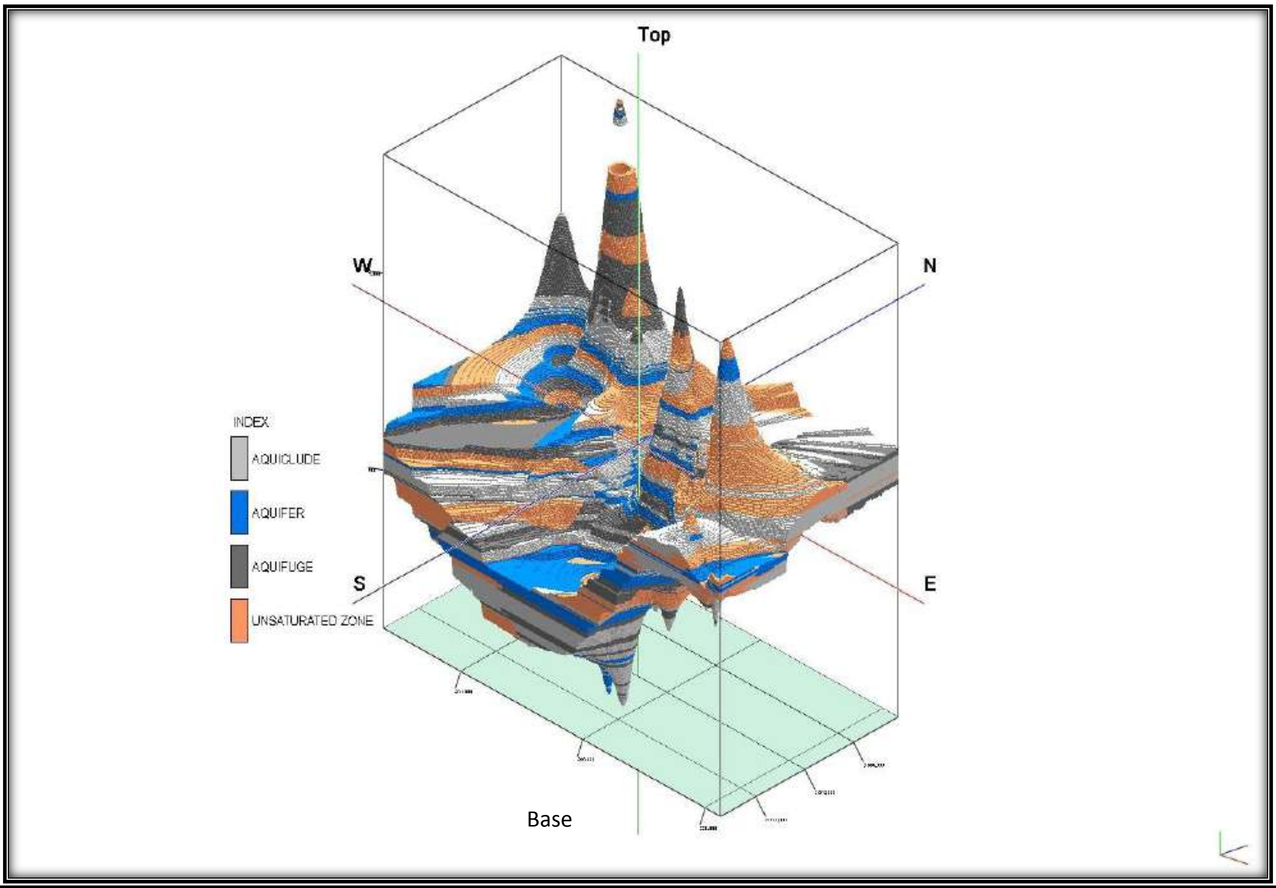
REPORT ON

AQUIFER MAPPING IN PARTS OF UDHAMPUR, KATHUA, RAJOURI AND REASI DISTRICT, J&K



GOVERNMENT OF INDIA
CENTRAL GROUND WATER BOARD
NORTH WESTERN HIMALAYAN REGION
MINISTRY OF WATER RESOURCES,
RIVER DEVELOPMENT & GANGA
REJUVENATION
JAMMU

REPORT ON

AQUIFER MAPPING IN PARTS OF UDHAMPUR, KATHUA, RAJOURI AND REASI DISTRICT, J&K

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Report on Aquifer Mapping in Parts of Udhampur, Kathua, Rajouri and Reasi District, J&K

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Aquifer Mapping in Parts of Udhampur, Rajouri, Kathua, Reasi Districts, Jammu & Kashmir

1.0 INTRODUCTION

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic, chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. The National Project on Aquifer Management (NAQUIM) is an initiative of the Ministry of Water Resources, Government of India, for mapping and managing the entire aquifer systems in the country. The study integrates multiple disciplines and scientific approaches, including remote sensing, hydrogeology, geophysics, hydrochemistry, drilling, groundwater modelling, and management approaches.

Total targeted area of Aquifer Mapping Implementation Plan for XII Plan period is 8.89 lakh sq km out of 23.25 lakh sq km Mappable area of the country. As far as maps depicting aquifers are concerned, the first map on Hydrogeology was published by Geological Survey of India in 1969 under the title "Geohydrological Map of India" on 1: 2,000,000 scale. Subsequently, CGWB published "Hydrogeological Map of India" on 1:5,000,000 scale with the data updated from the work of CGWB. On the basis of surveys, exploration and special studies undertaken, Central Ground Water Board published its first edition of Hydrogeological Map of India 1:2 Million scale in 1985 and its second edition in 2001. Based on stratigraphy, with the data available at that time, 9 major aquifers (hydrogeological units) were depicted in the map. Aquifer Atlas of Jammu & Kashmir was prepared on 1: 250,000 scale.

Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the potability of ground water.

1.1. Objectives

The major objectives of Aquifer Mapping are

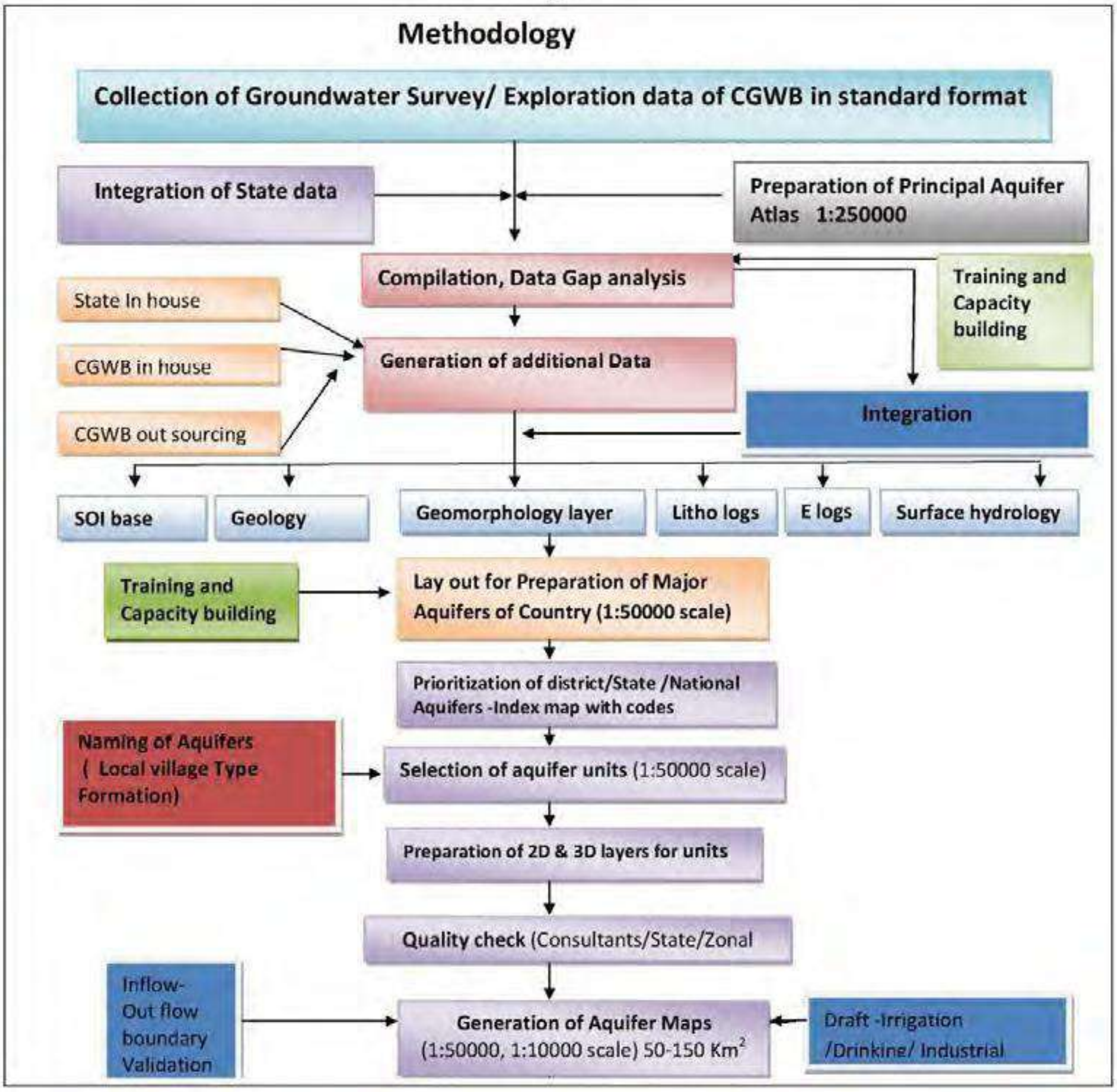
- To identify and map subsurface aquifer geometry at the micro level,
- To evaluate aquifer parameters
- To quantify the available groundwater resources and to propose plans appropriate to the scale of demand and aquifer characteristics, and institutional arrangements for participatory management.

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. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used planners, policy makers and other stakeholders. Aquifer mapping at the appropriate scale can help prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development in the country as a whole.

1.3. Approach and Methodology

The major activities involved in this process include i) collection of data from various sources like CGWB records, State Government agencies and available literature on internet; ii) compilation of existing data; iii) identification of data gaps; iv) generation of data for filling data gaps and finally v) preparation of aquifer maps and Management Plan. The overall methodology for aquifer mapping is shown in the flow chart given below



1.4. Location of the study area

The report deals with Aquifer Mapping carried out in Parts of Udhampur, Kathua, Rajouri & Reasi districts of Jammu and Kashmir State which covers an area of 1286 sq km. It falls in the Survey of India Degree Sheet No 43 K, 43 L and 43 P and Topo Sheet No's 43L/13, 43K/3, 43K/4, 43K/8, 43K/12, 43K/16, 43P/1, 43P/2, 43P/5, 43P/6, 43O/4 (1:50,000 scale) and as extension of Dun belt in 43 P/10 it was also covered under this study. The area lies between North Latitude 32°34" and 33°17" and East Longitude 74°00" and 75°38" (Figure 1).

While studying the area from the geological maps it was observed that Most of the areas are covered by Siwalik and Murree group of rocks and the alluvium is found in patches and along the river terraces which is of Quaternary age. The limestone occurring in the study area belongs to the Subathu and Sirban Groups. The Sirban limestone is of Meso-Proterozoic age and is also known as Trikuta Limestone which occurs in Reasi District, occurs as inliers and comprises dolomite, cherty dolomite and stromatolitic dolomite. The Subathu limestone is of Eocene age and occurs only in Kalakote area of Rajouri district and fall in toposheet no. 43 K/8 comprised of shelly limestone with shale bands, calc siltstone, olive green shale with limestone bands and coal lenses.

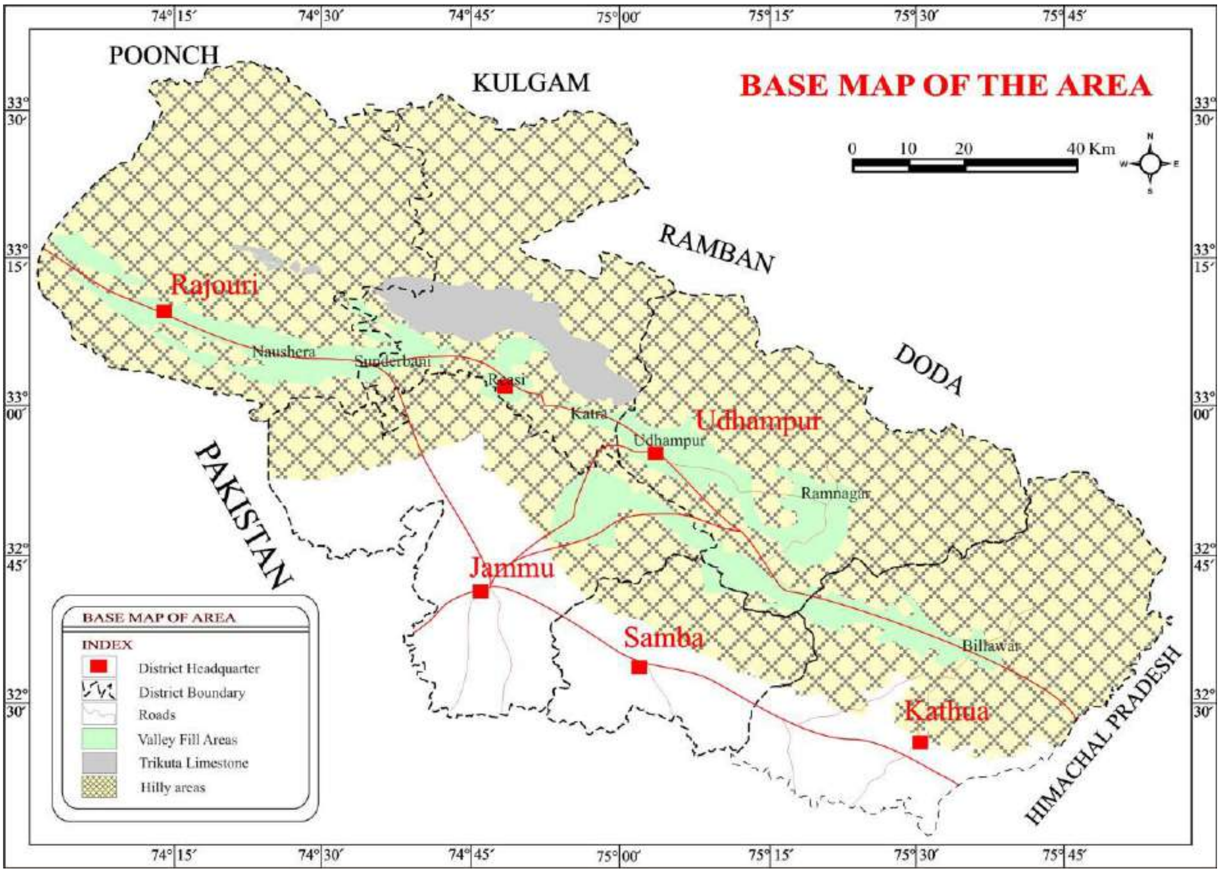


Figure 1: Base Map of the Area

1.5. Climate

Due to variation in altitude there is a wide variation in climatic conditions in different parts of the districts experiencing a temperate climate, tropical climate, semitropical to sub tropical climate. During summers temperature rises as high as 47°C and winter temperature falls as low as 3°C in the plains and subzero in upper hilly areas. The monsoon starts from the beginning of July to the first week of September. From October to June the precipitation and temperature patterns resemble closely the valley temperature zones. However, the summer rainfall and temperature resemble the precipitation pattern in the sub-tropical zone. The average annual rainfall is 1400 mm in Udhampur district, 1150 mm Rajauri, 1320 mm in Reasi and 1360 mm in Kathua district while most of the higher hilly areas experiences snowfall. The maximum rainfall in the area is received through southwest monsoon during July-September.

