfined and Confined Aquifer System

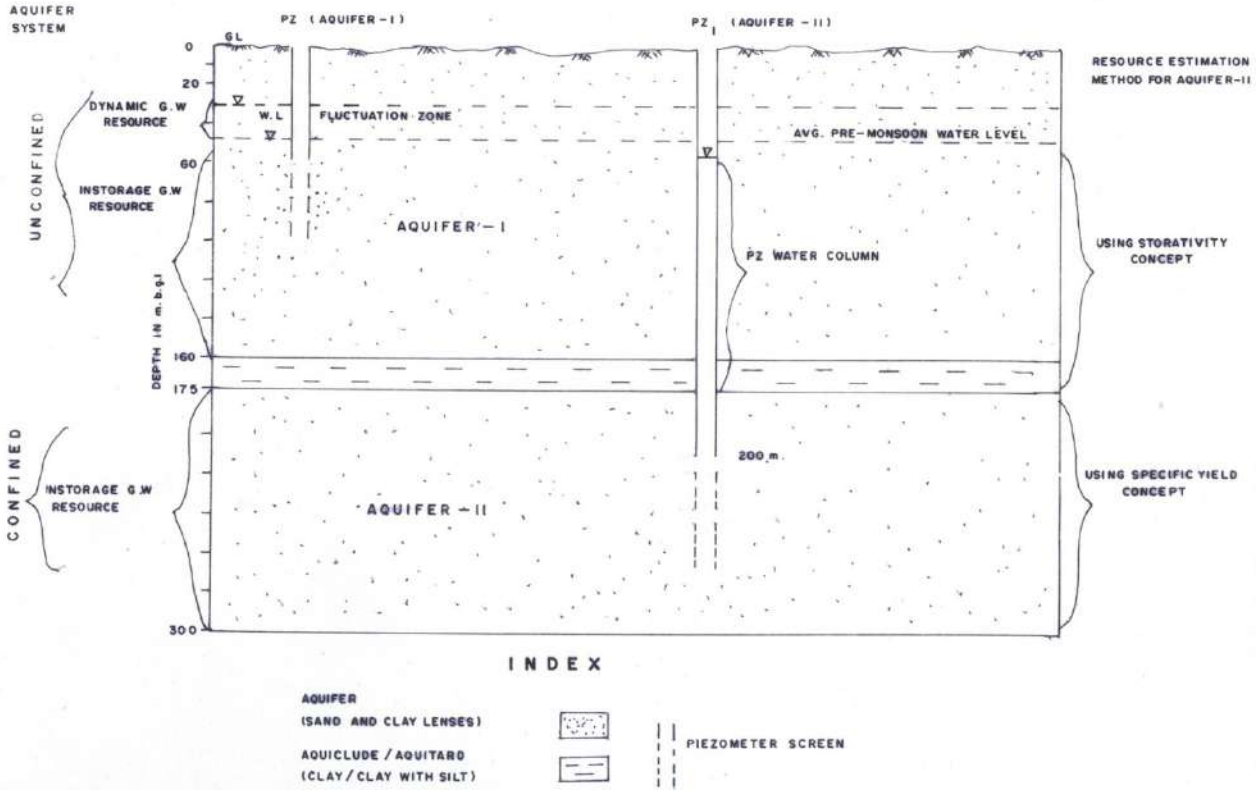


Table 5: BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED AQUIFER-I

Annexure II A-1 (for unconfined aquifer, alluvial area)													
GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF TARN TARAN DISTRICT (2013)													
Type of Ground Water Assessment Unit (Block):													
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)				Average Pre-monsoon Water Level (m bgl)	Depth to bottom of unconfined aquifer (m bgl)	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Thickness of the Granular Zone in unconfined aquifer below Pre-monsoon WL (m)	Average Specific Yield	In-Storage Ground Water Resources [(6)*(11)*(12)*] FRESH (ham)	In-Storage Ground Water Resources [(7)*(11)*(12)*] BRAKISH/SALINE (ham)
			Total Geographical Area	Assessment Area									
				Total	Fresh Water	Brackish/Saline Water							
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Tarntaran												
1	Bhikhiwind	Alluvium	33300	33300	33300	0	14.19	60	45.81	40	0.072	96407.5	0
2	Chola Sahib	Alluvium	34980	34980	34980	0	17.435	89	71.57	62	0.072	155558.9	0
3	Gandiwind	Alluvium	33690	33690	33690	0	14.78	87	72.22	63	0.072	151871.8	0
4	Khadur Sahib	Alluvium	34150	34150	34150	0	18.16	88	69.84	61	0.072	150380.2	0
5	NausherPanuan	Alluvium	19920	19920	19920	0	18.66	85	66.34	61	0.072	87689.4	0
6	Patti	Alluvium	37550	37550	37550	0	15.095	90	74.91	65	0.072	176315.3	0
7	Tarntaran	Alluvium	32000	32000	32000	0	17.53	64	46.47	43	0.072	99164.2	0
8	Voltaha	Alluvium	32750	32750	32750	0	11.61	61	49.39	43	0.072	101252.5	0
	Dist.Total (ham)		**258340**	**258340**	**258340**	**0**						**1018640**	**0**
	Dist.Total (mcm)											**10186.40**	**0.00**

Table 6: BLOCK WISE INSTORAGE GROUND WATER RESOURCES - CONFINED (AQUIFER II)

Annexure II A-1 (for AQUIFER GROUP II, alluvial area)															
GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF TARN TARAN DISTRICT (2013)															
Type of Ground Water Assessment Unit (Block):															
Sr. No.	Name of Assessment Unit	Areal extent (ha)			water level	Top Aquifer II (m bgl)	water coloumn in PZ	Depth to bottom of Aquifer II (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 value of Storativity	average sp.Yield	In-Storage Ground Water Resources [(6)*(b)*(12)*] FRESH (ham)	in storage ground water resource with in aquifer [(6)*(11)*(c)*] FRESH	Total Ground Water Resource (13) + (d)FRESH
		Total Geographical Area	Assessment Area												
			Total	Fresh Water											
1	2	4	5	6	a	8	b	9	10	11	12	c	13	d	14
	Tarntaran														
1	Bhikhiwind	33300	33300	33300	13.33	73	59.67	286	226.33	188	0.00238	0.072	4729	450749	455478
2	Chola Sahib	34980	34980	34980	12.65	109	96.35	244	147.65	117.5	0.00238	0.072	8021	295931	303952
3	Gandiwind	33690	33690	33690	14.42	96	81.58	218	136.42	100	0.00238	0.072	6541	242568	249109
4	Khadur Sahib	34150	34150	34150	15.95	106	90.05	190	99.95	76	0.00238	0.072	7319	186869	194188
5	NausherPanuan	19920	19920	19920	12.92	101	88.08	228	139.92	103	0.00238	0.072	4176	147727	151903
6	Patti	37550	37550	37550	11.93	111	99.07	269	169.93	132	0.00238	0.072	8854	356875	365729
7	Tarntaran	32000	32000	32000	13.69	76	62.31	220	157.69	96	0.00238	0.072	4746	221184	225930
8	Voltaha	32750	32750	32750	12.37	76	63.63	239	175.37	111	0.00238	0.072	4960	261738	266698
	Dist.Total(ha	258340	25834	25834									31875	2163640	2212986

	m)		0	0											
	Dist.Total (mcm)												318.75	21636.40	22129.86

Table 7: BLOCK WISETOTAL AVAILABLE GROUND WATER RESOURCES IN AQUIFERS UP TO 300m DEPTH

Annexure II A-1 (for AQUIFER GROUP III, alluvial area)* upto depth 300m															
GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF TARN TARAN DISTRICT (2013)															
Type of Ground Water Assessment Unit (Block):															
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (ha)			water level	Top Aquifer III (m bgl)	water colou mn in PZ	Depth to bottom of Aquifer III (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 value of Storativity	average sp.Yield	In-Storage Ground Water Resources [(6)*(b)*(12)*] FRESH (ham)	in storage ground water resource with in aquifer [(6)*(11)*(c)*] FRESH	Total Ground Water Resource (13) + (d)FRESH
			Total Geographical Area	Assessment Area												
				Total	Fresh Water											
1	2	3	4	5	6	a	8	b	9	10	11	12	c	13	d	14
	Tarntaran															
1	Bhikhiwind	Alluvium	33300	33330	33330	20	286	266	300	34	0	0.00238	0.072	21082	0	21082
2	Chola Sahib	Alluvium	34980	34980	34980	20	264	244	300	56	23	0.00238	0.072	20314	57927	78240
3	Gandiwind	Alluvium	33690	33690	33690	20	240	220	300	80	52	0.00238	0.072	17640	126135	143775
4	Khadur Sahib	Alluvium	34150	34150	34150	20	198	178	300	122	88	0.00238	0.072	14467	216374	230842
5	NausherPan	Alluvium	19920	19920	19920	20	248	228	300	72	37	0.00238	0.072	10809	53067	63876

	uan															
6	Patti	Alluvium	37550	37550	37550	20	290	270	300	30	8	0.00238	0.072	24130	21629	45758
7	Tarntaran	Alluvium	32000	32000	32000	20	238	218	300	82	52	0.00238	0.072	16603	119808	136411
8	Voltaha	Alluvium	32750	32750	32750	20	258	238	300	62	36	0.00238	0.072	18551	84888	103439
	Dist.Total (ham)		**258340**	**258340**	**258340**									**31875**	**679828**	**823424**
	Dist.Total (mcm)													**318.75**	**6798.28**	**8234.24**

Table 8: BLOCK WISETOTAL AVAILABLE UNSATURATED GRANULAR ZONE

Annexure II A-1 (for unconfined aquifer, alluvial area)

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OFT TARNTARAN DISTRICT (2013)