1.6. Physiography

The study area shows the conspicuous physiographic variations comprising moderately high hills, isolated hillocks and valley fill deposits with gentle slopes. The major physiographic slope is towards south and south-west. The part of hilly terrain consists of the sub-Himalayan parallel hill ranges separated by narrow valleys and the alluvial terraces along the Rivers. The number of terraces reflects the number of period of rejuvenation. The study area is mountainous and has rugged topography. Here alluvium lies in the small patches in the low lying areas and terraces of the rivers. The average altitude of which varies from 500 to 690 m amsl except for that of Nowshera (850-920 m amsl). In Dun Belt, the altitudes range from 450 to 650 m amsl. The Trikuta limestone in the north eastern part of the study area forms the hills. The limestone formation of Kalakote area has an average altitude from 750 to 830 m above mean sea level whereas in Reasi area the altitudinal variation is from 800 to 950 m amsl.

1.7. Geomorphology

A variety of conspicuous geomorphic features are present in the area. It is seen that tectonics played major role in the development of these geomorphic features. The important geomorphic features are:

Denudation Hills: High denudational hills exist in the northern and eastern part of the area. These erosional hills vary in elevation from 1100 m to 2400 m above M.S.L. The crest lines of these hills are generally sharp. At some place these have rounded top such as around Ardhkumari, Patnitop.

Structural Hills: The structural hills in the area belong to Murree and Siwalik groups. They are mostly longitudinal hills i.e. their trends parallel to strike of the bed. The altitude of these hills varies between 700 m to 900 m. Some peaks of these hills attain an altitude upto 2300 m. The slope of the hills is generally gentle to moderate. Along some river valley slope is steep eg. along Ans River.

Residual Hills: Residual hills also exist in southern part of the area. A small mound is a residual hill (700 m above msl) occur near Garan where Reasi fort is situated..

River Terraces: In this area between Talwara and Derababa these are developed in pairs along the river bank, known as paired terraces. Near Reasi, Bida etc. a non-cyclic terrace is moderately dissected by various streams. The alluvial deposits of Udhampur are entrentched by Tawi River. Among these terraces youngest one is terrace-5 has widespread extention.

Cup/Fan Terrace: It is widely observed in the study area. A series of fan terraces is developed on hill slopes. They have thin veneer of sediments. It is developed due to merger of the tributaries nala to the others, in this process velocity of the tributary or nala lessen and a subsequent deposition take place.

Meanders: In the study area, major rivers i.e. Chenab and Tawi make meandering river Channel i.e. the river flows across the flood plain in broad sweeping curves. The Chenab River produces meandering course near Salal which is controlled by a group of a shear zones. River Tawi exhibits meandering in the northern part of the study area near Chenani due to structural control. It shows the same after emerging from the Udhampur Dun and traversed through terrace deposits. The low gradient and obstructions in the course of river produces such type of meandering. Here sediments are deposited at the convex side of the channel as point bar, which is more potential for the ground water.

1.8. Drainage

The entire study area lies in the sub-basin of Chenab, which is a part of Indus River basin. It is drained by a number of perennial rivers and ephemeral streams. These nallas and streams remain dry in summer but create havoc due to flash floods especially in rainy seasons. The main rivers draining the study area are Munnawar Tawi in Rajouri district, Chenab in Reasi district, Tawi in Udhampur, Jammu district (Figure 2). All these carry huge load of boulders, pebbles, sand and silt during monsoon period.

These streams originate from northern mountainous regions and flows in southwestern direction. These rivers are fed by number of first to fourth order streams which have alluvium patches near them. Among these main are Pei Khad, Anji Khad etc. The Chenab River produces meandering course near Salal which is controlled by a group of a shear zones. River Tawi exhibits meandering in the northern part of the study area due to structural control. It shows the same after emerging from the Udhampur Dun and traversed through terrace deposits. The low gradient and obstructions in the course of river produces such type of meandering. Here sediments are deposited at the convex side of the channel as point bar, which is more potential for the ground water.

The drainage pattern of the area has a lithological and structural control depicting dendrites, trellis and sub-rectangular to rectangular pattern. Due to partial internal nature of the drainage and impervious formations, medium to fine drainage density occurs in this area.

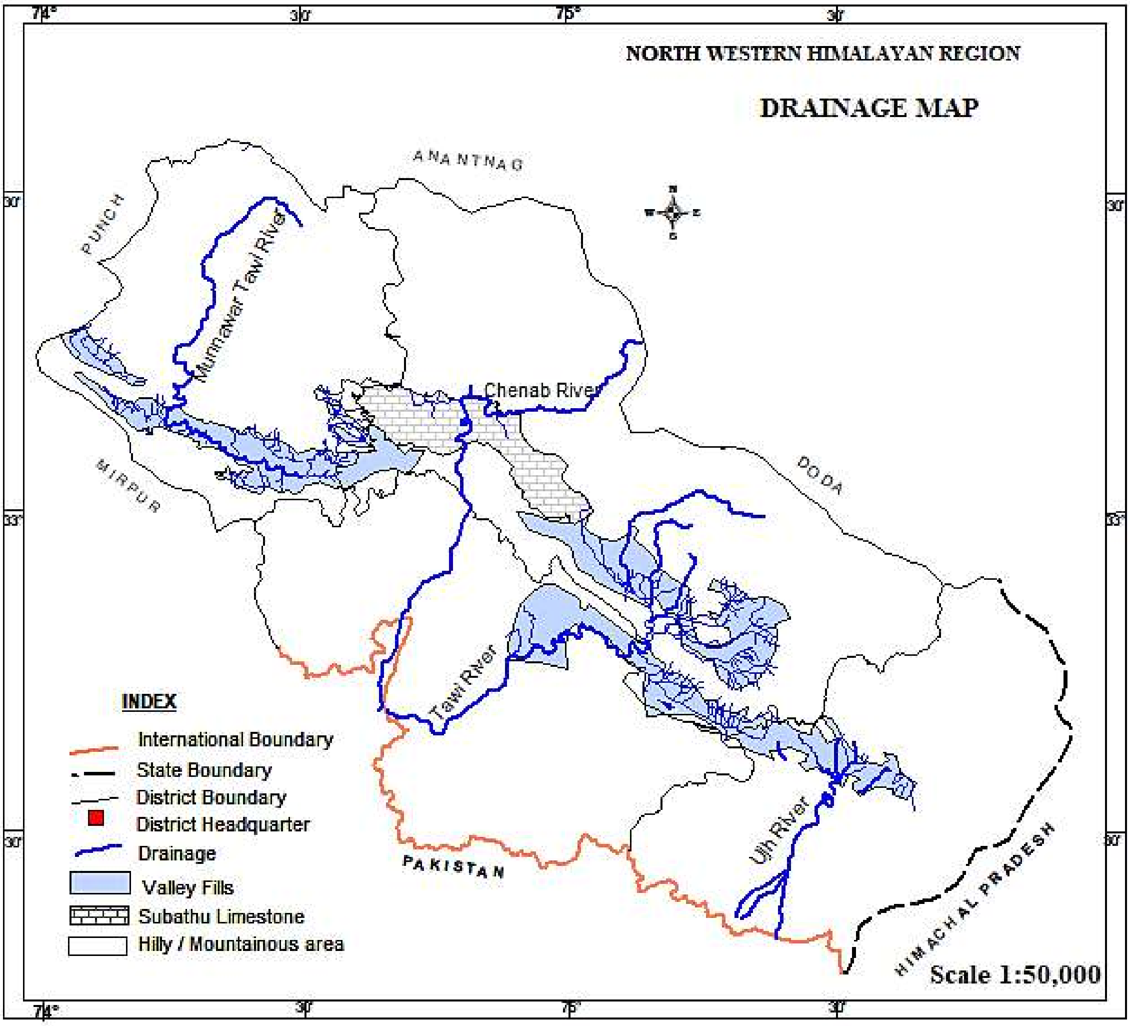


Figure 2: Drainage Map of the Area

1.9. Water Table Contour

The area has a mountainous topography and the aquifer systems are discontinuous hence water level and water table contour maps could not be generated.

1.10. Data Availability

The summarized table presenting the data availability, data requirement, data adequacy, data gap analysis & data generation is shown in table 1 and 2 given below.

Table: 1 Data Availability in Aquifer Mapping Area

S. No.	Type of structure	Agency	Quantity	Remarks
1	Tube Wells	CGWB	34	
2	Tube Wells	State Govt.	5	
3	Hand Pumps	State Govt.	35	
4	Dug Wells	CGWB	53	CGWB NHS wells
5	Key Wells	CGWB	38	Established under NAQUIM later some wells introduced in NHNS

Table: 2 Data Requirement, Data Adequacy, Data Gap Analysis & Data Generation

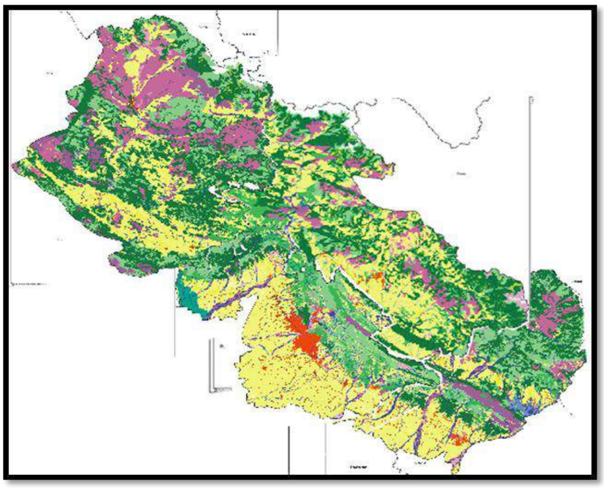
S. No.	Parameters	Data Requirement	Data Availability	Data Gap	Data Generation
1	Rainfall data	Meteorological stations spread over the project area	District – wise rainfall data	No data	Data to be collected from IMD
2	Soil	Soil Map and soil infiltration rate	Not available on any scale	Data Gap in whole area	Soil infiltration rate across study area
3	Land Use/Land cover	Land Use/Land cover pattern	Land Use data latest	Data Gap in whole area	Latest data required in GIS platform
4	Geomorphology	Digitized geomorphological map	Downloaded from NRSC, ISRO Hyderabad	Data Gap in whole area	Digital geomorphological maps in GIS compatible software
5	Geophysics	Geophysical data in each quadrant	Not available as required	Data Gap in whole area	Data to be generated
6	Exploration Data	EW in each quadrant	Not available	Data Gap in whole area	Data to be generated
7	Aquifer Parameters	Aquifer parameters in all the quadrants	Not available	Data Gap in whole area	Data to be generated
8	Recharge parameters	Recharge parameters for different types of soil and aquifer based on field studies	Available in Resources Estimation but insufficient	Nil	More Data required for accurate results
9	Discharge Parameters (Draft data)	Discharge Parameters of different Ground Water abstraction structures	Available in Resources Estimation but insufficient	Nil	More Data required for accurate results
10	Geology	All the data/maps on 1:50,000 scale. Hard and soft copy	Not available	Data Gap in whole area	Data to be compiled for Survey of India as hard as well as soft copies compitable in GIS

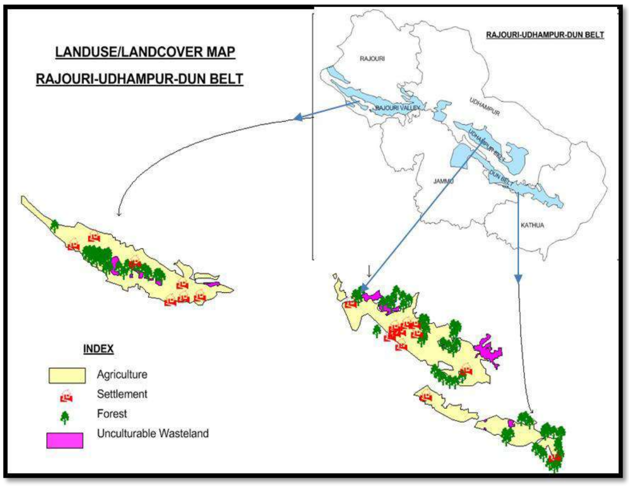
1.11. Soil

Various types of soils are formed in different regions of the state owing to marked physiographic and climatological variations. Different types of soil groups present in the study area are i) Alluvial soil, ii) Clay loam, iii) Sandy loam, iv) Brown, Red hill soil. Alluvial soils occur in parts of Kathua Districts where the land elevation is less than 300 m above mean sea level (m amsl). These soils are homogeneous and very fertile. Clay loam and Sandy loam occurs in parts of Udhampur district. Brown, Red hill soils are formed at land elevations between 300 and 1500 m amsl in parts of Udhampur, Rajouri, Reasi district. These soils are confined to small strips and terraces along the intervening valleys. In general, these soils are less productive.

Landuse/Landcover

The district-wise landuse/landcover map prepared by the National Natural Resource Centre and National Remote Sensing Centre of ISRO, Hyderabad was downloaded from bhuvan-noeda.nrsc.gov.in/theme (figure). It has been observed that major parts of the area are covered by agricultural land followed by forest and settlement.





1.12. Agriculture

Agriculture as we know plays a very prominent role for development of economy of J&K State. Around 70% of the population in the State get livelihood directly or indirectly from Agriculture. Rice is the predominant crop followed by wheat, maize, pulses, vegetables and other crops**.**

Maize is main Kharif crop of Udhampur which comprises of 4589 hectares area irrigated of the total cropped area Kharif crops viz. Bajra is sown in small area whereas wheat is harvested in Rabi season and constitutes 1682 hectares of the total cropped area. Rice is sown in 2941 hectares area especially in the terraces deposits. Rice is the main crop in Kathua, Rajouri and Reasi, with 6261.3, 4505 and 1430 hectares area respectively followed by wheat, maize, barley and other crops (Table 3).

1.13. Irrigation

Irrigation is a crucial input for the development of agriculture in the state. State does not receive rain throughout the year and sometimes it is quite insufficient and it is neither uniform nor certain. Rainy season provides sufficient water from July to September. In winter also this region receives several showers of rain. The remaining months of the year are dry.

The net area irrigated by different sources during 2013-14 was 20740.5 hectares. The mode of irrigating the crops mainly used is the canals. About 13608.9 hectares of the net area irrigated through canals followed by wells (2889.9 hectares), tanks (1160.3 hectares) and other means (3081.4 hectares) (Table 4)

About 5.0% of the total area sown in Udhampur district is irrigated which shows that 95% of cultivation is till dependent on rainfall. Rajauri district does not have well developed irrigation network. Most of the cultivable lands are located in the slopes where irrigation network is not possible. Rajal Canal is the only surface water irrigation system in the district and irrigates about 660 ha of the land.