BLOCK WISE INSTORAGE GROUND WATER RESOURCES IN UNCONFINED AQUIFER –I									
Sr. No.	**Name of Assessment Unit**	**Areal extent (ha)**				**Average Unsatuated zone (m bgl)**	**Thickness of the Granular Zone in Unsaturated part (m)**	**Average Specific Yield**	**In-Storage Ground Water Resources [(6)*(11)*(12)*] FRESH (mcm)**
		Total Geographical Area	**Assessment Area**						
			Total	**Fresh Water**	**Brackish/Saline Water**				
1	**2**	**3**	**4**	**5**	**6**	**7**	**10**	**11**	**12**
	TARNTARAN								
1	Bhikhiwind	33300	33300	33300	0	14.19	6	0.012	2398
2	Chola Sahib	34980	34980	34980	0	17.435	7	0.012	2938
3	Gandiwind	33690	33690	33690	0	14.78	6	0.012	2426
4	Khadur Sahib	34150	34150	34150	0	18.16	9	0.012	3688
5	NausherPanuan	19920	19920	19920	0	18.66	8	0.012	1912
6	Patti	37550	37550	37550	0	15.095	7	0.012	3154

7	Tarntaran	32000	32000	32000	0	17.53	9	0.012	3456
8	Voltaha	32750	32750	32750	0	11.61	5	0.012	1965
Dist.Total (mcm)		**258340**	**258340**	**258340**	**0**				**21937**
Dist.Total (bcm)									**21.94**

Table9. AVAILABILITY OF TOTAL FRESH GROUNDWATER RESOURCES IN TARN TARAN DISTRICT UPTO 300 METRE DEPTH

Sl.No	**BLOCK**	*Dynamic Groundwater Resources (2013) AQUIFER-I*	*In-storage Groundwater Resources AQUIFER-I*	**Total Groundwater Resources AQUIFER-I [(3)+(4)]**	**In-storage Groundwater Resources AQUIFER-II**	**In-storage Groundwater Resources AQUIFER-III**	**Total Availabilty of Groundwater Resources [(5)+(6)+(7)]**	
							ham	**mcm**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	Bhikhiwind	*17673.08*	*96407.50*	114081	455478	21082	590640	5906.4
2	Chola Sahib	*16174.96*	*155558.86*	171734	303952	78240	553926	5539.3
3	Gandiwind	*26771.03*	*151871.82*	178643	249109	143775	571528	5715.3
4	Khadur Sahib	*17541.44*	*150380.21*	167922	194188	230842	592951	5929.5
5	NausherPanuan	*9975.05*	*87689.43*	97664	151903	63876	313443	3134.4
6	Patti	*16084.94*	*176315.27*	192400	365729	45758	603888	6038.9
7	Tarntaran	*22192.19*	*99164.16*	121356	225930	136411	483697	4837.0
8	Voltaha	*14607.70*	*101252.52*	115860	266698	103439	485997	4860.0
Dist.Total (ham)		***141020***	***1018640***	**1159660**	**2212986**	**823424**	**4196070**	41960.7
Dist.Total (mcm)		**1410**	**10186**	**11597**	**22129.86**	**8234.24**	**41961**	419.6

8 HYDROCHEMISTRY

8.1 Sample Collection, Chemical Analysis and Chemical Characteristics

In order to ascertain the variation in chemical quality of ground water from aquifer-I, water samples were collected during pre-monsoon period from the Ground Water Observation Wells (GWOW). The major element and arsenic analyses were carried out as per standard methods at Regional Chemical Laboratory, North Western Region, and Chandigarh. The details of sample locations are shown in Appendix-III and depicted in Fig.

The specifications for drinking water issued by Bureau of Indian standards (BIS) in 2012, have been revised and issued under publication specification IS: 10500:2012 (Table-3). The chemical characteristics of water samples analysed (Table-4) and the common source and distribution are discussed below.

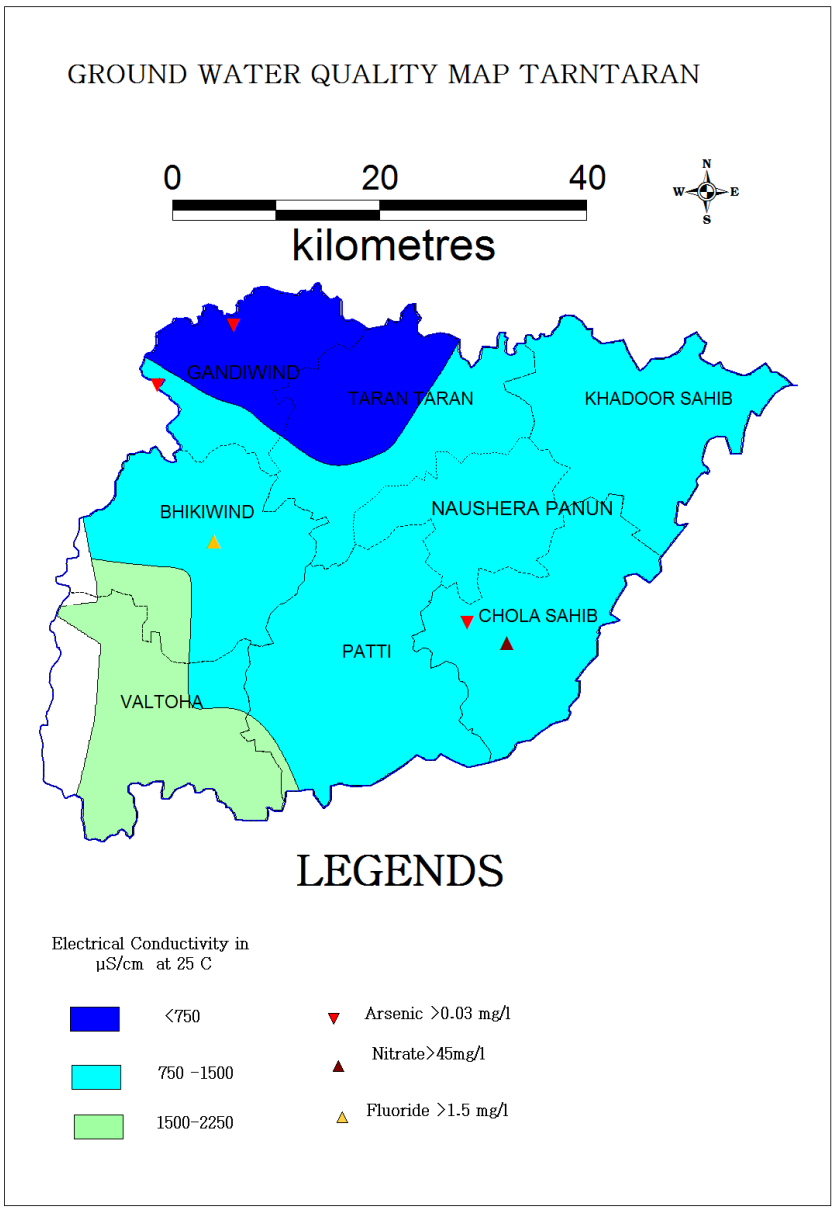


Fig14 Ground Water Quality Map Tarntaran District

Table Drinking Water Specification as per BIS (10 500:2012).

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in Absence of Alternate Source	Remarks
General Parameters and MajorIons(mg/l)				
i)	*p*H value	6.5-8.5	No	-
ii)	EC(μScm^{-1})	-	-	Not noted in IS
iii)	Total dissolved solids (mg/l)	500	2000	-
iv)	Turbidity(NTU)	1	5	-
v)	Total HardnessasCaCO3(mg/l)	200	600	-
vi)	Alkalinityas CaCO3 (mg/l)	200	600	-
vii)	Fluoride (as F) mg/l	1.0	1.5	-
viii)	Chloride (as Cl), mg/l	200	1000	-
x)	Carbonate, mg/l	-	-	Not noted in IS
	Sulphate (as SO4)mg/l	200	400	Maybe extended to 400 provided that Magnesium does
xi)	Nitrate (as NO3)mg/l	45	No relaxation	-
xii)	Calcium (as Ca)mg/l	75	200	-
xiii)	Magnesium (as Mg)mg/l	30	100	-
xiv)	Sodium (as Na) mg/l	-	-	Not noted in IS
xv)	Potassium (as K) mg/l	-	--	Not noted in IS
xvi)	Iron (as Fe) mg/l	0.3	No relaxation	Total concentration of manganese(asMn) an ion as Fe) shall not exceed0.3 mg/l
xxiii)	Total Arsenic(as As)mg/l	0.01	0.05	-

Table : Results of chemical analysis of water samples collected from GWOW (May 2014)

	TARANTARAN																				
38	AMNISHA KALRA		7.88	1165	564	757	210	25	36	185	7.5	Nil	564	56	75	0.63	0.36	0.02	24	5.55	5.04
39	CHABAL	Gandiwind	8.40	440	255	286	105	13	18	65	5.4	26	228	10	5	0	0.07	0.01	25	2.76	2.52
40	GOINDWAL	Gandiwind	8.15	488	349	317	147	29	18	70	4.2	Nil	349	10	0	0	0.17	0.02	23	2.51	2.78
41	KALSIA KALAN	Bhikhiwind	8.20	1040	510	676	95	13	15	195	10	Nil	510	28	69	0.36	0.12	0.02	18	8.73	6.47
42	GANDIWIND	Gandiwind	8.55	755	375	491	189	17	36	108	10	79	295	35	0	10	0.95	nd	15	3.42	3.70
43	BHIKIWIND	Bhikhiwind	8.10	1480	792	962	200	38	26	270	6.5	Nil	792	49	46	27	1.85	0.05	30	8.31	8.99
44	RATTOKE	Valtoha	7.95	1775	698	1154	158	25	23	335	6.5	Nil	698	160	78	13	0.74	nd	23	11.61	8.29
45	CHOLA SAHIB	Chohla Sahib	7.55	915	443	595	252	42	36	108	6.8	Nil	443	35	35	55	0.40	0.01	26	2.96	2.22
46	SAHABPURA	Tarn Taran	7.95	930	582	605	105	17	15	185	5.8	Nil	582	21	0	0	0.95	nd	25	7.85	7.45
47	KHANDUR		8.45	845	510	549	179	29	26	130	10	26	483	14	0	13	0.80	nd	14	4.23	5.23
		Max	**8.65**	**2155**	**792**	**1401**	**515**	**130**	**51**	**335**	**305**	**79**	**792**	**174**	**352**	**225**	**1.85**	**0.90**	**35**	**11.61**	**10.67**
		Min	**7.00**	**198**	**80**	**129**	**95**	**13**	**5**	**2**	**0.70**	**Nil**	**54**	**7**	**0**	**0**	**0.00**	**0.01**	**8**	**0.09**	**-4.57**

9. GROUND WATER RELATED ISSUES

Tarntaran is famous for its paddy cultivation and is also known as 'Rice Bowl' of Punjab.The quality of ground water in the district is potable for both the drinking and irrigation purposes therefore, the ground water is constantly being pumped for the irrigation due to its easy access through tube wells and they are the main source of irrigation.

This will lead to its major ground water issue which is deepening of ground water level as the recharge of the groundwater through rainfall and other sources are less than the overall extraction.

9.1 GROUND WATER IRRIGATION SCENARIO

As per the data available from minor irrigation census 2006-07, the number of shallow and deep, tube wells, lined, unlined water distribution system, land holdings of wells are given in Table 9, 10 and 11

Fig 10: Irrigation tube wells as per depth.

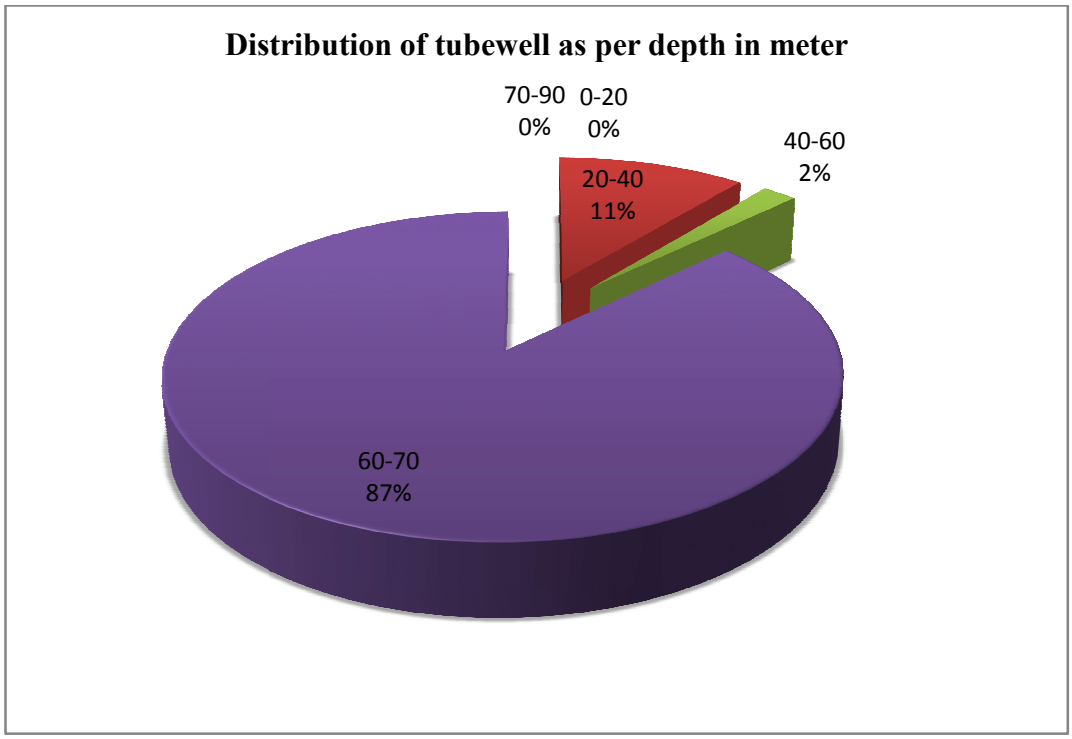


Table 9:Distribution of Shallow Tube wells According to Owner's Holding Size

No. of shallow tube wells by size class of individual owner							
Sr.no	district	Marginal (0-1 ha)	Small (1-2 ha)	Semi-Medium (2-4 ha)	Medium (4-10ha)	Big (>=10 ha)	Total
1	**Tarn**	**1870**	**7475**	**19184**	**16395**	**3361**	**48285**

	Taran						

Table10:Distribution of Shallow Tubewells According to Depth of tube well

No. by the depth of shallow Tube well							
Sr.no	district	(0-20 mts)	(20-40 mts)	(40-60 mts)	(60-70 mts)	(>70 mts)	Total
1	**Tarn Taran**	**0**	**5244**	**948**	**42140**	**0**	**48332**

Table 11.Number of Ground Water Schemes and Potential Utilized by water distribution device

Ground Water Schemes according to water Distribution System				
	Open Water Channel			
Sr.no	**District**	**Lined/pucca**	**Unlined/kutcha**	**Underground pipe**
1	**Tarn Taran**	**2621**	**56648**	**308**

10. AQUIFER MANAGEMENT PLAN

A summery outline of the artificial recharge plan for the entire district of each OE block is given at the beginning in tabular forms. This is followed by the salient features of each block along with the detailed structure-wise recharge plan and cost estimates.Details of the block wise type of suitable recharge structures and volume of water assured for annual recharge for each block in rural area, urban area and artificial recharge in agricultural farm are given in table and design of recharge structures are annexed at annexure I, II. More than 5 meter Mean decadal water level with falling trend is considered for block wise artificial recharge calculation.

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 in the whole district.

10.1 SCOPE OF IMPLEMENTATION

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

Agriculture University, Engineering Collages, Academic and Research Institution and 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.

10.2POTENTIAL 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 by the state of Punjab, particularly in overexploited blocks. There are around 48332tube wells operated by farmers for irrigation through unlined/Kutcha (78.31%) open channel system in Tarntaran district where water from the tube-well is discharge to the agricultural field. In this process huge quantity of ground water is wasted in soil moisture and evaporation losses.

Dynamic ground water resources (2011) indicate that Gross ground water draft for irrigation in Tarntaran district is estimated at 1881.96 MCM. It is expected that 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 the tune of 1411.5 MCM assuming there is no crop diversification by the farmers.

The benefit will lead to saving of precious ground water resources in overexploited blocks of tarntaran Districts. The measure if implemented will bring down the ground water overdraft from 133% to 98.74 %. The category of the blocks will also improve drastically resulting in boosting of agriculture and industrial development otherwise not sustainable in majority of the blocks in the state.

The tube wells also consume enormous electricity which is subsidized and government incurs significant revenue on this account. The measures therefore will result in saving of energy and money. Pollution impact will be reduced whenever diesel engines are used by the farmers. The environmental and ecological condition in the irrigated land will improve. Unwanted weed growth will also be controlled inside the farm land. This will also be useful in the waterlogged/ shallow water table areas as the seepage losses in these areas also aggravate the water logging. Government should make/launch a mission mode program for installing the underground pipe lines instead of having kutcha channel in the entire Punjab. Heavy ground water overdraft can be reduced by these efforts. This will ensure more crops per drop.

10.3 Water Saving Potential from Crop Diversification-Change Paddy to Maize/Pulses:

As the requirement of water for paddy is much high therefore by changing paddy to maize/Pulses 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 pulses planted in one sq km of land. In case of pulses even higher amount of ground water can be saved.

Table 12: Scope of Quantitative Impact on Stage of Development after applying various management strategies

Block	t Ground Water ailability (mcm)	tal Draft (mcm)	Present Stage of draft (SOD) (%) 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		
BHIKHIWIND	176.73	221.38	125	55.3	2.50	0	57.8	92.53	Not Required
CHOLA SAHIB	161.75	188.50	117	47.1	2.40	0	49.5	85.92	Not Required
GANDIWIND	267.71	286.72	107	71.7	1.40	0	73.1	79.8	Not Required
KHADUR SAHIB	175.41	259.05	148	64.8	2.90	16.8	84.5	100	8
NAUSHEHRA PANUAN	99.75	164.19	165	41.0	1.60	21.576	64.176	100	12
PATTI	160.85	258.70	161	64.7	2.70	30.564	97.964	100	11
TARN TARAN	221.92	283.25	128	70.8	3.30	0	74.1	94.24	Not Required
VALTOHA	146.08	220.14	151	55.0	2.20	17.03	74.23	100	7
Total	1410.2	1882.0	133	470.5	19.00	85.97	575.47	98.74	Not Required

BLOCK WISE AQUIFER MAP AND MANAGEMENT PLAN

(I) Bhikhiwind Block (333 KM)

1. Salient Information

Population (2011) Rural-2133
Urban--3835
Total-25968

Average Annual Rainfall (Bhikhiwind block) 512mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown- 299.97sq.km
Gross Cropped Area-302.95sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers that can be used for irrigation after treatment. The canal irrigation is available in theBhikhiwindblock.

Ground Water Reso**urce Availability**: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as**Over Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tube wellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~13.8- 16.02 (mbgl)Post Monsoon-~6.67-15.7 (mbgl)

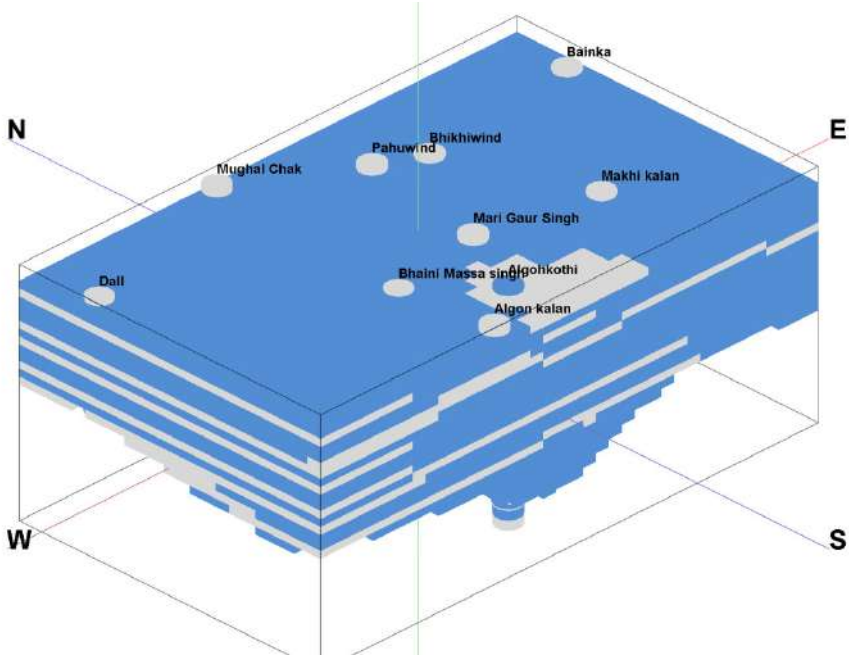
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (17-109m)	Quaternary Alluvial	Unconfined	46	1450-4140	0.072	484.5-4504
Aquifer-II (67-287m)		Unconfined to Confined	88	-	NA	-

Aquifer comprises of freshwater only and the main aquifermaterial is sand.