Table: 3 Crop irrigated by district 2013-14									
		Area irrigated {Hectares}							
S. No	District	Rice	Maize	Wheat	Barley	Other cereals pulses & millets	Other food crops	Other nonfood crops	Total Area Irrigated under All Crops
1	Udhampur	2941	4589	1682	159	68	338	295	10072
2	Reasi	1430	182	907	1	32	44	59	2655
3	Kathua	6261.3	84.3	5109	7.8	11.1	69.9	1262.4	12805.8
4	Rajouri	4505	134	3280		52	252	475	8698
	Total	**15137.3**	**4989.3**	**10978**	**167.8**	**163.1**	**703.9**	**2091.4**	**34230.8**

Table: 4 Net area irrigated by district from different sources 2013-14						
S. No	District	Net Area irrigated by				(Area in ha)
		Canals	Tanks	Wells	Other Sources	Total
1	Udhampur	4221	914	2339	329	7803
2	Reasi	1628	26	-	-	1654
3	Kathua	5064.9	168.3	288.9	932.4	6454.5
4	Rajouri	2695	52	262	1820	4829
	Total	**13608.9**	**1160.3**	**2889.9**	**3081.4**	**20740.5**

(Source: Digest of Statistics 2013-14)

1.14. Cropping Pattern

Agriculture is the main source of livelihood in the area. Topography, climate and soil are the main factors affecting agriculture. The crop calendar for the area is shown in table 5

Table:5 Crop Calendar of the area			
S. No.	Crop	Period of Sowing	Period of Harvesting
1	Rice	June to July	October & November
2	Wheat	October	April
3	Barley	October & November	April & May
4	Maize	April & May	September & October

1.15. Water Conservation and Recharge Practices

Ground water extraction through wells, hand pumps, tube-wells, Bowlies & springs are the major sources of water supply to both rural and urban areas but availability of water during summer is limited in hilly uplands particularly in drought years and requires immediate attention to augment these resources. Roof top rainwater harvesting need to be adopted in urban areas and hilly water deficit areas and proper scientific intervention for spring development and revival is required in water scarce areas.

The area being hilly and mountainous, traditional sources of ground water mainly springs have played a major role since past in providing assured irrigation and water supply. These include the nallas, springs, chashamas. In some areas, at present too, these are the only sources of water for settlements, but the availability of the water during summer is limited. Based on the climatic conditions, topography, hydrogeology of the area, suitable structure for rain water harvesting and artificial recharge to ground water is required.

All the old tanks/ ponds are required to be revived. These practices will help to conserve surface water with resources otherwise being lost and revive depleting/drying of springs.

In the hilly areas, Check dams, Gabion structures and Nalla bunding, Roof top rainwater harvesting structures like storage tanks are recommended while in low hill ranges, low height check dam and roof top rainwater harvesting structures can be adopted. The traditional water sources like springs and bowlies needs to be protected.

2.0 DATA COLLECTION AND GENERATION

2.1. Hydrogeology

Ground water in the major part of the study area occurs in localized, disconnected bodies under favorable geological conditions. Major part of the study area is occupied by rocks belonging to Murree and Siwalik formations of tertiary period. In general, the ground water potential is poor here. The shallow dug wells located in the terrace and valley fill deposits yield low to moderate discharge of groundwater. There is no homogenous aquifer system having wide areal extent. However zones of secondary porosity in them form suitable areas for ground water and occur in fissures, weathered, jointed and fractured parts. Further it also occurs in solution cavities, channels etc. in the carbonate rocks. In alluvial formation it occurs in the valley fill deposits, terraces and river terraces, thin veins of soil cover over hard rock. Ground water occurrence in the area occupied by Siwalik rocks is restricted to small isolated patches in hilly areas. The Murrees are totally devoid of primary porosity. However, the Ground water emerges in the form of springs at contact of pervious and impervious beds and other structural features. Most of the springs are originating from higher reaches, two-three springs jointly makes a high discharge also originating and meeting at higher reaches of mountains under gravity. The Alluvial deposits are highly heterogeneous comprising of varying grades from gravels, sand, silt & clay. These deposits possess a good degree of primary porosity & permeability controlling the occurrence and movement of ground water. Ground water in the area occurs under water table condition in alluvium and confined condition in the underlying rocks of the older age. The ground water occurrence is mainly controlled by topography, drainage, structure and lithology. Springs, in the areas are main source of groundwater. Springs are formed where the water table is intercepted by the topography. In the study area, the springs are widely distributed, occurring in the different formations at varying altitudes. Occurrence of spring is controlled by lithological and structural character of rock formation. Majority of the springs occur along fracture zones. Kishanpur-Mandli Thrust are some major fractures along which springs are located. Rainfall & snowmelt is the main source of recharge to ground water body

2.2. Monitoring of Water Level through NHNS Wells

The field study was carried out to study the behaviour of water Levels in the study area in parts of Rajouri, Reasi, Udhampur and Kathua districts. In the study area a total number of 53 Hydrograph Network Stations have so far been established and are being monitored four times annually in the month of May, August, November and January. Locations of monitoring wells are shown below in figure 3.

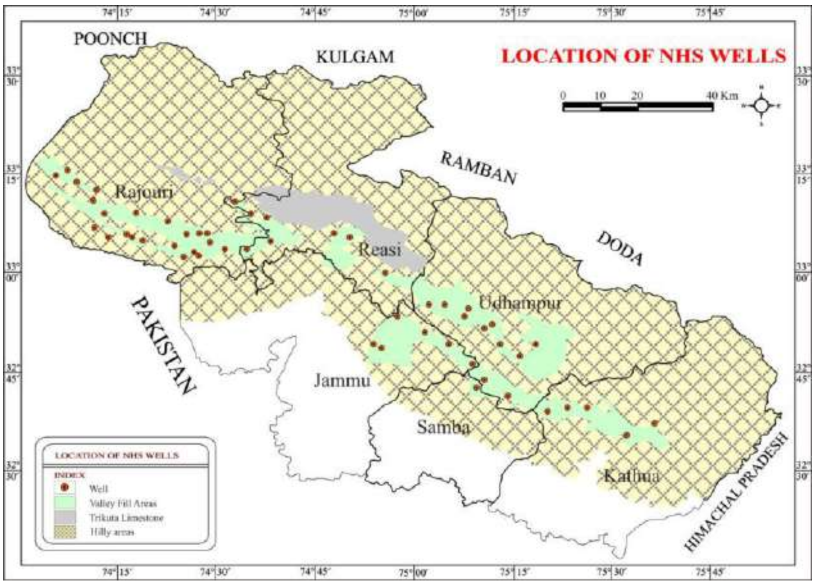


Figure 3: Location of National Hydrograph Monitoring Stations

2.3. Hydrochemistry

The concentration of ions/elements in natural water is governed by general factors, like nature of formation through which water circulates, soil characteristics, concentration due to activities of men etc. Hence the content of natural water may vary from place to place. Water for different purpose should comply with the given specifications. Different parameters for drinking water are as:

a. ***General Parameters (mg/l):*** Iron (as Fe), Aluminium (as Al), Copper (as Cu), Zinc (as Zn), Magnessium (as Mg), Barium (as Ba), Calcium (as Ca0, Silver (as Ag), Selenium (as Se), Molybdenum (as Mo), Boron (as B), Nitrate (as NO_3), Sulphate (as SO_4), Sulphide (as H_2S), Fluoride (as F), Chlorides (as Cl), Ammonia (as total ammonia – N), Chloramines (as Cl_2), Residual, Free chlorine, Total Alkilinity as calcium carbonate, etc.

b. ***Physical Parameters:*** Colour (Hazen units), Odour, Taste, Turbidity (NTU), Dissolved solids (mg/l), pH value, Total Hardness (as $CaCO_3$) mg/l.

c. ***Parameters concerning toxic substances (mg/l):*** Total Arsenic (as As), Lead (as Pb), Mercury (as Hg), Total chromium (as Cr6+), Nickel (as Ni), Cadmium (as Cd), Cyanide (as CN), etc.

A total of 35 samples were collected from different dugwells and tubewells falling in the study area. These samples were sent for chemical laboratory of CGWB NWHR Jammu for chemical analysis. All the collected samples were analysed by adopting standard methods of analysis (APHA). The results of the NHS wells falling in the area reveals that the chemical quality of ground water is good and is suitable for irrigation as well as for domestic purpose except for a few localized pockets where concentration of EC, NO_3, F, Fe and pH. Results of chemical analysis data of ground water samples is given in Annexure – I. The brief description of the chemical parameters is given as under-

2.3.1. Nitrate

Nitrate concentration in most part of the study area is within the permissible limit of BIS (45 mg/l), whereas Nitrate concentration is exceptionally high and above the permissible limit at Lam (127 mg/l), Rumli Dara (52 mg/l), and Nagrota Gujroo (48 mg/l) (Figure 4) which may be due anthropogenic contamination.

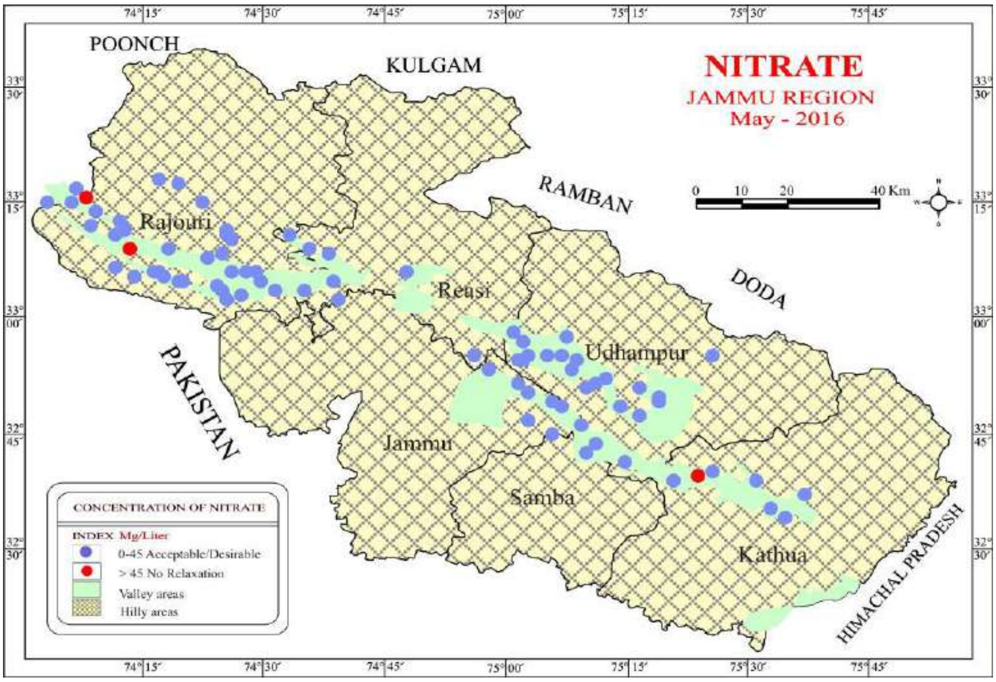


Figure 4: Nitrate Distribution Map

2.3.2. Sulphate

Sulphate concentration is within the permissible limit of BIS (0-200 mg/l)), with slightly higher value hereas at Manwal (297 mg/l) shows slightly higher value and above acceptable limits at Lam (467 mg/l) (Figure 5).

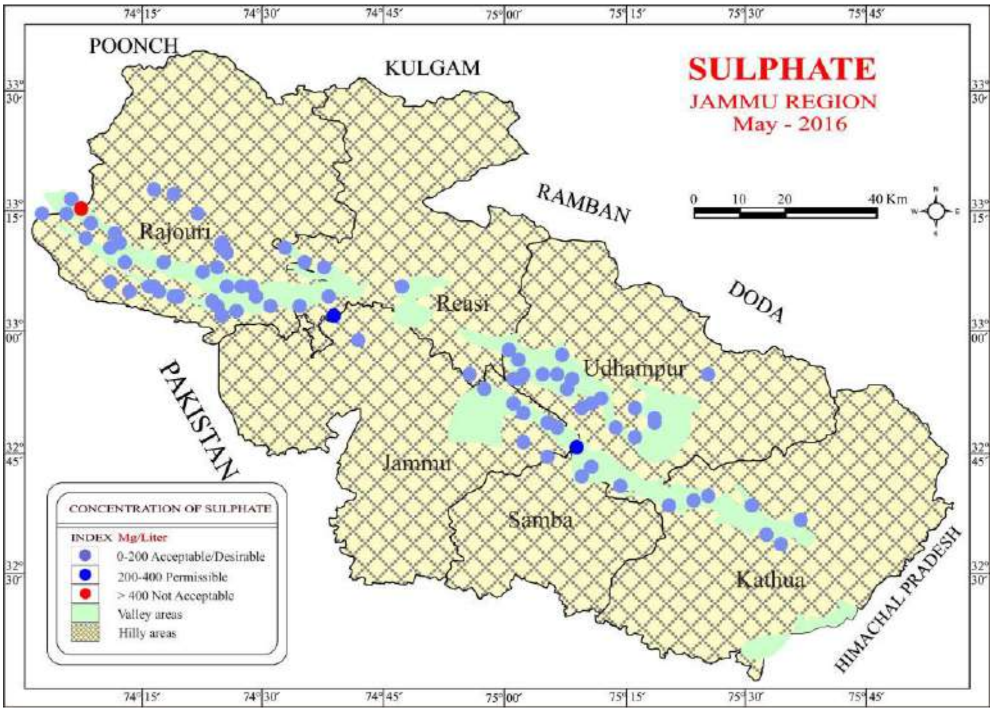


Figure 5: Sulphate Distribution Map

2.3.3. Calcium

Calcium concentration in water determines the hardness of water. The calcium concentration is within the acceptable/desirable limit of BIS (0-75 mg/l) in all part of the study area except for few localised pockets where calcium concentration is within the permissible limit (75-200 mg/l) which is found at Eastern Mand (92 mg/l), Lam (86 mg/l), Billawar (86 mg/l) and Ramkot (82 mg/l) (Figure 6).

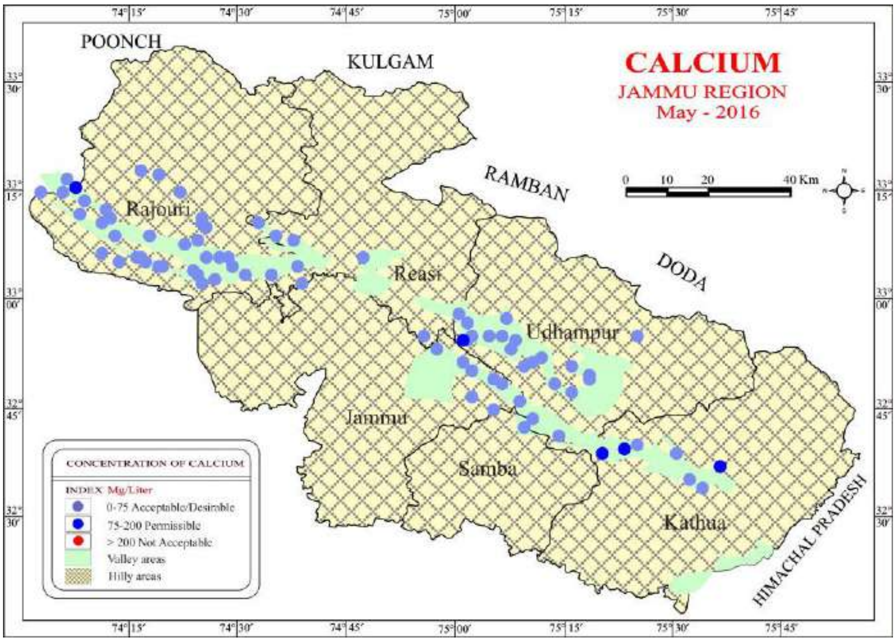


Figure 6: Calcium Distribution Map

2.3.4. Fluoride

Fluoride concentration is within the acceptable/desirable limit of BIS (0-1.0 mg/l) in all part of the study area (Figure 7).

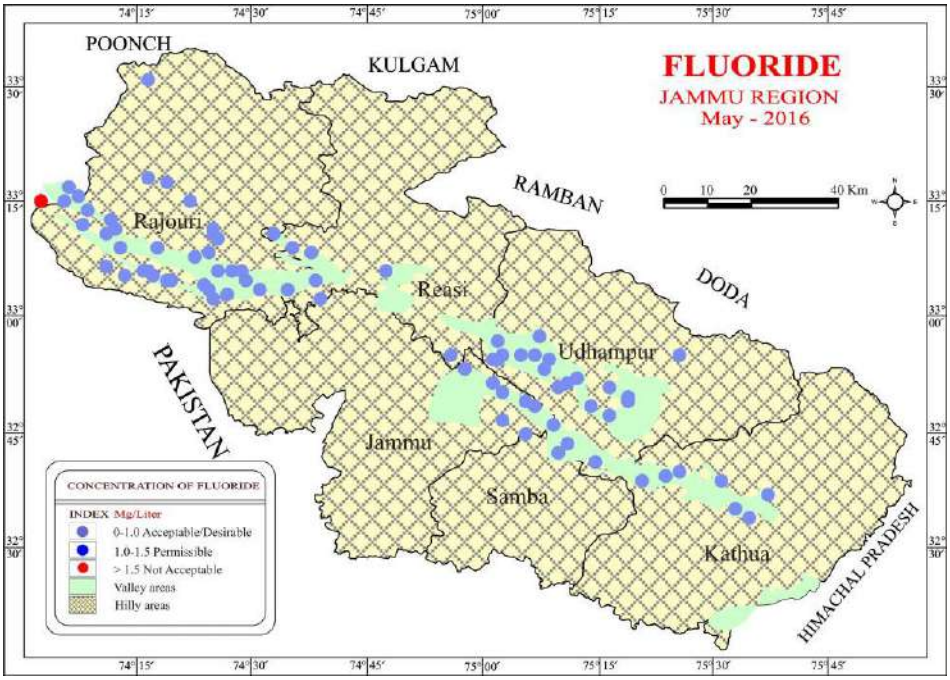


Figure 7: Fluoride Distribution Map

2.3.5. Chloride

Chloride concentration is within the acceptable/desirable limit of BIS (0-250 mg/l) in all part of the study area (Figure 8).

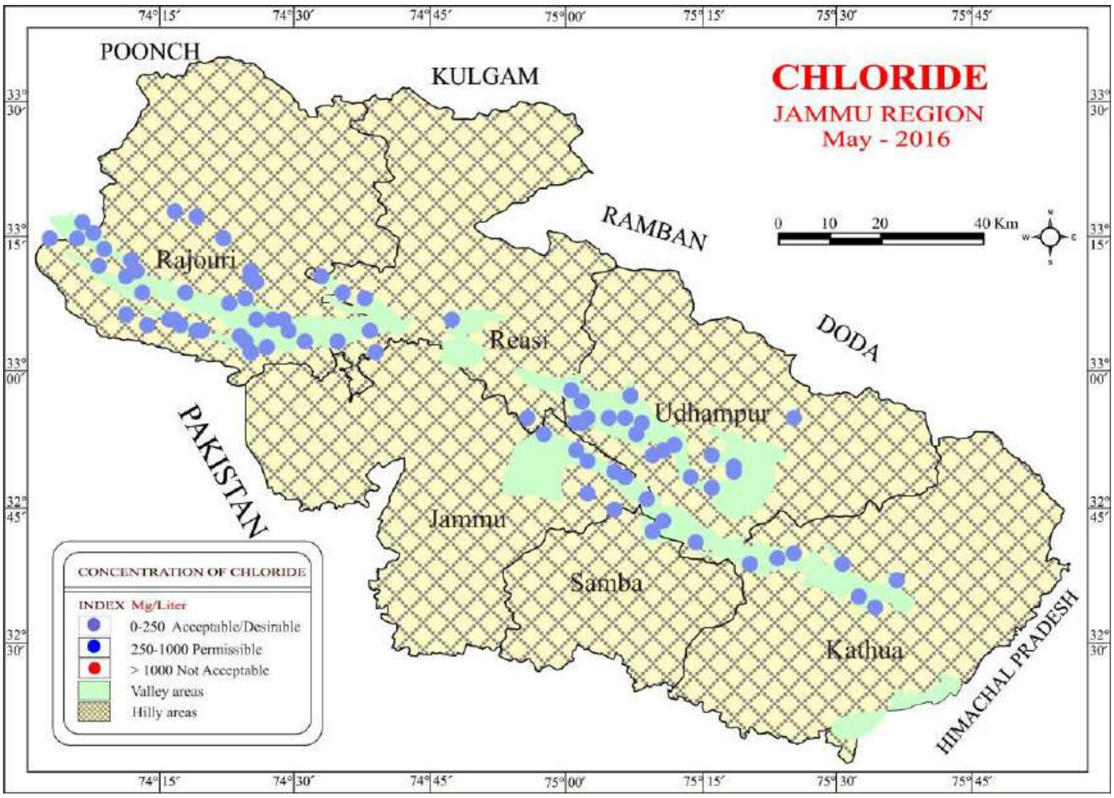


Figure 8: Chloride Distribution Map

2.3.6. Iron

Iron concentration in most part of the study area is within the acceptable/desirable limit of BIS (0-1 mg/l), whereas higher values of Iron concentration i.e. greater than 1.0 mg/l have been reported in 11 wells which are shown in (Figure 9). The iron in the region is due to iron bearing rocks / minerals like Hematite, magnetite and its oxide which forms iron bacteria in anoxic conditions.

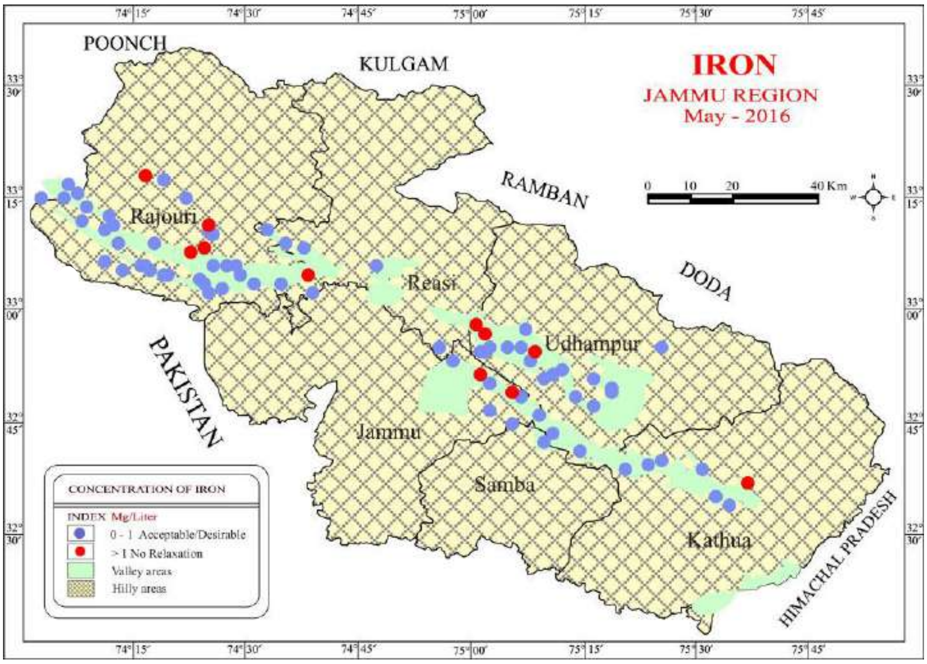


Figure 9: Iron Distribution Map

2.3.7. Magnesium

Magnesium concentration in most part of the study area is within the acceptable/desirable limit of BIS (30 mg/l), whereas few places like Bareri (43 mg/l), Salote (36 mg/l), Talwara (47 mg/l), Kara (39 mg/l), N. Gujroo (39 mg/l) and Phinter (38 mg/l) shows slightly higher value but are within the permissible limit of BIS (30-100mg/l) shown in the Figure 10.

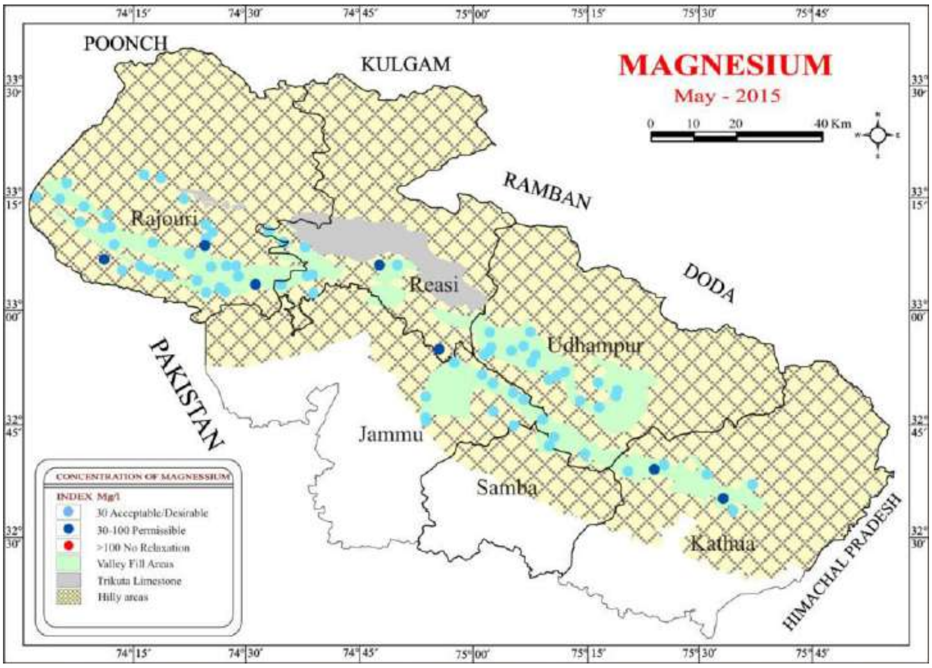


Figure 10: Magnesium Distribution Map

2.3.8. pH

pH is a measure of the hydrogen ion concentration of a solution. It shows how acidic/basic water is. pH in most part of the study area is within the acceptable/desirable limit of BIS (6.5-8.5 mg/l) and is neutral to alkaline in nature, whereas higher values of pH i.e. greater than 8.5 mg/l have been reported in 29 wells which are shown in (Figure 11).

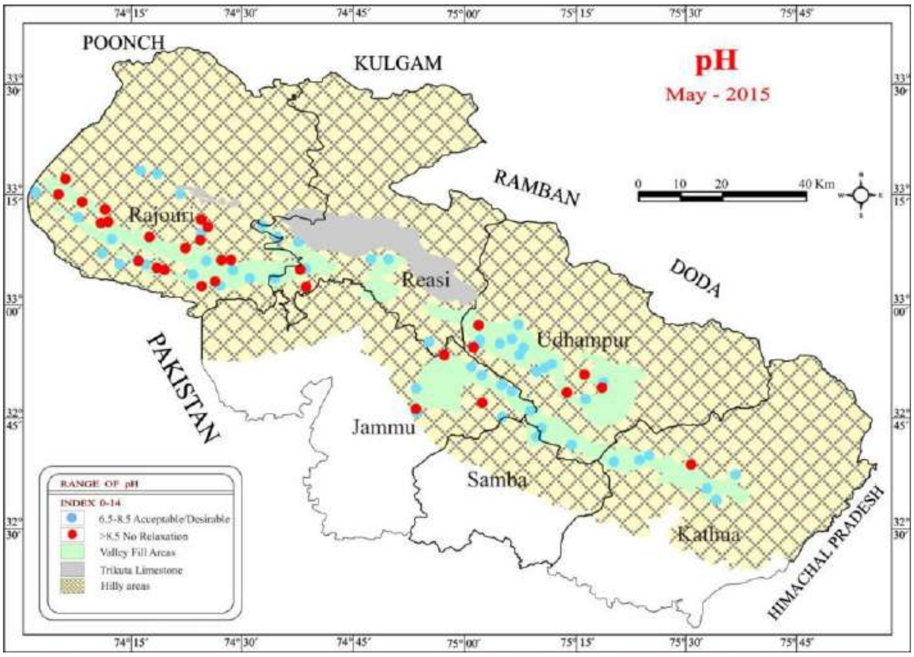


Figure 11: pH Map

2.3.9. Electrical Conductivity

Electrical Conductivity of ground water is generally medium. Few localized patches have higher Specific conductance values i.e. > 2000 µS/cm at 25^{o}C which are shown in (Figure 12).

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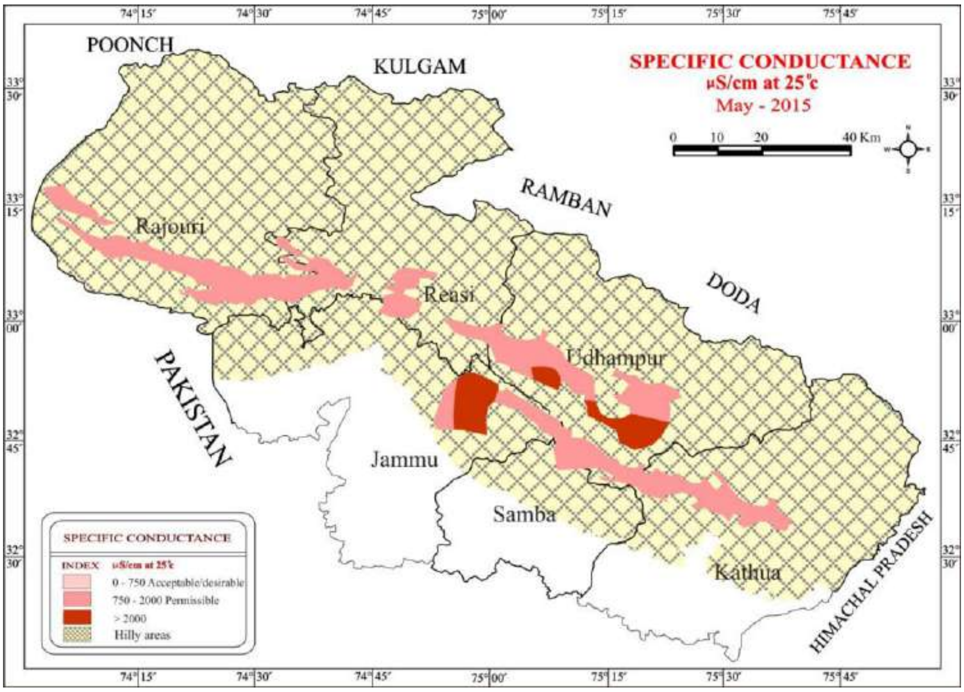


Figure12: Specific Conductance Map

2.3.10. Total Hardness

High concentration of carbonates, bicarbonates of calcium and magnesium, in ground water causes hardness. Hardness concentration in most part of the study area is within the acceptable/desirable limit of BIS (0-200 mg/l), whereas few places like Bareri (280 mg/l), Dharamsal (250 mg/l), Salote (205 mg/l), Talwara (345 mg/l), Battal Ballian (210 mg/l), and N. Gujroo (210 mg/l) shows slightly higher value but are within the permissible limit of BIS (200-600 mg/l) shown in the Figure 13.