The non-aquifer material comprise of clay.

3D Lithological model



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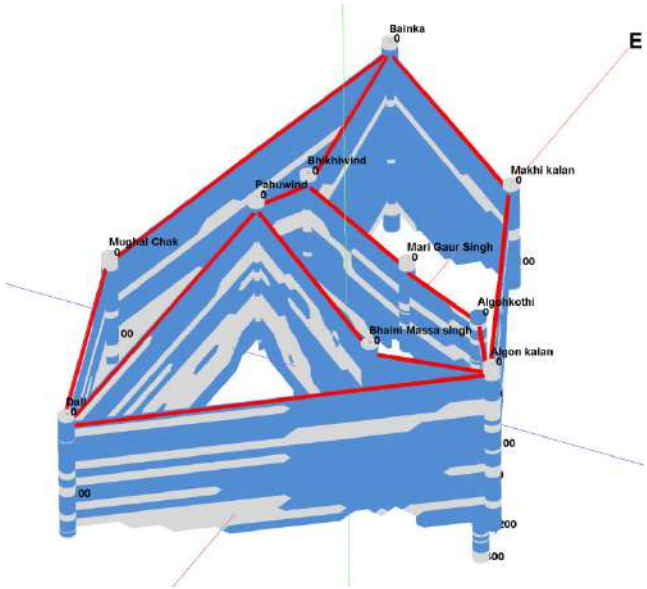
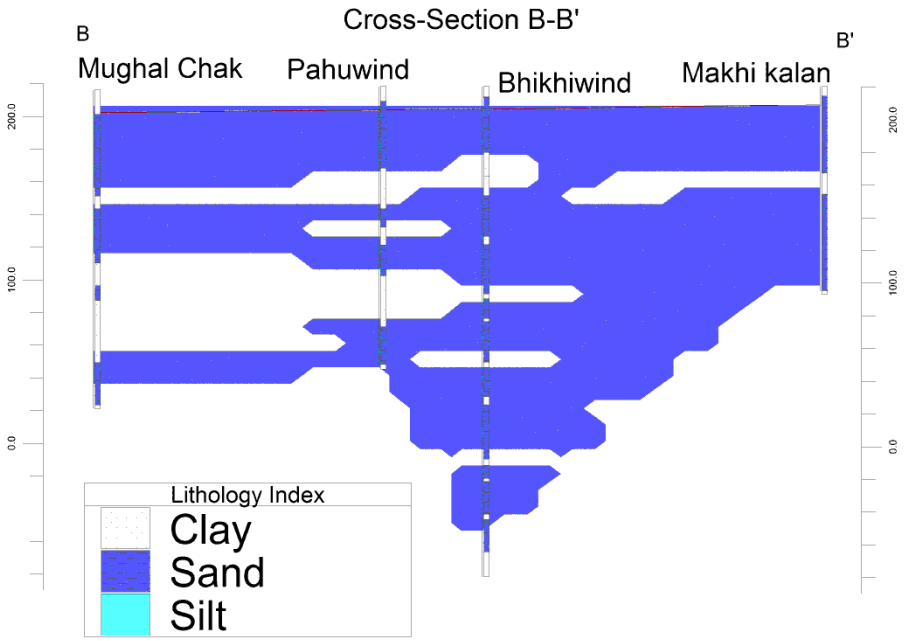




1. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	176.73
	In-storage Ground Water Resources	5729.67
	Total	5906.40
Ground Water Extraction (in mcm)	Irrigation	218.64
	Domestic & Industrial	2.74
Provision for domestic & Industrial requirement upto 2025 (in mcm)		4.05
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

2. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (14.14m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.5mcm volume of water

3. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 55.3mcm volume of water wastage
Change in cropping pattern	Change in cropping pattern not required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

(II) CHOLA SAHIB BLOCK (349.9 SQ KM)

Salient Information

Population (2011) Rural-21152
Urban-0
Total-21152

Average Annual Rainfall(Chola Sahib block) 526mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-224.21sq.km
Gross cropped area-227.31sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Chola Sahib block**Ground Water Resource Availability**: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **OverExploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tube wellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-*~17.69-19.17(mbgl)*&Post Monsoon-*~16.55-18.00(mbgl)*

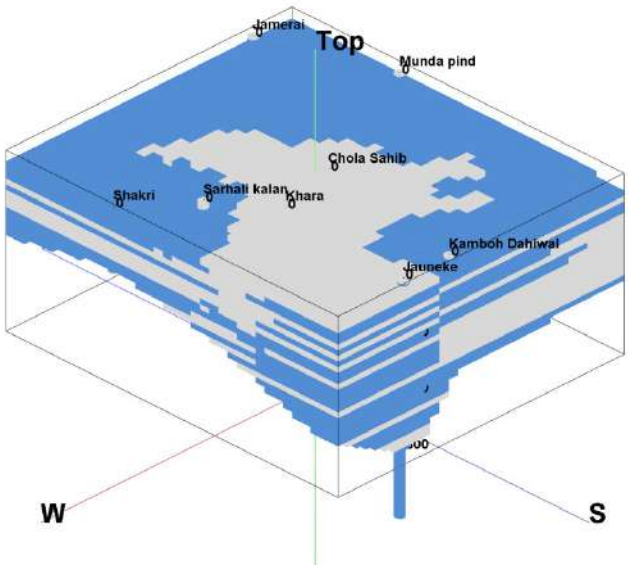
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (12-114m)	Quaternary Alluvial deposits	Unconfined	71.54	1450-4140	0.072	484.5-4504
Aquifer-II (70-264m)		Unconfined to Confined	117	-	NA	-
Aquifer-III (245-300m)		Unconfined to Confined	23	-	NA	-

Aquifer comprises of freshwater only and the main aquifermaterial is sand.

The non-aquifer material comprise of clay.

3D Lithology model



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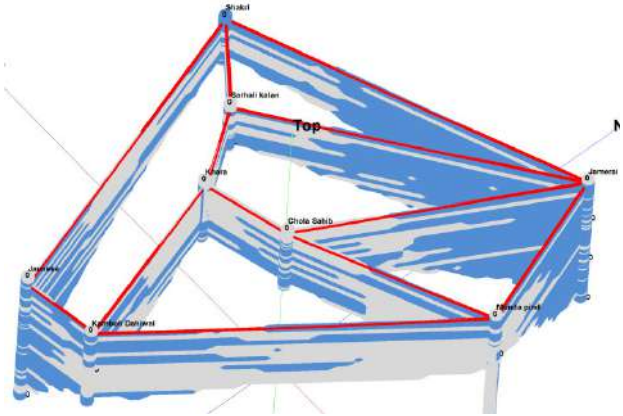
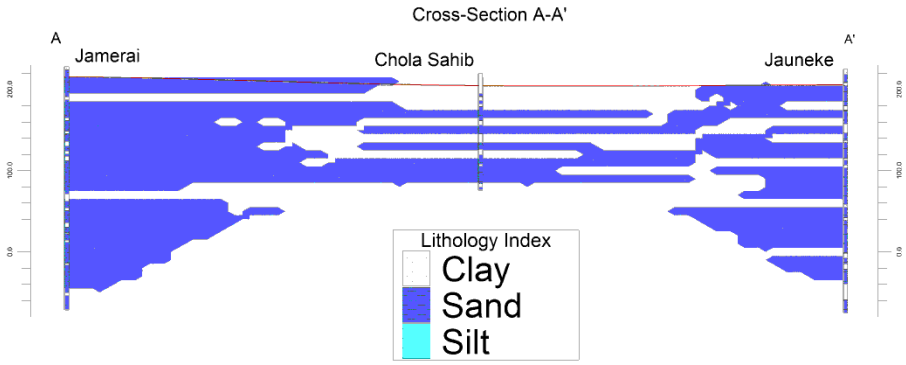




4. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*161.75*
	In-storage Ground Water Resources	*5377.51*
	Total	5539.26
Ground Water Extraction (in mcm)	Irrigation	185.86
	Domestic & Industrial	2.65
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.93
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

5. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (17.435m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.4 mcm volume of water

6. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 47.1mcm volume of water wastage
Change in cropping pattern	Not Required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

3. GANDIWIND BLOCK(336.9 SQ KM)

Salient Information

Population (2011) Rural-21152
Urban-0
Total-21152

Average Annual Rainfall 633mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-151.35sq.km
Gross Crped Area- 151.35 sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the GANDIWINDblock.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over exploited Area** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~10.75 – 19.68 (mbgl)Post Monsoon-~10.44 – 18.9 (mbgl)

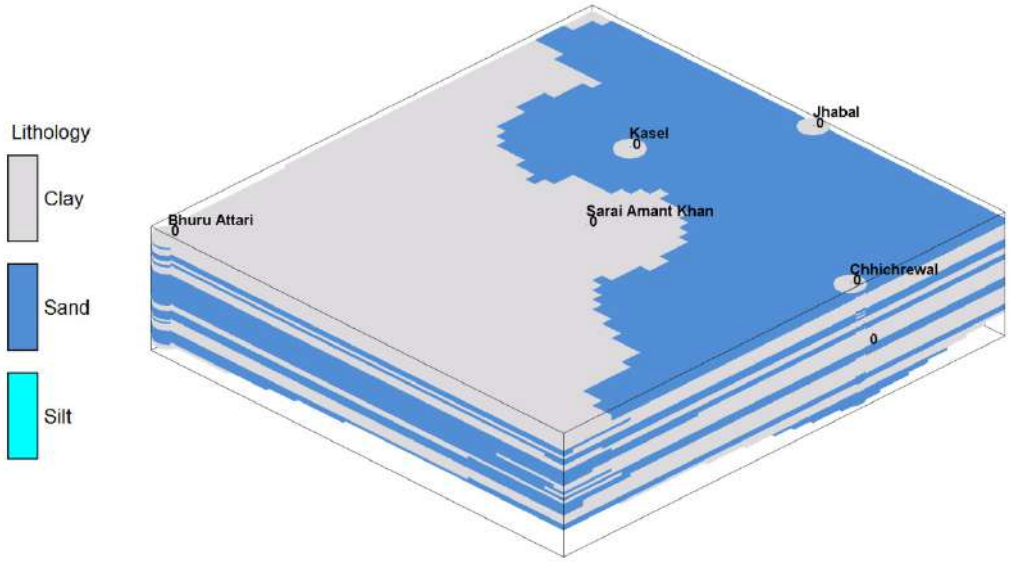
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (14-110m)	Quaternary Alluvial	Unconfined	72	1450-4140	0.072	484.5-4504
Aquifer-II (55-196m)		Unconfined to Confined	100	-	NA	-

Aquifer comprises of freshwater only and the main aquifermaterial is sand.