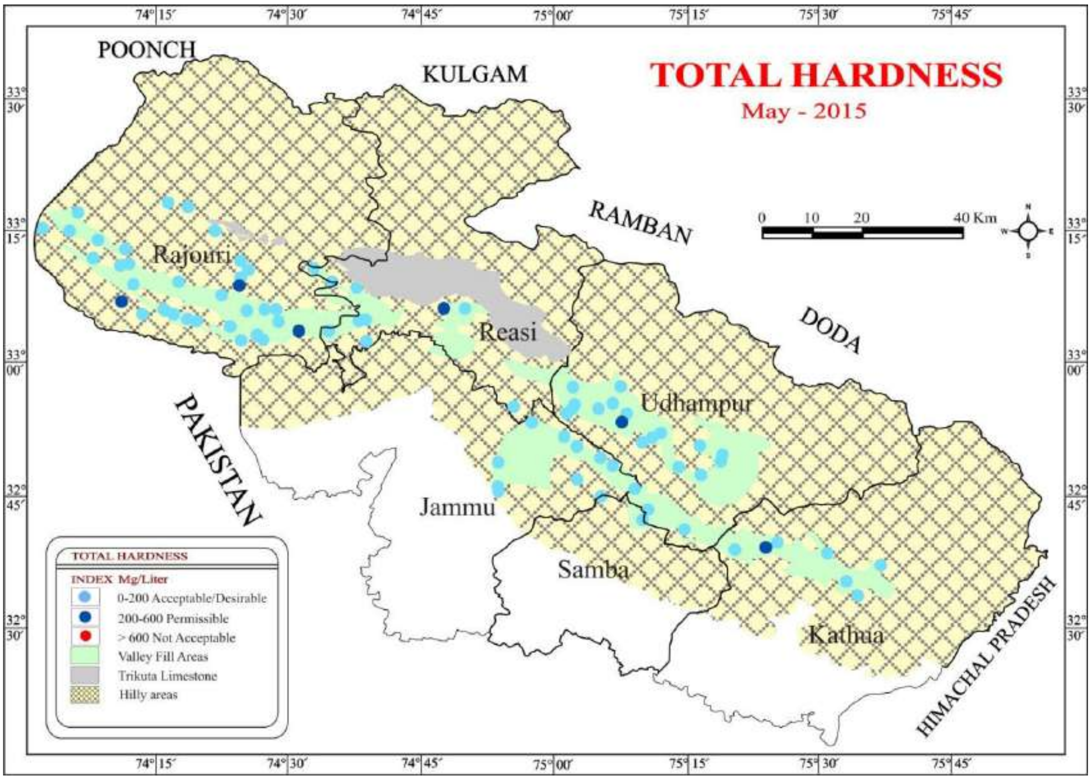


Figure13: Total Hardness Map

2.4. Geophysical

Geophysical studies carried out in the Aquifer Mapping area comprises of VES with Schlumberger array, Resistivity Profiling with Wenner configuration and need based Borehole Electrical Loggings. As per the Data Gap Analysis carried out upto March-2014, the geophysical data available is 167 VES conducted at 91 locations. The Resistivity profiles available are 14, by which traverses of 2340 line-m have been covered. The VES have earlier been mostly conducted at a location, in close vicinity, like Badsu EW, Bamiyal EW, Kathel – Batal, Lohara Lehar, Malhori, Letar, in campus like BSF, Sunderbani, Northern Command HQ, Udhampur etc. therefore, lacking wide coverage for making cross-sections. During AAP 2013-14, a total of 22 VES have been conducted in Rajouri and Dun belt of Udhampur Districts, as per the data gap requirement of aquifer mapping study. A total of 12 VES were conducted during AAP 2014-15, in parts of Jammu and Dun belt of Udhampur Districts. The location Map of the VES & Electrical logging is given in (Figure 14)

As the drilling in the Aquifer Mapping area has been done mostly by DTH rig with odex attachment, due to which boreholes are cased. Thus, leaving very little scope to conduct electrical logging. However, in two boreholes geophysical borehole electrical logging have been conducted namely at Tanori & Kotli, where appreciable uncased portion was available.

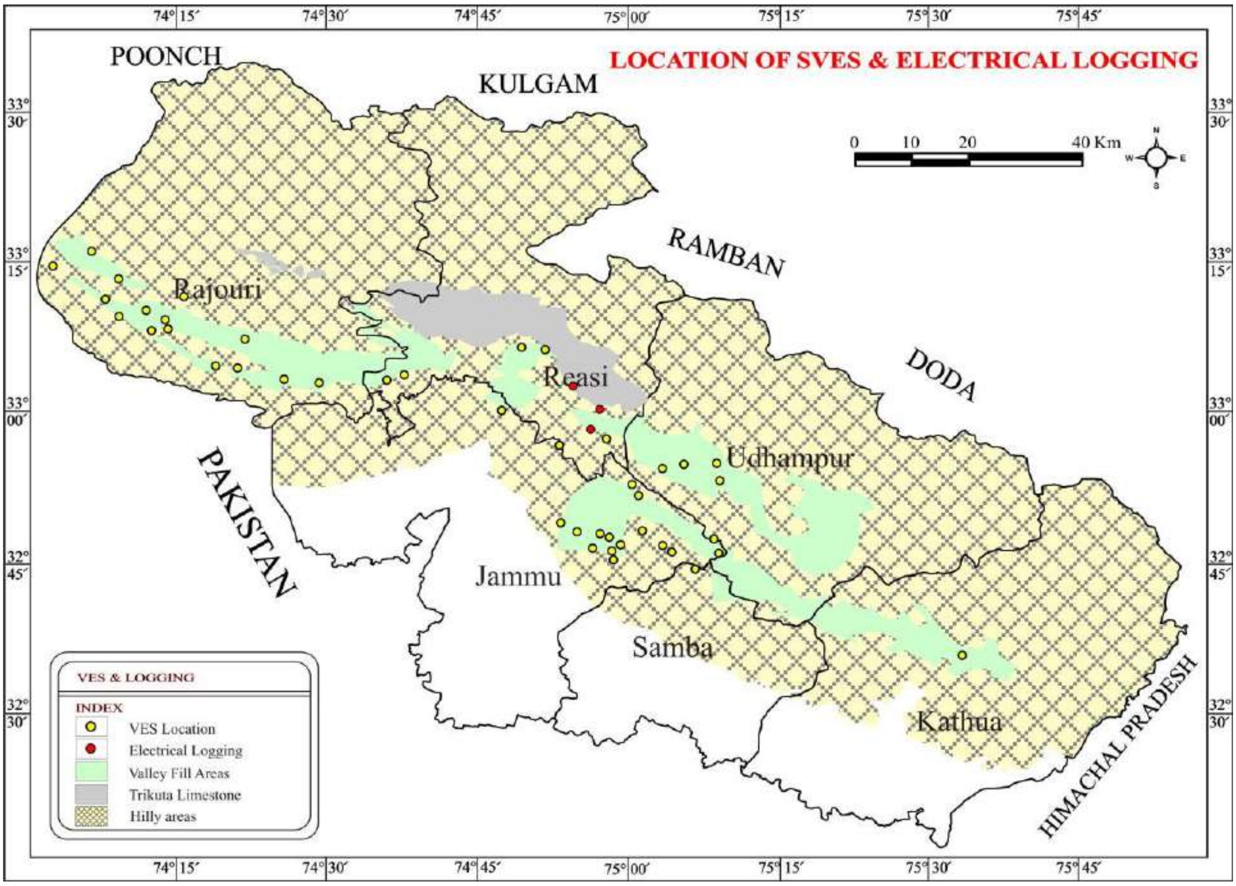


Figure14: Location Map of VES & Electrical Logging

2.4.1. **Findings**:

1) Northern Command HQ, Udhampur:

The interpreted true resistivity of the field VES curves indicates 5 to 11 sub-stratum geo-electrical layers in the depth range of 26 m bgl to 84 m bgl. The 5 geo-electrical layers have been identified at VES-4 & 5. The 6 geo-electrical layers have been identified at VES-3 whereas 11 geo-electrical layers have been found in VES-2.

The WRP were conducted on the same line of VES. The station at which the VES point lies on profile was noted carefully. On the qualitative analysis of the WRP profiles, it is observed that there is high resistive (hard) formation zone in the depth range of 25 to 30 m bgl below the observation point at distance 25 m toward MT area from the VES-1 location on the profile.

From the study and analysis of field VES curves, it is implied that most of the curves are of H, Q or HA type. The sounding curves indicate the presence of clay/shale at shallow depths. The small troughs in curves are indicative of resistivity lows in the background of resistivity high. The hard formation is represented by high resistivity values whereas the low resistivity value corresponds to clay mixed formation.

The geo-electrical section prepared on the basis of WRP-1 to WRP-5 data indicates that there is not much abrupt variation in sub-surface lithology, except toward MT area, which shows slightly high resistivity values. The geo-electrical section prepared on the basis of WRP-1 to WRP-5 data is given in figure 15.

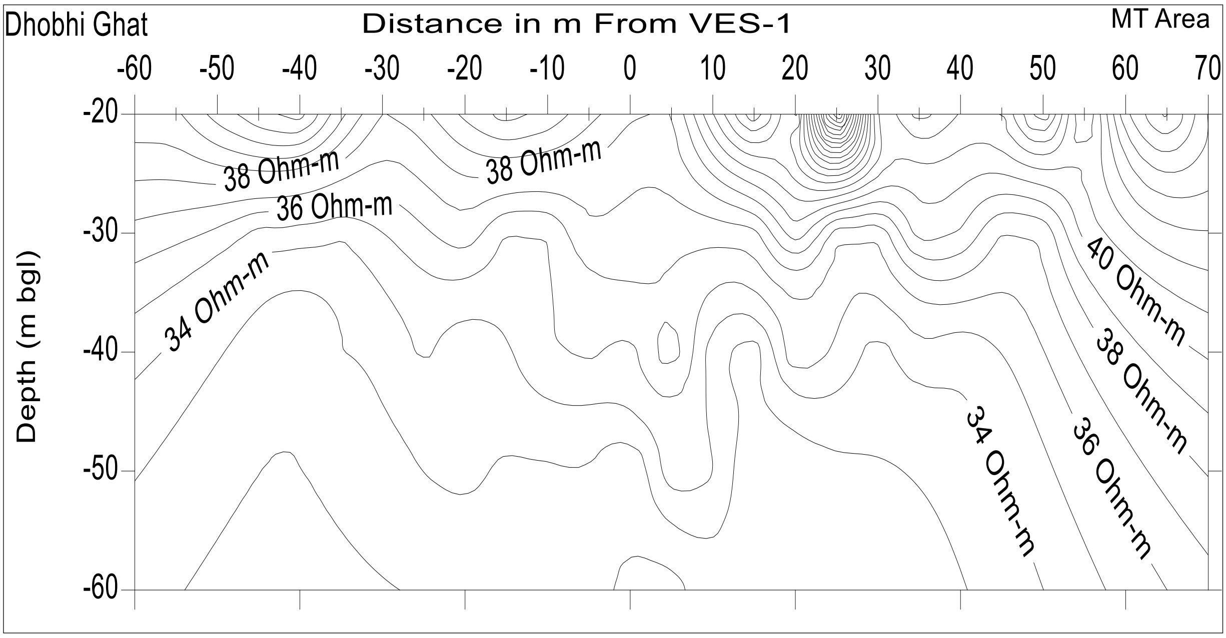


Figure 15: Geo-electrical resistivity profile of WRP-1 to WRP-5 of Northern Command, Udhampur. Distance 0 corresponds to VES-1 location.

2) Phinter – Billawar Road:

A total of Forty-Five Vertical Electrical Sounding (VES) with Schlumberger electrode configuration were carried out along the Phinter – Billawar road. The soundings were conducted with the maximum current electrode separation (AB/2) ranging from 35 m to 130 m. The interpreted true resistivity of the field VES curves indicates 4 to 8 sub-stratum geo-electrical layers. The resistivity sounding curves obtained in the area are of KH, KQ, QH, QQ and HK type. Based on the analysis of the field VES curves and interpreted layer parameters, it is deciphered that there is a possibility of encountering a ground water potential zones at VES 31 & VES 35 points. The prominent expected ground water feasible zones identified by interpreted results are in the depth ranges of 42 to 50 m bgl at VES 31 & 32 m bgl at VES 35. (VES 31- In the ground of Govt. Degree Collage, Behind Shiva Playway School, Dewal. VES 32 - Near Temple of Children Public School, along the unlined road, N-S direction & VES 35 - In the ground of mango tree garden, Dewal/Tilla).

3) 52 Bn BSF, Sunderbani:

A total of Fourteen VES with Schlumberger electrode configuration were conducted. One WRP was also conducted with electrode separation (a) of 20 m and a traverse of 100 line-m was covered keeping the station interval = 5 m. The VES and WRP were conducted in a nearly straight parallel survey line and orientation to avoid any ambiguity due to lateral in-homogeneity. The resistivity sounding curves obtained in the area are multi-layered in nature and represent Q, K, AH and QK type curves. The interpretated true resistivity layer parameter of the VES indicates four to nine sub-stratum geo-electrical layers. The four layers have been identified in VES 6, 9, 10 & 13 whereas nine layers have been found in VES 7. The true resistivity value ranges from 1.1 Ohm-m to 210 Ohm-m. The VES 12, 13 and 14 were carried out near the operational ground water extraction structures. The ground water zones in these ground water extraction structures are in the depth range of 4.5 – 15.45, 6 – 11 & 2.5 – 11.7 m bgl respectively, which corroborates with the geophysical interpreted results of ground water feasible zones and the depth of the dug wells.

From the analysis of the pseudo-geoelectrical cross section, it is inferred that the resistivity value of 24 Ohm-m is uniformly distributed, below the depth of 10 m under VES 3 spot and 16 m under VES 5 spot. At the VES 4 spot, there is convergence of resistivity contours at the depth of 6 m. At the VES 5 location, wide resistivity contours indicates the gradual decrease in resistivity upto the depth of 16 m and thereafter uniform distribution of 22 Ohm-m resistivity contour. (Figure 16)

Similarly, based on the electrical resistivity survey at various locations in parts of this aquifer mapping area, the lithology down to depth of 100 - 200 m below the surface was revealed. The high resistivity values in resistivity soundings interpretation indicates loose dry boulders, consolidated sandstone. Whereas, the intermediate high resistivity values in resistivity soundings interpretation indicates weathered fractured sandstone, sand, gravel, cobbles etc.. The resistivity values in the range of 2 to 15 Ohm-m, indicates the clay or clay mixed formation. The resistivity values in the range of 80 $\pm$ 20 Ohm-m, indicates the weathered / fractured formation, saturated / partially saturated with water. The low values in resistivity soundings interpretation shows the presence of clay mixed sediments

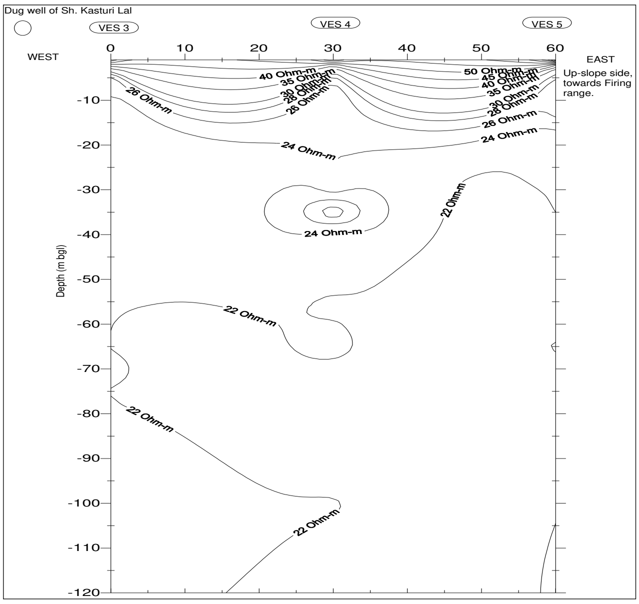
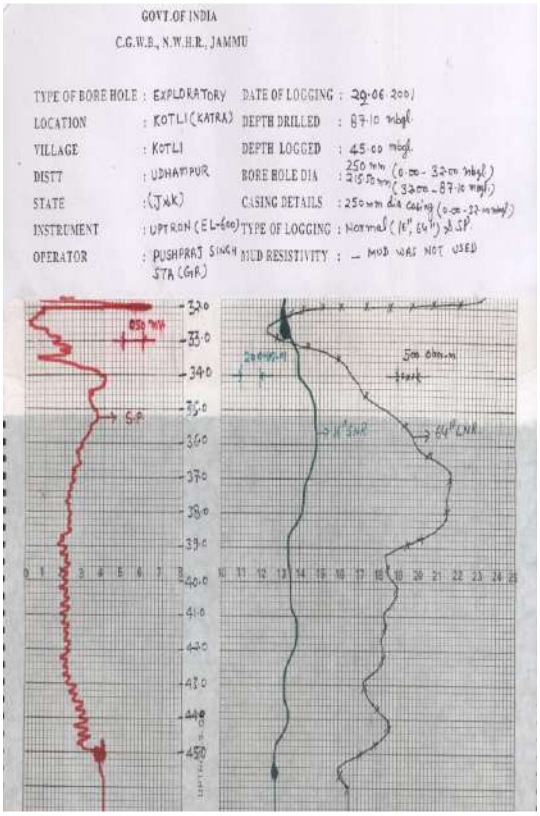
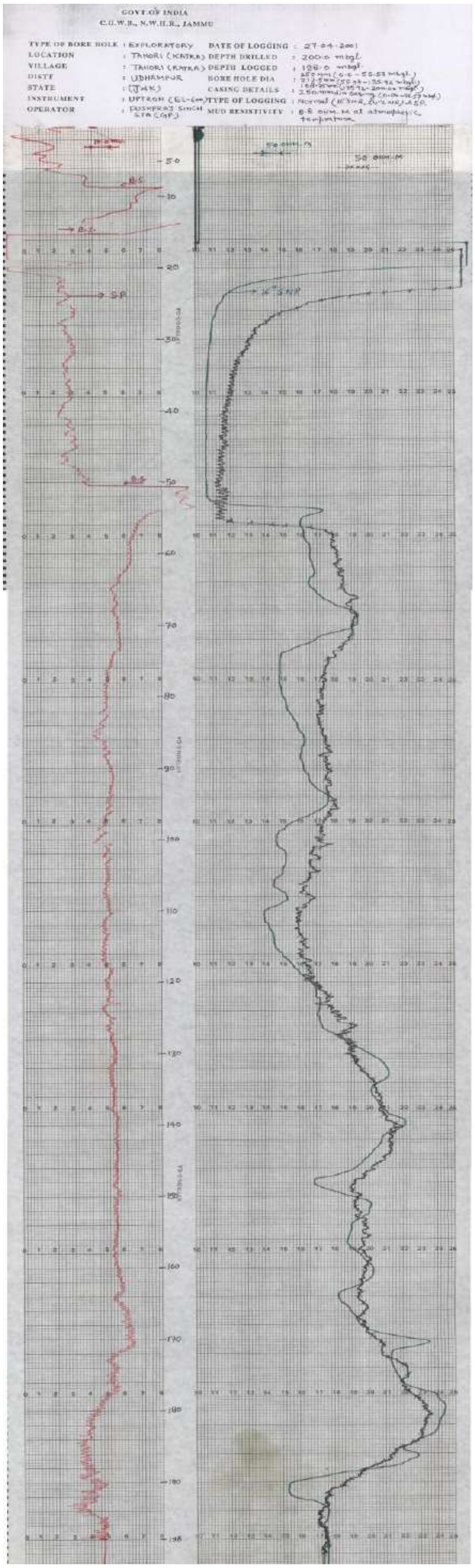


Figure 16: Psudo-Geoelectrical cross-section of VES 3, 4 & 5 near the dug well no.1





2.5. Exploration

Ground Water exploration work is carried out by CGWB in the area. Besides, state government also drilled mini tube wells and hand pumps in the area. In the present study the data of 05 wells and 35 hand pumps drilled by State agency along with 34 well drilled by Central Ground Water Board is analysed. Maps have been prepared with the help of Map Info software. As there is no Ground Water Department in Jammu and Kashmir and no other department is working in this field except for making ground water abstraction structures and extracting huge amount of water, hence the data of Central Ground Water Board was the only reliable source data. The location of tube wells and hand pumps used in preparation of aquifer maps and cross sections are shown below in figure 17 & 18 and the data is shown in Annexure II.

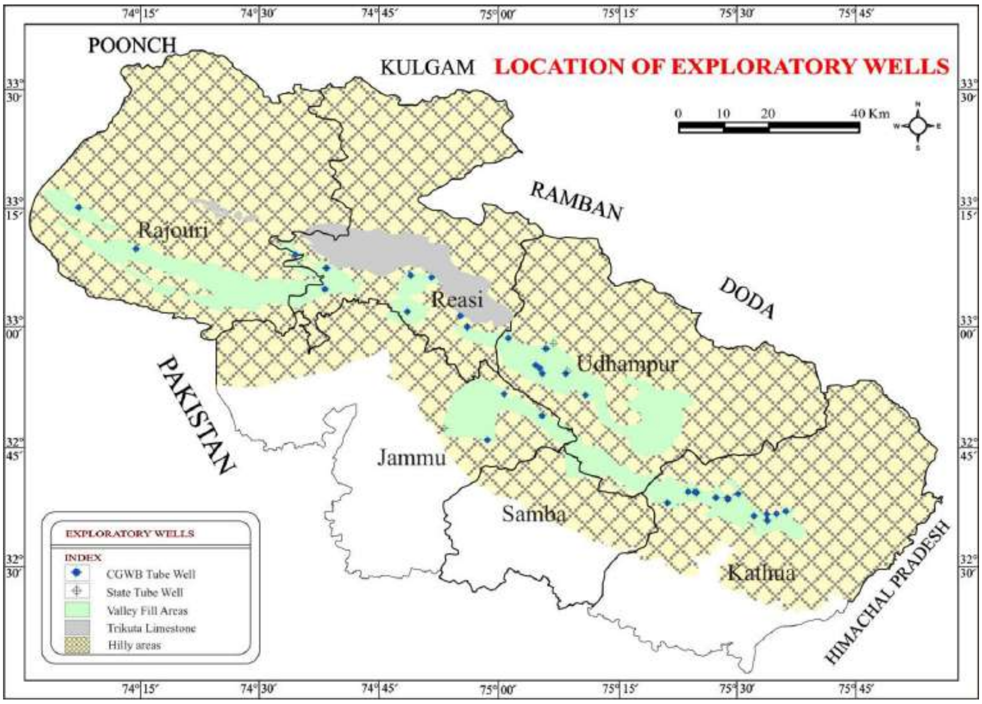


Figure 17: Location of Exploratory Wells

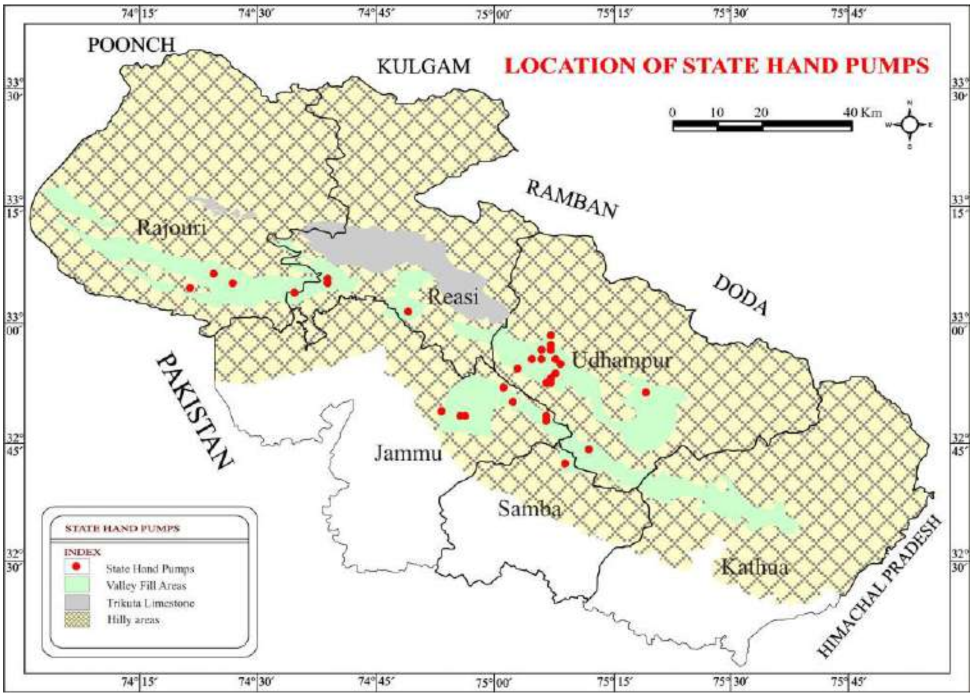


Figure 18: Location of State Hand Pumps

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1. Lithological Disposition and Aquifer Disposition

CGWB Ground Water Exploration data in the form of lithologs was compiled and was put in MS Excel. Data of wells drilled by State agency and CGWB were used for deciphering the lithology and aquifers by preparing cross-section, fence and 3-D models. The strata charts from Public Health Engineering Department, Irrigation & Flood Control Department and other State Government Departments were also collected and brought into digital form. The lithological layers are generated using borehole data. The uniform colour codes are used for preparation of Aquifer/Lithological Sections, Fence diagram and 3D Aquifer/ Lithological dispositions diagrams. In the study area the layers are broadly classified into nine types as:

1) Boulder
2) Clay
3) Limestone
4) Clayey sand
5) Sandy clay
6) Quartzite Sand
7) Sandstone
8) Sandstone, Limestone
9) Shale

The lithological disposition and the aquifer disposition interpreted through the models, fence and cross sections prepared using Rockworks software. The sections drawn for sub-surface formations and aquifers have vertical and horizontal scales in meters.

3.2. Principal Aquifer System in the study area

As the study area comprises of Valley Fills: (928 sq. km.) and Great/Sirban Limestone: (358 Sq.km.). There are two Principal types of Aquifer system in the study area-

Aquifer unit - I - The top most aquifer is the Aquifer Unit-I and mostly tapped by Dug wells ; and

Aquifer unit – II- The aquifer which lies below the Aquifer unit – I is the Aquifer Unit-I I and mostly tapped by the deep bore/tube wells.

A. Valley Fills- In Valley Fill area which covers 928 sq km Aquifer Mapping area, the *Aquifer unit –I* comprises of overburden in the form of unconsolidated sediments like Boulder, Gravels, sand interclated with clay wherein the top of the aquifer lies at 5-10 m bgl and gives low to moderate yield. The general yield is 1-5 lps in this Aquifer system.

Aquifer unit – II comprises of Weathered/Fractured Sandstones and the top of the aquifer lies at 17-80 m bgl. Aquifer unit –II gives Moderate to High Yield. The general yield is 2-20 lps in this Aquifer system with 20 lps yield at Kansi Patta.

B. Great/Sirban Limestone- In Limestone region which covers 358 sq km Aquifer Mapping area, *Aquifer unit – I* comprises of Scree Material and Talus and the top of the aquifer is at 2-6 m bgl.

Aquifer unit - II comprises of Limestone with secondary porosity/ shale intercalations and the top of the aquifer is at 9-50 m bgl. Aquifer unit –II gives moderate yield (good yield at places). The general yield is 3-15 lps in this Aquifer system with 15 lps yield at Kotli.

The 3-D lithological and Aquifer Model, Fence Diagram & Cross Sections

As the study area is in patches we have taken the 3-D lithological and aquifer model along with Cross Sections belt wise

3 D Model & Cross Sections depicting Lithology and Aquifer of Rajouri Belt

The 3 D Model and Cross Sections depicting Lithology and Aquifer of Rajouri Belt is shown in figure 19. **3 D Model** depicts Bambla with higher elevation of 662 m and the lower elevation of 561 m at Thanda Pani. The water level in the wells of Rajouri Belt varies from 8.14 m to deepest at Bambla of 39.63 m. The depth of well construction varies from 70.0 m at Barakh to 112.80 m at Upper Siot which is deepest in the aquifer mapping area of Rajouri Belt.

Cross Sections delineating the lithology and aquifer disposition is drawn between Barakh - Kothia - Garan Jagir - Dadooa depicts the occurrence of Sandy clay, Clayey sand, Sandstone and Boulder with thin lenses of Clay. At Barakh there is small zone of 6 m of Sandstone mixed with limestone at the top but the major zones encountered here consists of Clayey sand which is water bearing and acting as Aquifer unit -I & Aquifer unit-II while at Kothia sandy clay acting as Aquifer unit –I and clayey sand and clay acting as Aquiclude. At Garan Jagir sandy clay and small zone of sandstone acting as Aquifer unit-I while the fractured Sandstone acting as Aquifer unit-I separated by Clay lenses while at Dadooa the formation is alternate consisting of Shale and Sandstone wherein Sandstone is acting as Aquifer and Shale as Aquiclude. The water level at Garan Jagir is at 21.4 m and at Dadooa is shallow at 8.14 m while at Kothia Clay acts as Aquiclude and does not contain any water.

Aquifer unit –I- Here the depth of Aquifer unit –I ranges from 7 - 42.68 m bgl.
Aquifer unit –II- Here the depth of Aquifer unit –II ranges from 21- 103 m bgl.