The non-aquifer material comprise of clay.

3D Lithology model



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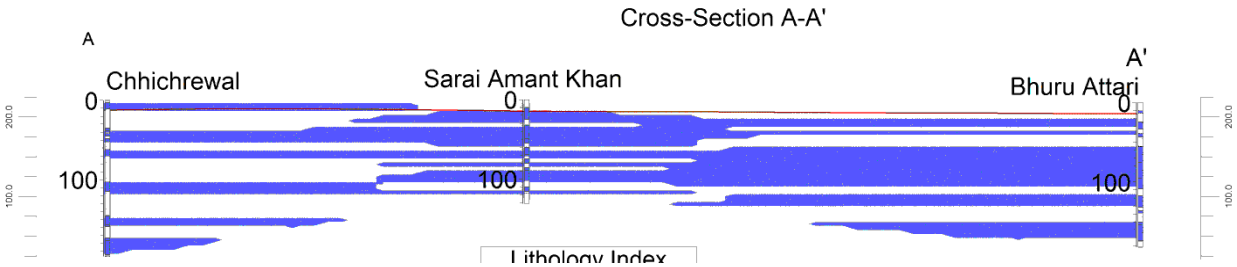


7. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*267.71*
	In-storage Ground Water Resources	*5447.57*
	Total	5715.28
Ground Water Extraction (in mcm)	Irrigation	285.07
	Domestic & Industrial	1.66
Provision for domestic & Industrial requirement upto 2025 (in mcm)		2.45
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

8. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (14.78m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 1.40mcm volume of water

9. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 71.7mcm volume of water wastage
Change in cropping pattern	Not Required
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

4.KHADOOR SAHIB BLOCK (341.5SQ KM)

1. Salient Information

Population (2011) Rural-25154
Urban--
Total-25154

Average Annual Rainfall 637mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-119.85 sq.km
Gross Cropped Area=252.35

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the **khadoor sahib** block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as Over-Exploited as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~18.15-21.30(mbgl)&Post Monsoon-~16.60-20.19(mbgl)

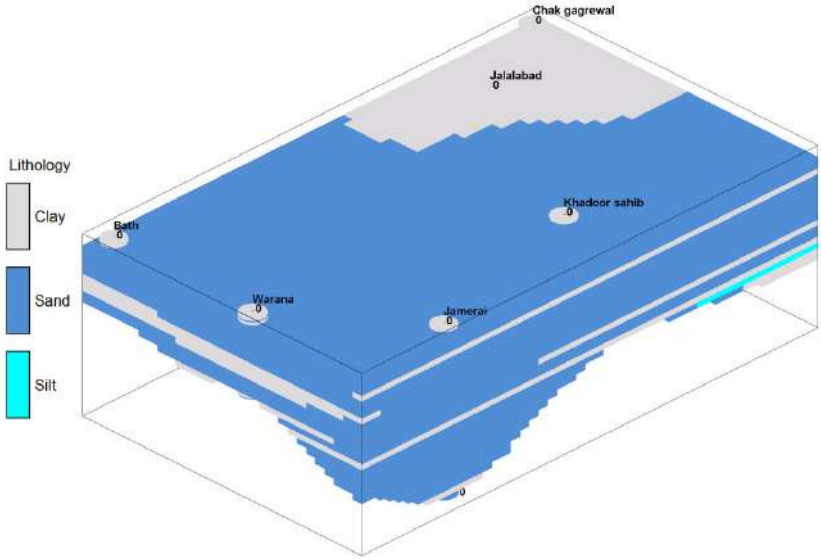
Aquifer Disposition: Combined Aquifer System

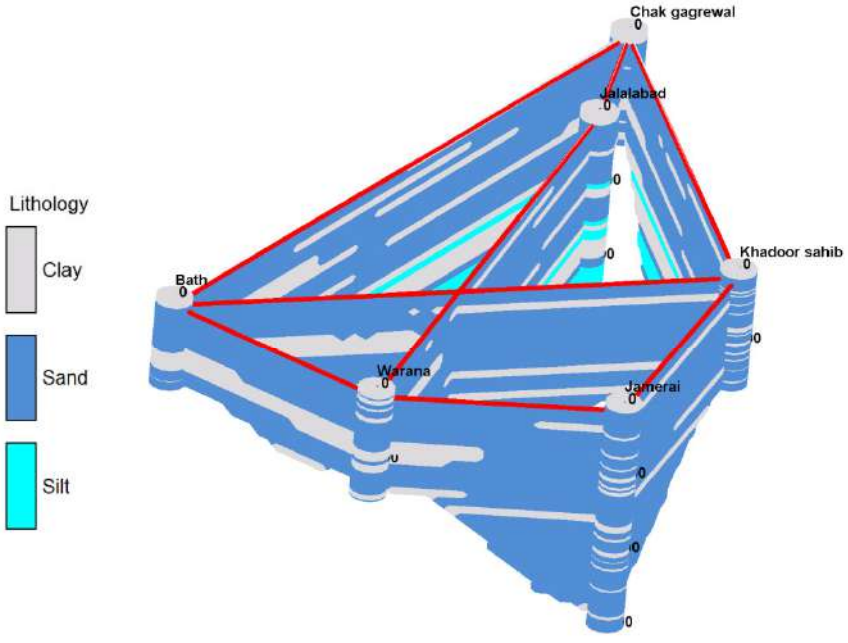
Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (12-97m)	Quaternary Alluvial deposits	Unconfined	70	1450-4140	0.072	484.5-4504
Aquifer-II (77-166m)		Unconfined to Confined	76	-	NA	-
Aquifer-III (191-300m)		Unconfined to Confined	55	-	NA	-

Aquifer comprises of freshwater only and the main aquifermaterial is sand.

The non-aquifer material comprise of clay.

3D Lithology model





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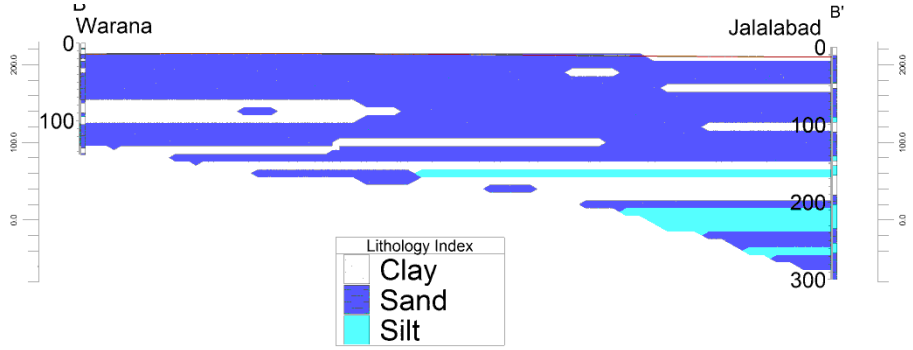


3. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*175.41*
	In-storage Ground Water Resources	*5754.1*
	Total	5929.51
Ground Water Extraction (in mcm)	Irrigation	256.04
	Domestic & Industrial	3.02
Provision for domestic & Industrial requirement upto 2025 (in mcm)		4.47
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

4. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (18.16m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.90mcm volume of water

5. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 64.8mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 8 % of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 16.8mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

5. NAUSHERA PANUUN BLOCK (199.2 SQ KM)

Salient Information

Population (2011) Rural-17051
Urban--
Total-17051

Average Annual Rainfall547mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-153.03 sq.km
Gross cropped Area Sown-154.56 sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in theNAUSHERA PANUUNblock.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as Over-Exploited as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~17.50-19.37(mbgl)&Post Monsoon-~16.00-18.16(mbgl)

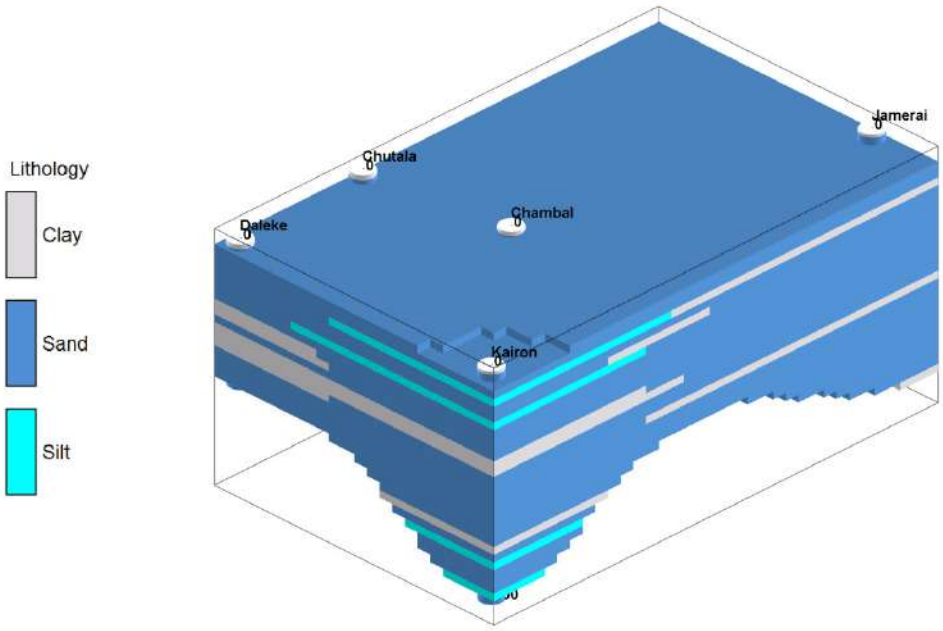
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (14-95m)	Quaternary Alluvial	Unconfined	66	1450-4140	0.072	484.5-4504
Aquifer-II (83-152m)		Unconfined to Confined	45	-	NA	-