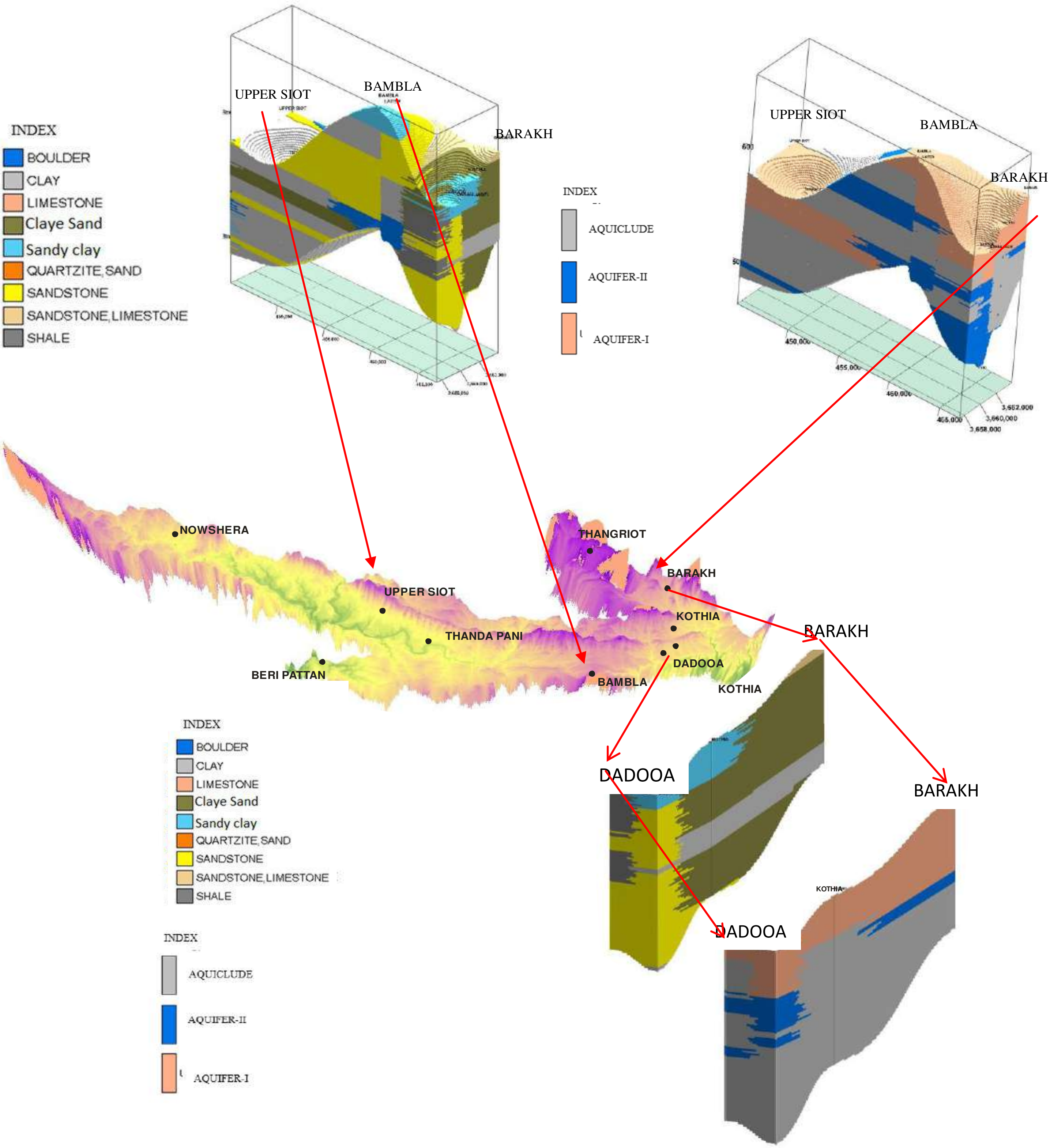


Figure 19: 3 D Model & Cross-Section depicting Lithology and Aquifer of Rajouri Belt

3 D Model , Cross Sections and Open Fence depicting Lithology and Aquifer of Udhampur Belt

The 3 D Model and Cross Sections depicting Lithology and Aquifer of Udhampur Belt is shown in figure 20. **3 D Model** depicts Bambla with higher elevation of 662 m and the lower elevation of 561 m at Thanda Pani. The water level in the wells of Rajouri Belt varies from 21.4 m to 42.19 m. The depth of well construction varies from 70.0 m at Barakh to 112.80 m at Upper Siot which is deepest in the aquifer mapping area of Rajouri Belt.

Cross Sections delineating the lithology and aquifer disposition is drawn between Battal Kothi – Pathli Battal - Ballian – Fangial- Kashirah depicts the occurrence of Sandy clay, Sandstone and Boulder with Clay. At Battal Kothi sandy clay is acting as Aquifer unit –I while the Sandstone formation is acting as Aquifer unit-II separated by clay lenses Aquifers and the water level here is at 18.228.96 m bgl. At Pathli Battal and Ballian sandy clay and Sandstone formation acting as Aquifer unit-I while Bouldery formation acting as Aquifer unit –II separated by Clay lenses with water level of 22.15 m bgl at Ballian and deepest water level of Pathli Battal well at a depth of 42 m bgl. At Fangial Bouldery formation acting as Aquifer unit –II, while Clay and Sandstone formation acting as Aquiclude, no Aquifer unit-I is present here and the water level is at 18.29 m bgl. At Kashirah sandy clay and Boulders acting as Aquifers and the water level here is at 18.29 m bgl.

Aquifer unit –I- Here the depth of Aquifer unit –I ranges from 7 – 12.19 m bgl.
Aquifer unit –II- Here the depth of Aquifer unit –II ranges from 76.21 m bgl.

Open Fence is shown in figure 21 depicting Lithology and Aquifer of Udhampur Belt is drawn between Battal Kothi to Mansar Yard and NCH Udhampur to Independent R+O FLT Udhampur. The occurrence of Sandy clay, Sandstone, Boulder, depicts various lithotype in the study area acting as Aquifers with Clay and Clayey sand acting as Aquicludes. At Bttal Kothi Sandy clay acting as Aquifer unit-I and Boulders as Aquifer unit-II with Clay acting as Aquiclude with water level at 28.96 m bgl

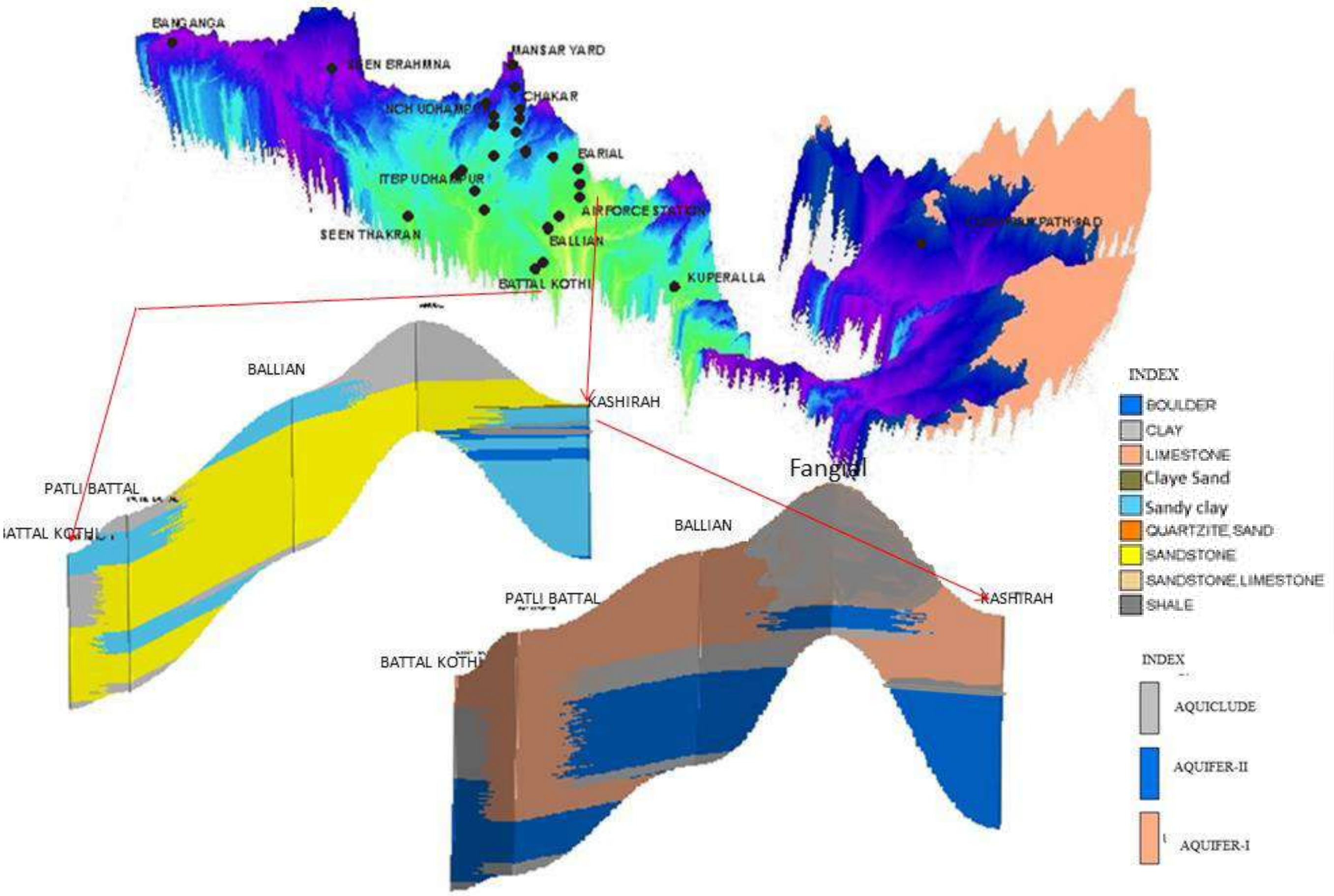


Figure 20: 3 D Model & Cross-Section depicting Lithology and Aquifer of Udhampur Belt

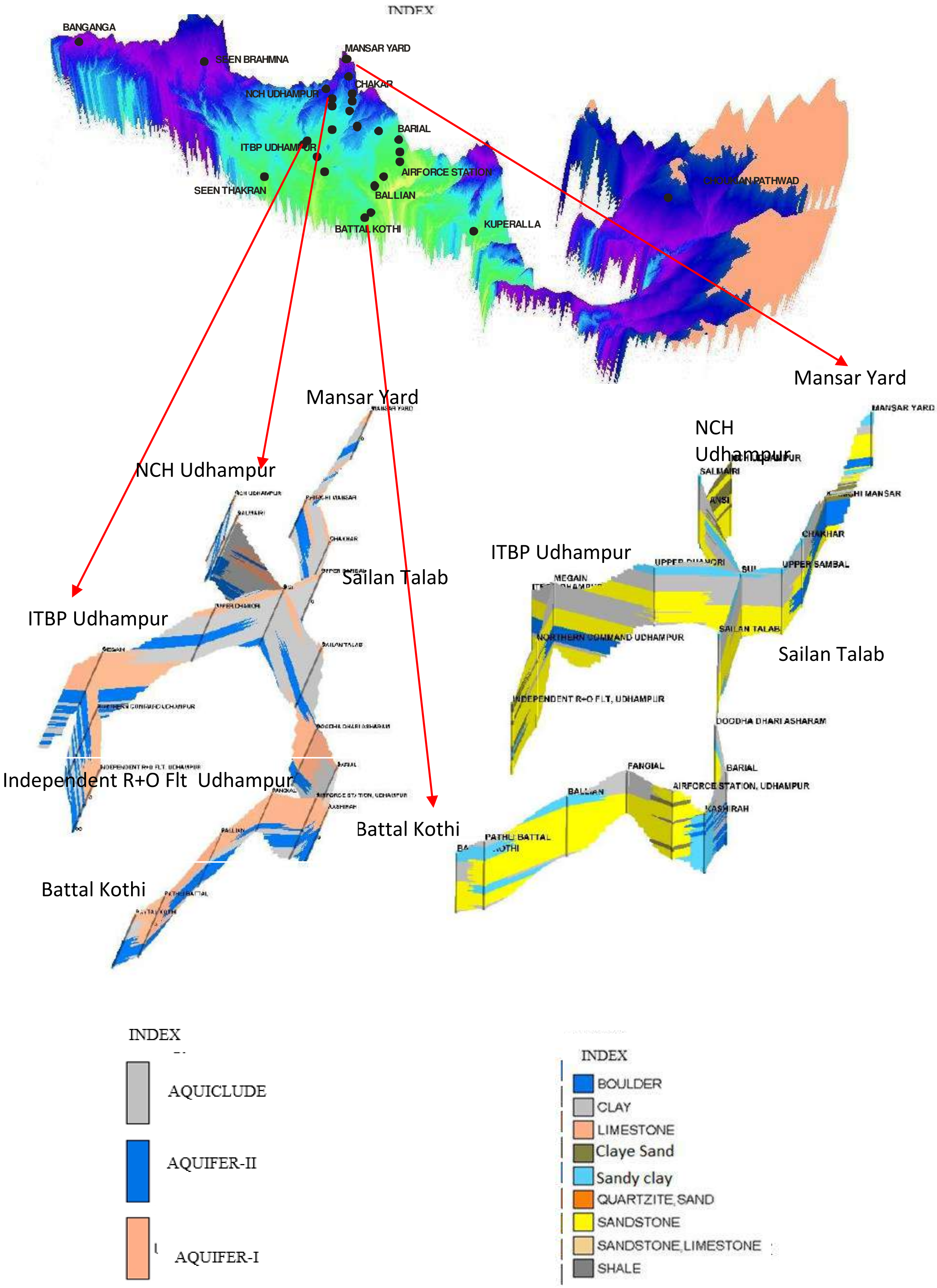


Figure 21: Open Fence depicting Lithology and Aquifer of UdhampurBelt

3 D Model & Cross Sections depicting Lithology and Aquifer of Dun Belt

The 3 D Model and Cross Sections depicting Lithology and Aquifer of Rajouri Belt is shown in figure 19. **3 D Model** depicts Bambla with higher elevation of 662 m and the lower elevation of 561 m at Thanda Pani. The water level in the wells of Rajouri Belt varies from 21.4 m to 42.19 m. The depth of well construction varies from 70.0 m at Barakh to 112.80 m at Upper Siot which is deepest in the aquifer mapping area of Rajouri Belt.

Cross Sections delineating the lithology and aquifer disposition is drawn between Barakh - Kothia - Garan Jagir - Dadooa depicts the occurrence of Sandy clay, Clayey sand, Sandstone and Boulder with thin lenses of Clay. At Barakh the formation is Clay wherein Clayey sand contain small zone as water bearing while at Dadooa the formation is alternate consisting of Shale and Sandstone. The water level at Garan Jagir is 21.4 m and at Dadooa is shallow at 8.14 m while at Kothia Clay acts as Aquiclude and does not contain any water.

Aquifer unit –I- Here the Aquifer unit –I ranges from 7 - 42.68 m bgl.
Aquifer unit –II- Here the Aquifer unit –II ranges from 21- 103 m bgl.

The **fence diagram 2** is drawn between Khanpur, Jagti Tanda, Narian Alory and Nadore (Figure 21 a, b) depicts the occurrence of Sandy clay, Clayey sand, Clay, Sandstone and Boulder. At Nadore the formation is alternate consisting of Clay and Sandstone. The Bouldary formation, Sandy clay and Sandstone acting as Aquifer and the water level varies from 16 m at Khanpur to 51 m which is deepest at Nadore.