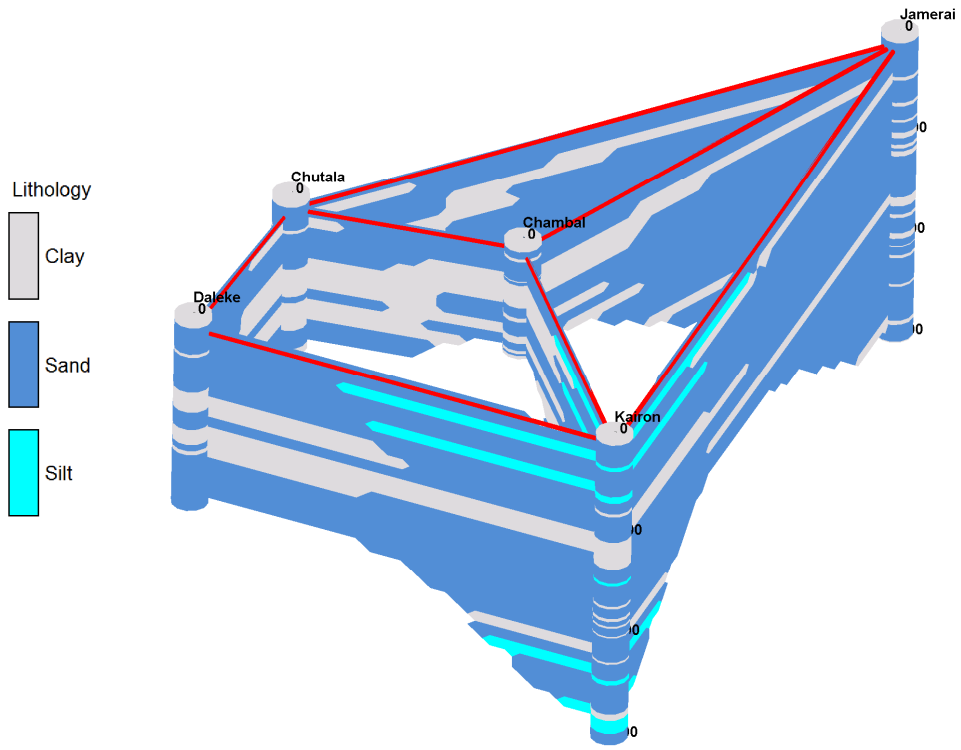
Aquifer comprises of freshwater only and the main aquifermaterial is sand.

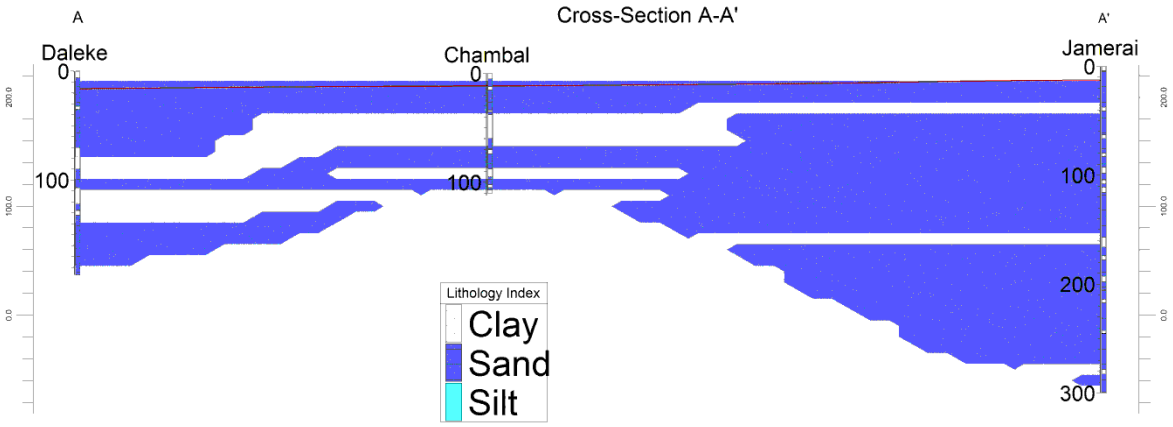
The non-aquifer material comprise of clay.

3D Lithology model



3D Lithology Fence





1. Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*99.75*
	In-storage Ground Water Resources	*3034.68*
	Total	3134.43
Ground Water Extraction (in mcm)	Irrigation	162.10
	Domestic & Industrial	2.09
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.10
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes

Other issues	Declining water level trend

2. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (18.66m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 1.60mcm volume of water

3. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 41.0 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 12% of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 21.57mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

6. PATI BLOCK (375.5 SQ KM)

1. Salient Information

Population (2011) Rural-25723
Urban-0
Total-25723

Average Annual Rainfall451mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-258.62sq.km
Gross cropped Area-261.14
Total Irrigated Area- 205.64 sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers that can be used for irrigation after treatment. The canal irrigation is available in the

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Overexploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~17.53 – 18.73(mbgl)&Post Monsoon-~16.63-17.64 (mbgl)

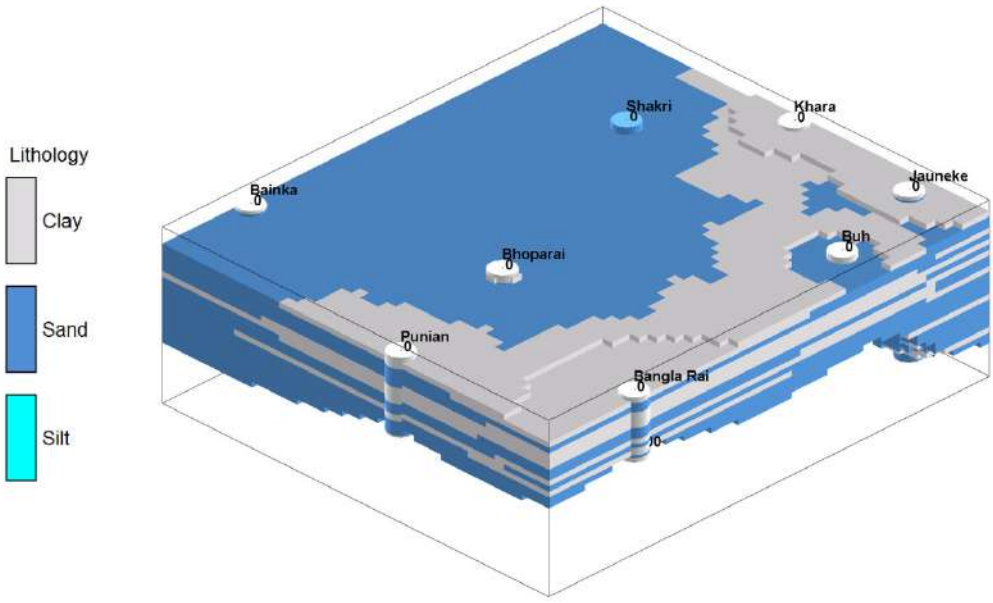
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (14-112m)	Quaternary Alluvial	Unconfined	36.33	1450-4140	0.072	484.5-4504
Aquifer-II (95-268m)		Unconfined to Confined	18.26	-	NA	-

Aquifer comprises of freshwater only and the main aquifermaterial is sand.

The non-aquifer material comprise of clay.

3D Lithology model



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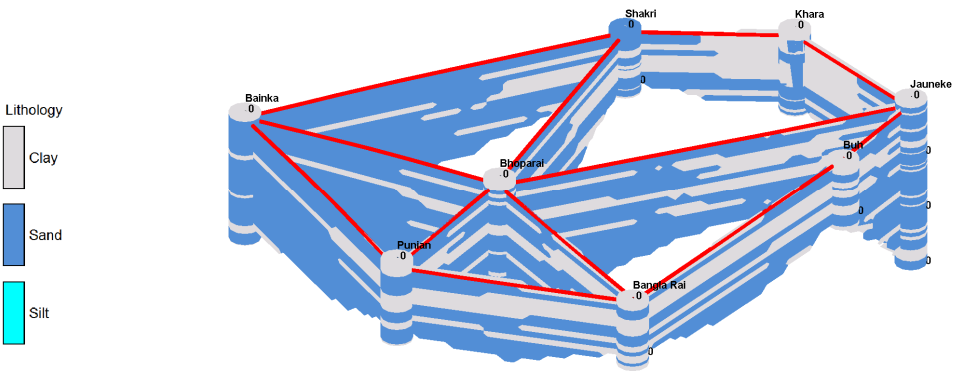
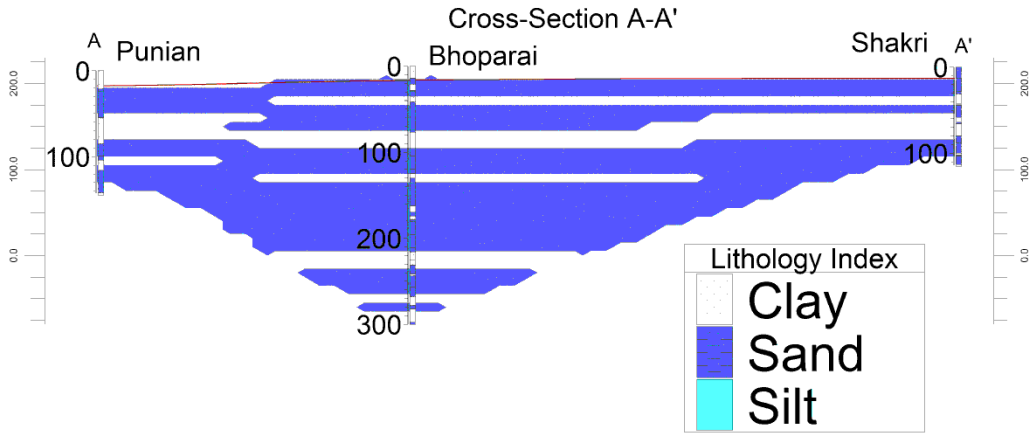




Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*160.85*
	In-storage Ground Water Resources	*5878.03*
	Total	6038.88
Ground Water Extraction (in mcm)	Irrigation	253.57
	Domestic & Industrial	4.94
Provision for domestic & Industrial requirement upto 2025 (in mcm)		7.27
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

2. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (17m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.7mcm volume of water

3. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 64.7mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 11% of the total area needs to change the crop from

	paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 30.56mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

7. TARANTARAN BLOCK (320SQ KM)

Salient Information

Population (2011) Rural-35178
Urban-0
Total-35178

Average Annual Rainfall 562mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-203.91 sq.km
Gross cropped Area Sown-203.91 sq.km
Total Irrigated Area-203.64 sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the TarnTaran block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over Exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~15.03-20.40(mbgl)&Post Monsoon-~14.00-18.94(mbgl)

Aquifer Disposition: Combined Aquifer System

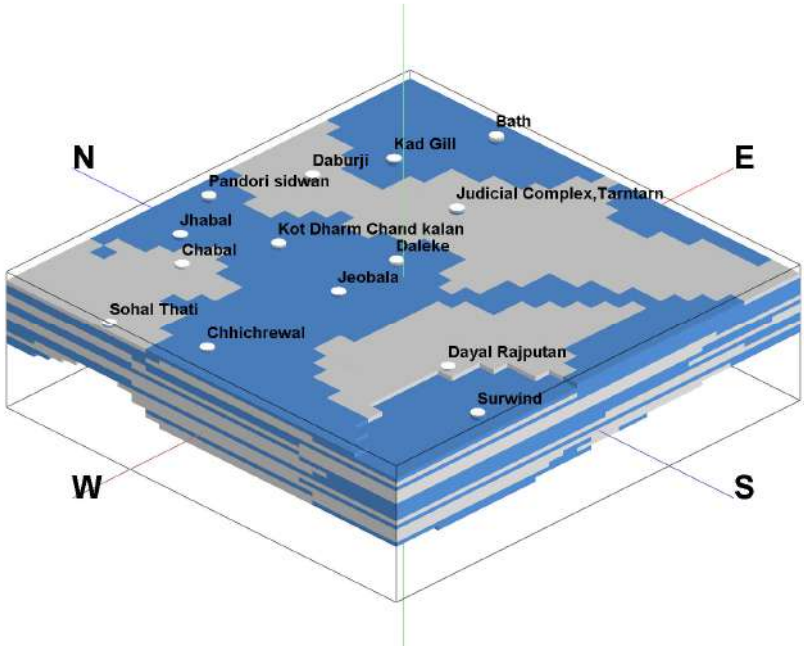
Aquifer	Geology	Type of Aquifer	Thickness of Granular	Transmissivity(m^2/day)	Specific Yield	Storativity

			Zones (m)		%	
Aquifer-I (14-138m)	Quaternary Alluvial deposits	Unconfined	47	1450-4140	0.072	484.5-4504
Aquifer-II (73-220m)		Unconfined to Confined	96	-	NA	-
Aquifer-III (238-300m)		Unconfined to Confined	52	-	NA	-

Aquifer comprises of freshwater only and the main aquifermaterial is sand.

The non-aquifer material comprise of clay.

3D Lithology model



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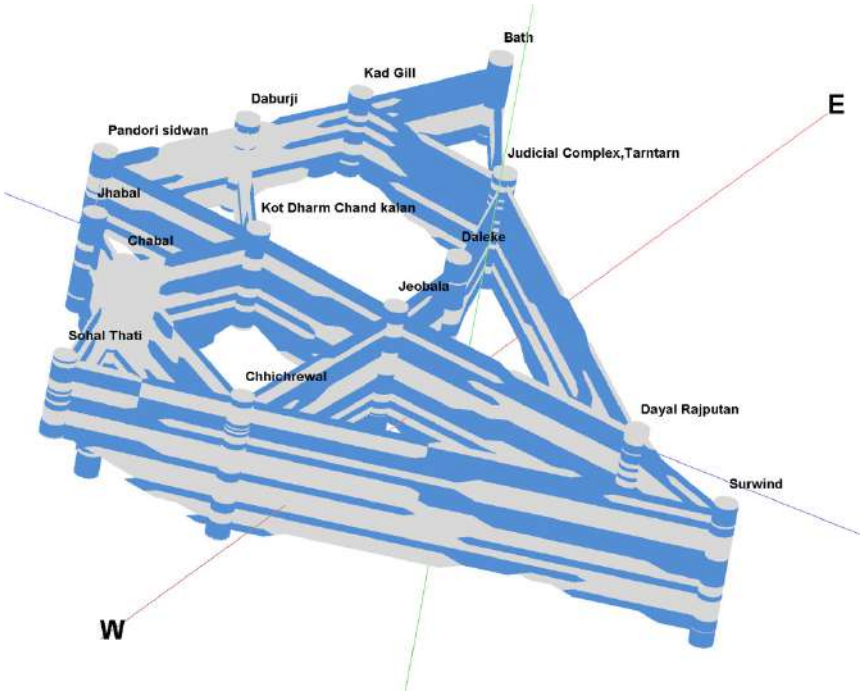
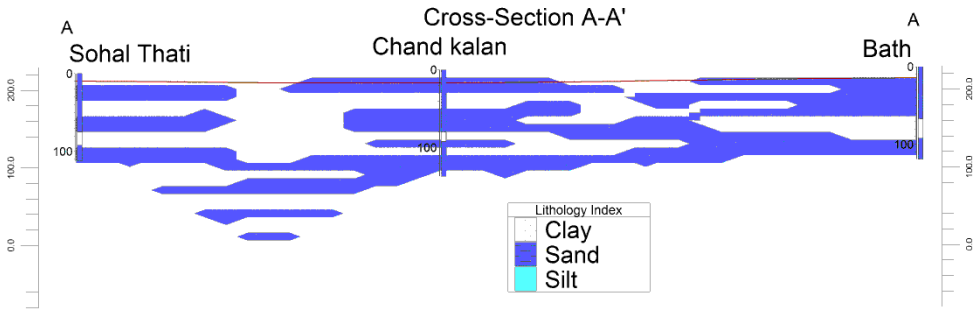




Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*221.92*
	In-storage Ground Water Resources	*4615.05*
	Total	4836.97
Ground Water Extraction (in mcm)	Irrigation	277.26
	Domestic & Industrial	6.00
Provision for domestic & Industrial requirement upto 2025 (in mcm)		8.79
Chemical Quality of ground		Suitable for drinking and

water&contamination	irrigationpurposes
Other issues	Declining water level trend

4. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (17m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.7mcm volume of water

5. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel) will save 13.8 mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 11% of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 30.56mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

8. VALTOHA BLOCK (327.5 SQ KM)

Salient Information

Population (2011) Rural-17332
Urban-0
Total-17332

Average Annual Rainfall 408mm

Agriculture and Irrigation Major Crops- Rice, Wheat
Other crops-Sugarcane, Potatoes, Pulses,
Net Area Sown-295sq.km
Gross cropped area-298sq.km
Total Irrigated Area- 295sq.km

Water Bodies&Canal Irrigation

Water bodies available in the villages for the storm water and untreated waste water of villagers, that can be used for irrigation after treatment. The canal irrigation is available in the Ropar block.

Ground Water Resource Availability: Ground Water Resources available in the combined group of aquifers. The resources are calculated as per Dynamic ground water resources (2013) and In-storage ground water resources up-to fresh water. Block is categorized as **Over exploited** as per Ground Water Assessment 2013.

Ground water Extraction: Information regarding the abstraction from different Aquifers is not available, but there are drinking water supplies from tubewellstapping combined aquifer and separate aquifer could not be assessed separately.

Water level Behavior (2015): Pre Monsoon-~6.12 – 17.33(mbgl)&Post Monsoon-~5-17.33(mbgl)

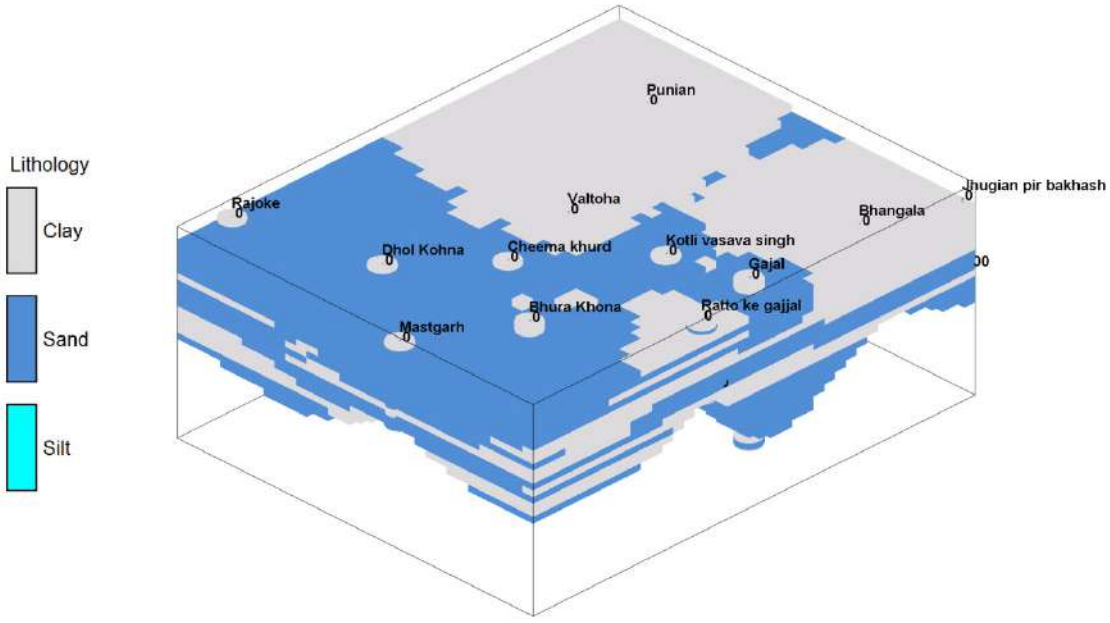
Aquifer Disposition: Combined Aquifer System

Aquifer	Geology	Type of Aquifer	Thickness of Granular Zones (m)	Transmissivity (m^2/day)	Specific Yield %	Storativity
Aquifer-I (17-115m)	Quaternary Alluvial deposits	Unconfined	50	1450-4140	0.072	484.5-4504
Aquifer-II (76-239m)		Unconfined to Confined	111	-	NA	-
Aquifer-III (258-300m)		Unconfined to Confined	36	-	NA	-

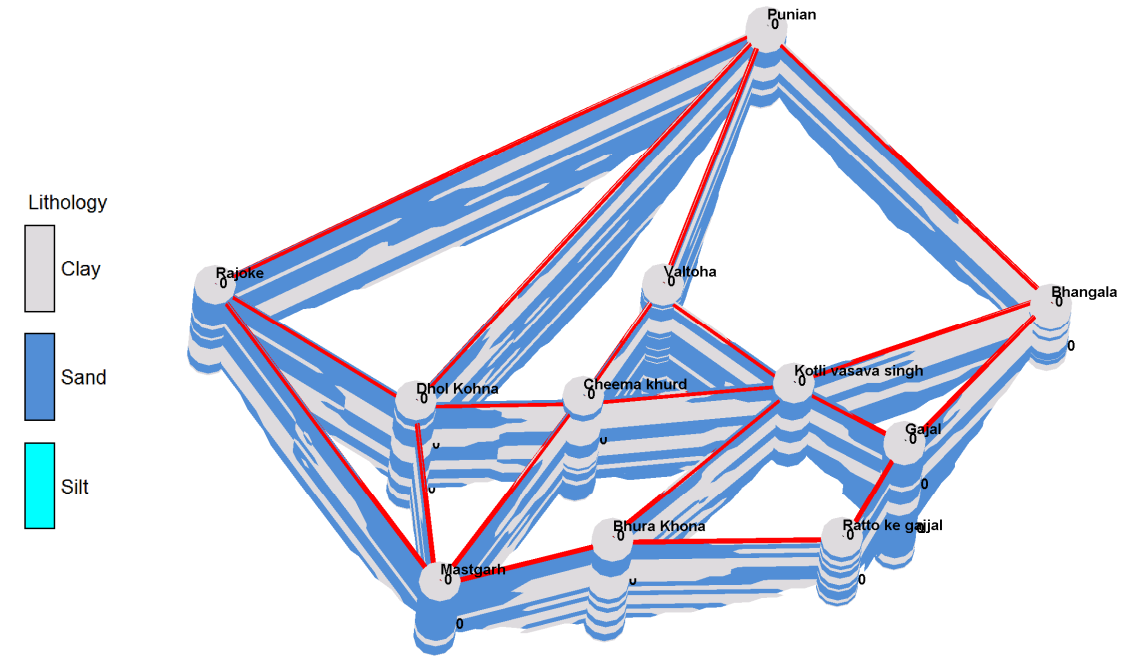
Aquifer comprises of freshwater only and the main aquifermaterial is sand.

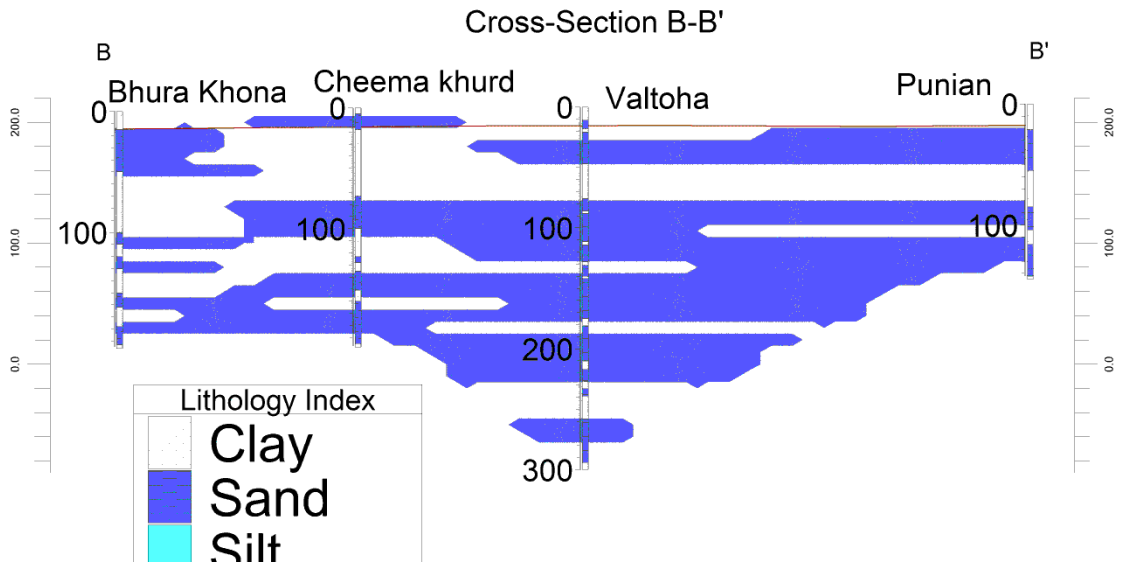
The non-aquifer material comprise of clay.

3D Lithology model



3D LithologyFence





Ground Water Resource, Extraction, Contamination and Other Issues

Combined Aquifer wise Resource available (mcm)	Dynamic Aquifer	*146.08*
	In-storage Ground Water Resources	*4713.89*
	Total	4859.97
Ground Water Extraction (in mcm)	Irrigation	277.26
	Domestic & Industrial	6.00
Provision for domestic & Industrial requirement upto 2025 (in mcm)		3.3
Chemical Quality of ground water& contamination		Suitable for drinking and irrigation purposes
Other issues		Declining water level trend

6. Ground Water Resource Enhancement

Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone upto the average depth to water level (12m).
Other interventions proposed	Artificial Recharge, Roof top Rainwater Harvesting, Farm recharge by constructing pits will save 2.2mcm volume of water

7. Demand Side Interventions

Advanced Irrigation Practices	Lining of underground pipelines (Kutcha channel)

	will save 55.0mcm volume of water wastage
Change in cropping pattern	Proposed change in cropping pattern from Paddy to maize/soyabean 7% of the total area needs to change the crop from paddy to maize/soyabean Anticipated volume of water to be saved by maize/soyabean is 17.03mcm
Alternate water sources	Tanks, ponds and canals
Regulation and Control	-
Other interventions proposed, if any	-

CONCLUSION:

1.0Ground Water Recharge

Due to reduction in forest and green areas, the natural recharge to ground water has got reduced. Further, improvement in drainage pattern and lowering of water table has also affected ground water recharge. There is an urgent need to take up schemes for recharge to ground water to arrest further decline of water table. The recharge schemes using following source water is considered feasible:

(i) Unpolluted rain water harvested from rooftops, roads and used water of Sarovers.

(ii) Surplus canal water during monsoon period particularly in good rainfall years.

(iii) Unpolluted stored water in depressions and ponds.

(iv) Accumulated water in the low lying areas around agricultural fields.

(v) Monsoon runoff and escape canal water in drains.

(vi) Existing dugwells, dug-cum-borewells, abandoned tubewells, cavity wells, recharge wells in trenches, shaft-cum-recharge wells and excavated ponds are utilized/ considered effective ground water recharge structures.

2.0 Ground Water Conservation

Ground water conservation is proposed to be carried out by following methods:

3.0 Change in cropping pattern

The farmers have adopted paddy cultivation due to profitability. There is an urgent need to change the cropping pattern and to adopt cultivation of those crops which require less irrigation. Paddy is the main Kharif crop of the district and area under paddy is increasing year after year. Studies been carried out have indicated that by replacing paddy crop with maize, groundnut, kharif pulse, soybean, bajra, fodder, about thousand Hectare Meter irrigation water can be saved. To bring out desired change in cropping pattern, it is necessary that adequate support price and processing facilities are made available for the referred crops.

4.0 Change in Irrigation Policy

The irrigation policy is required to be modified as per the prevailing ground water conditions. The canal water allowances can be increased to save ground water. Thus, rationalization of the irrigation policy will help in controlling ground water depletion in the over-exploited areas.

5.0 Timely Plantation of Paddy

It has been estimated that paddy which is sown in the month of May requires 77 cms of evapotranspiration (E.T.) whereas paddy which is sown on or after 16th June requires only 62 cms of E.T. Thus, substantial water can be saved by postponing paddy cultivation from early May to late June. State Govt. has made an Act titled "The Punjab Preservation of Sub Soil Water Act, 2009" in year 2009 to preserve the sub soil water. It provides for the prohibition of sowing nursery of paddy before 10th May and transplanting paddy as notified by the state Government i.e before 10th of June.

6.0 Promotion of Sprinkler and Drip Irrigation

Wherever feasible, pipe conveyance system fitted with modern pressurized irrigation practices such as Sprinkler and Drip Irrigation should be introduced to conserve water and increase the yield of crops. It has been observed that by using drip irrigation system in sandy areas, about 60% water can be saved. Use of sprinkler irrigation results in water saving to the extent of 20%. 'More crop per drop' concept should be popularized.

7.0 **Realistic Irrigation Power Pricing**

Rate of power for tubewell irrigation is irrational and requires modification. There should be no free power for irrigation so that due care will be taken by the consumers for its economic and judicious use. Instead of flat rates, metering may be introduced.

8.0 Mass Awareness Program

Management of ground water resources cannot be successful without public participation. Therefore, public awareness is of prime necessity. To make the public aware, it is necessary to organize mass awareness program at grass root level and impart training on rainwater harvesting techniques for ground water recharge to various

State government agencies at regular intervals so that water policies made by government can be effectively implemented. Central Ground Water Board has taken a lead in this and conducting Tier III, Training Programs on 'Village Level Aquifer Management Plan" at Block level under Aquifer Mapping programme.

9.0 Ground Water Regulation

Ground Water regulation may be enforced for management of ground water resources as has been done by Central Ground Water Authority.