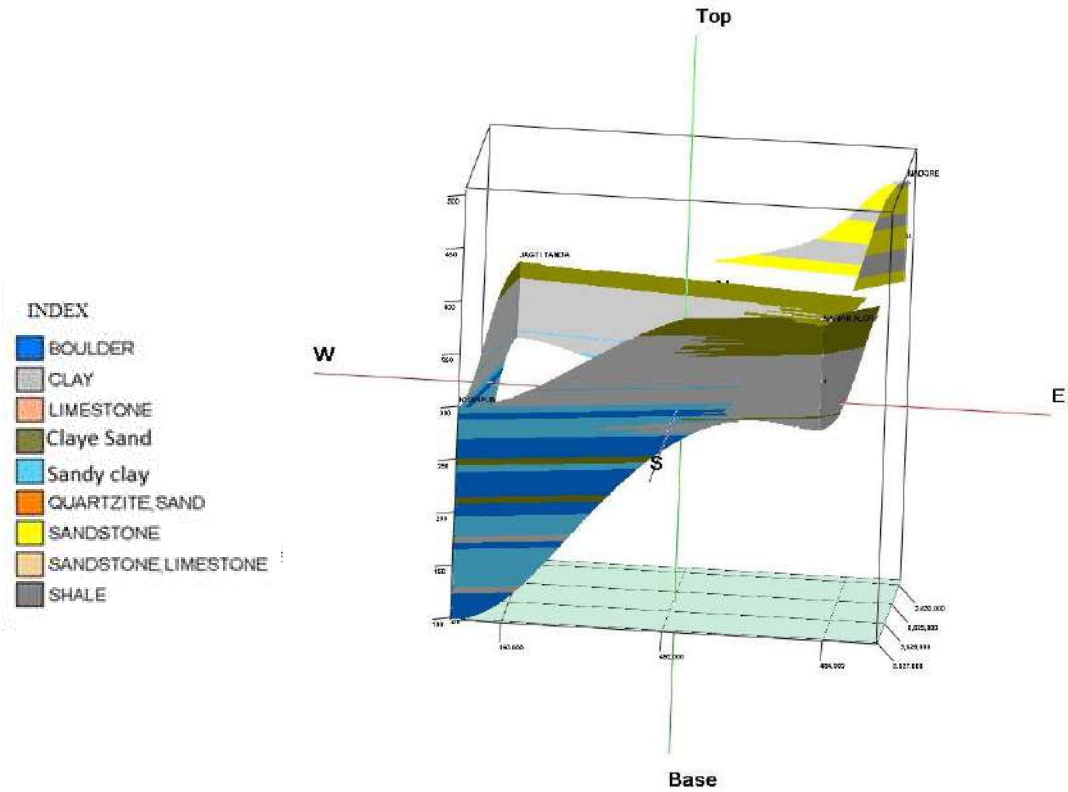


Figure 21 a: Fence Diagram depicting Lithological disposition

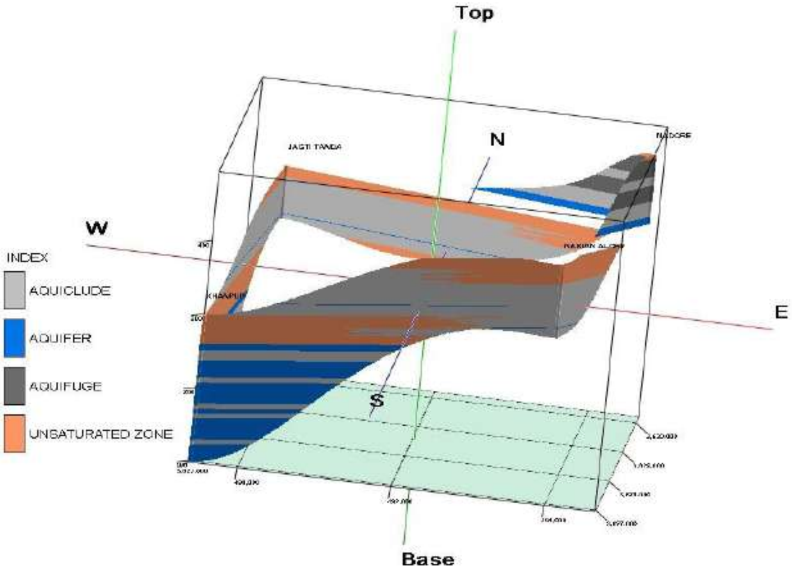


Figure 21 b: Fence Diagram depicting Aquifer disposition

The **fence diagram 3** is drawn between Surara, Dewal, DFO Billawar and FPF Gamma Unit Billawar (Figure 22 a, b) depicts the occurrence of Sandy clay, Clayey sand, Clay and Boulder. The Bouldary formation and Sandy clay acting as Aquifer and the water level varies from 10 m at Dewal to 17 m at DFO Billawar while at Suarara Sandy clay and Clay act as Aquifuge and Aquiclude and the well is dry.

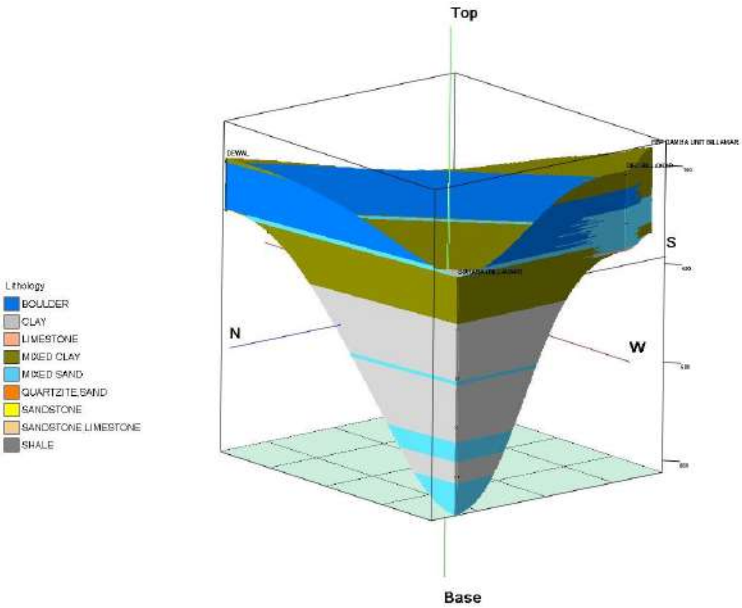


Figure 22 a: Fence Diagram depicting Lithological disposition

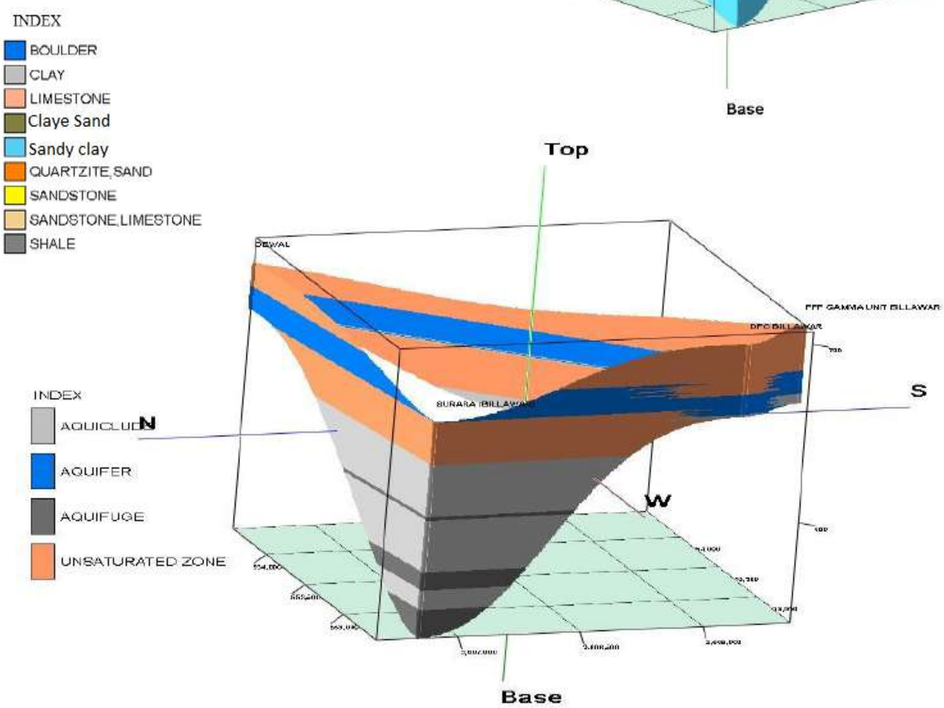


Figure 22 b: Fence Diagram depicting Aquifer disposition

3.3. Description of Cross Sections (2D Images):

The **cross section A-A’** drawn along Bambla to Garan Jagir (Figure 23) depicts the occurrence of Sandy clay, Clay, Sandstone and Boulder but the formation at Dadooa shows entirely of uniform lithology i.e. Shale. Water level varies from 8.14 at Dadooa to 39.63 at Bambla. There is a wide variation in the water levels, which are quite shallow in Dadooa and more than 20 m at Garan Jagir and Bambla.

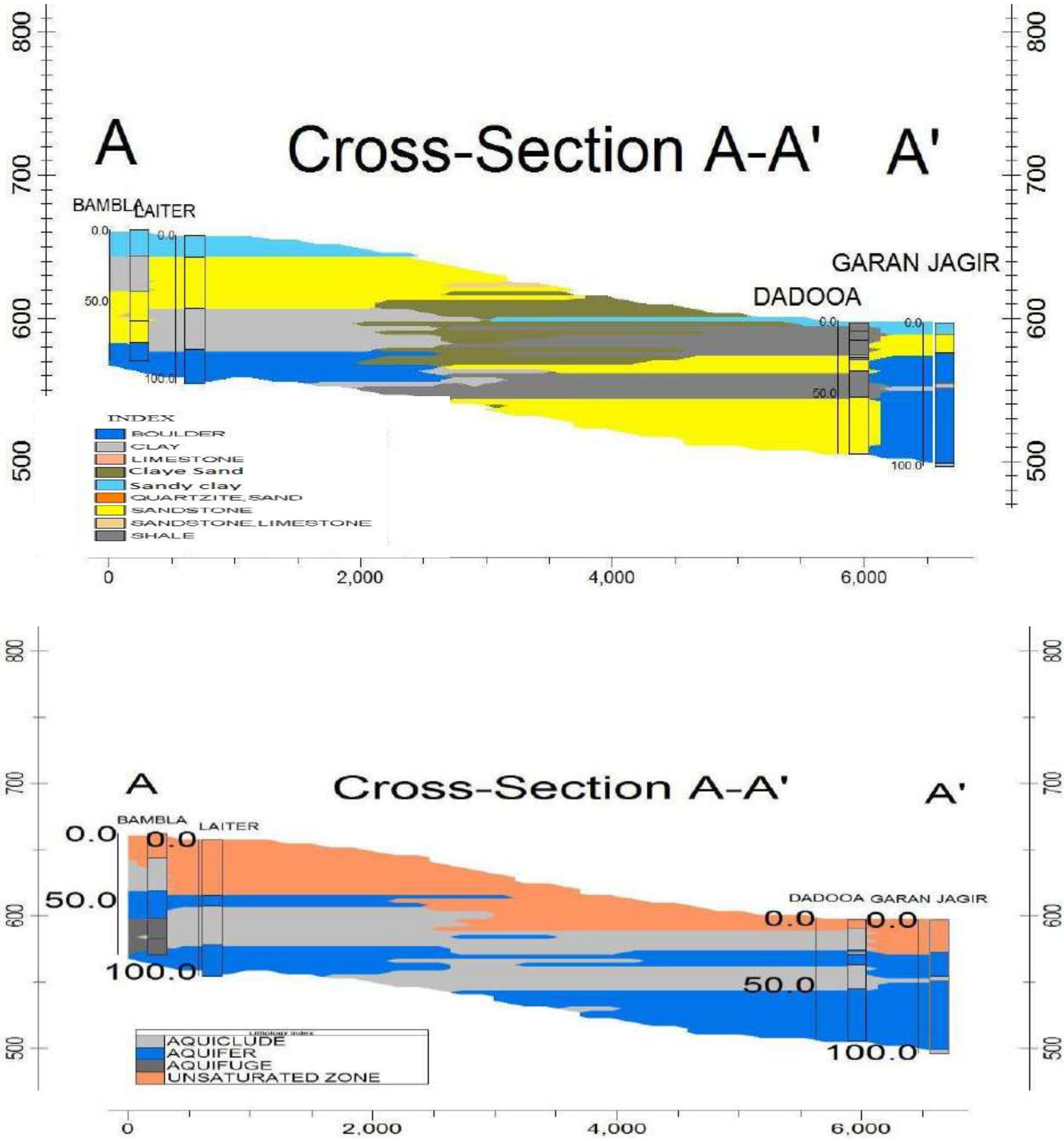


Figure 23: Cross Section depicting Lithological and Aquifer disposition along A-A’

The **cross section B-B’** drawn along Independent R+O Flt Udhampur to Megain (Figure 24) depicts the occurrence of Sandy clay, Clayey sand, Clay, Sandstone and Boulder. Sandstone is extended throughout the area. At Northern Command Udhampur clay lenses separates the sandstone horizon at depths, small lens of 3m thickness of clayey sand also seen. Bouldary formation is present only at Megain. Water level varies from 2.35 at Northern Command Udhampur to 35.06 at Megain. The aquifer encountered at great depth of 62.10 m depth at Megain where the Conglomerate formation is encountered.

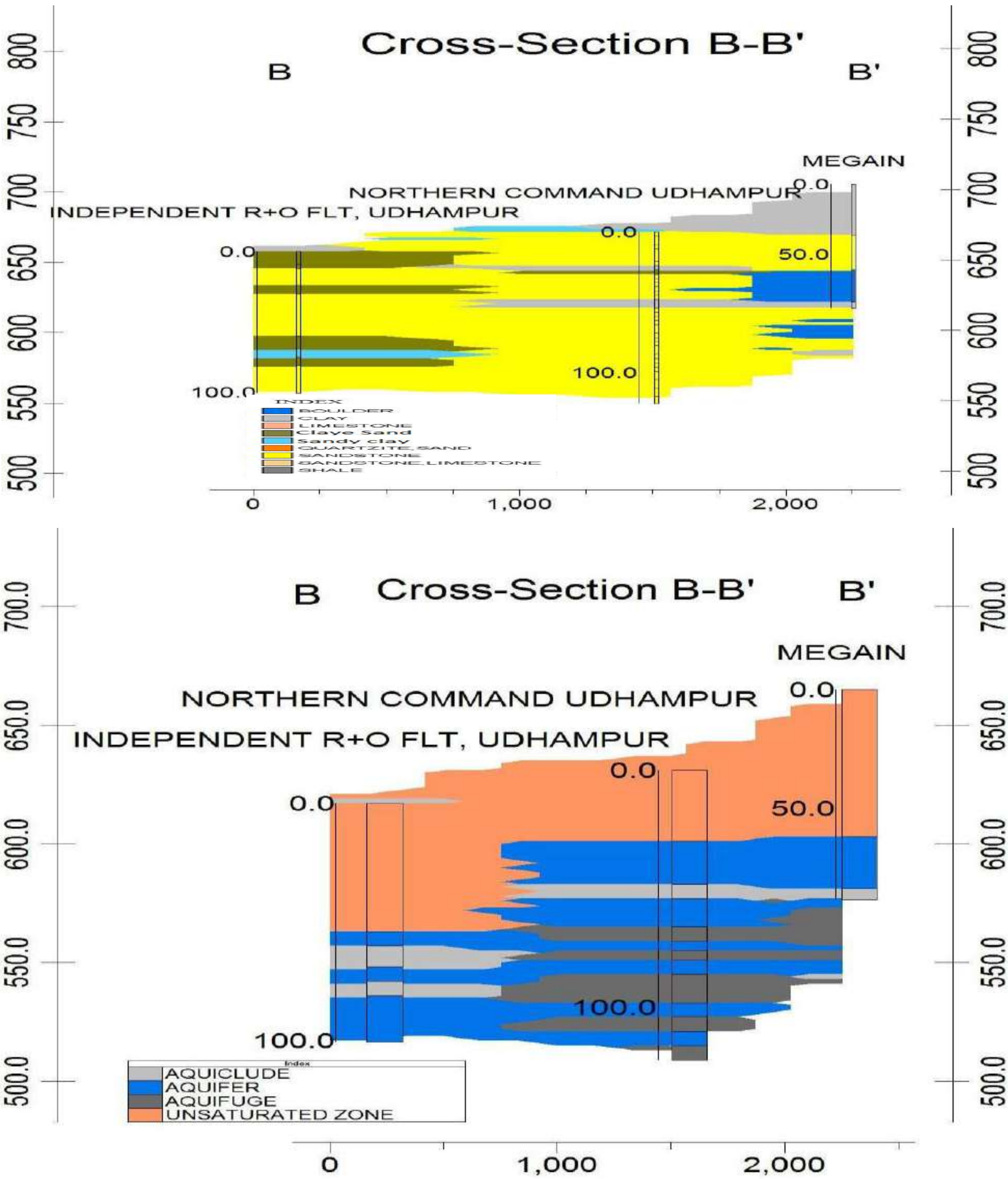


Figure 24: Cross Section depicting Lithological and Aquifer disposition along B-B'

The **cross section C-C'** drawn along Upper Dhanori to Upper Sambal (Figure 25). Sandy clay present at top of all wells in the section followed by Clay, Sandstone and Boulder. Water level varies from 9.14 at Upper Dhanori to 37.29 at Upper Sambal. Aquifer at Upper Sambal is found at great depth of about 73.17 m bgl.

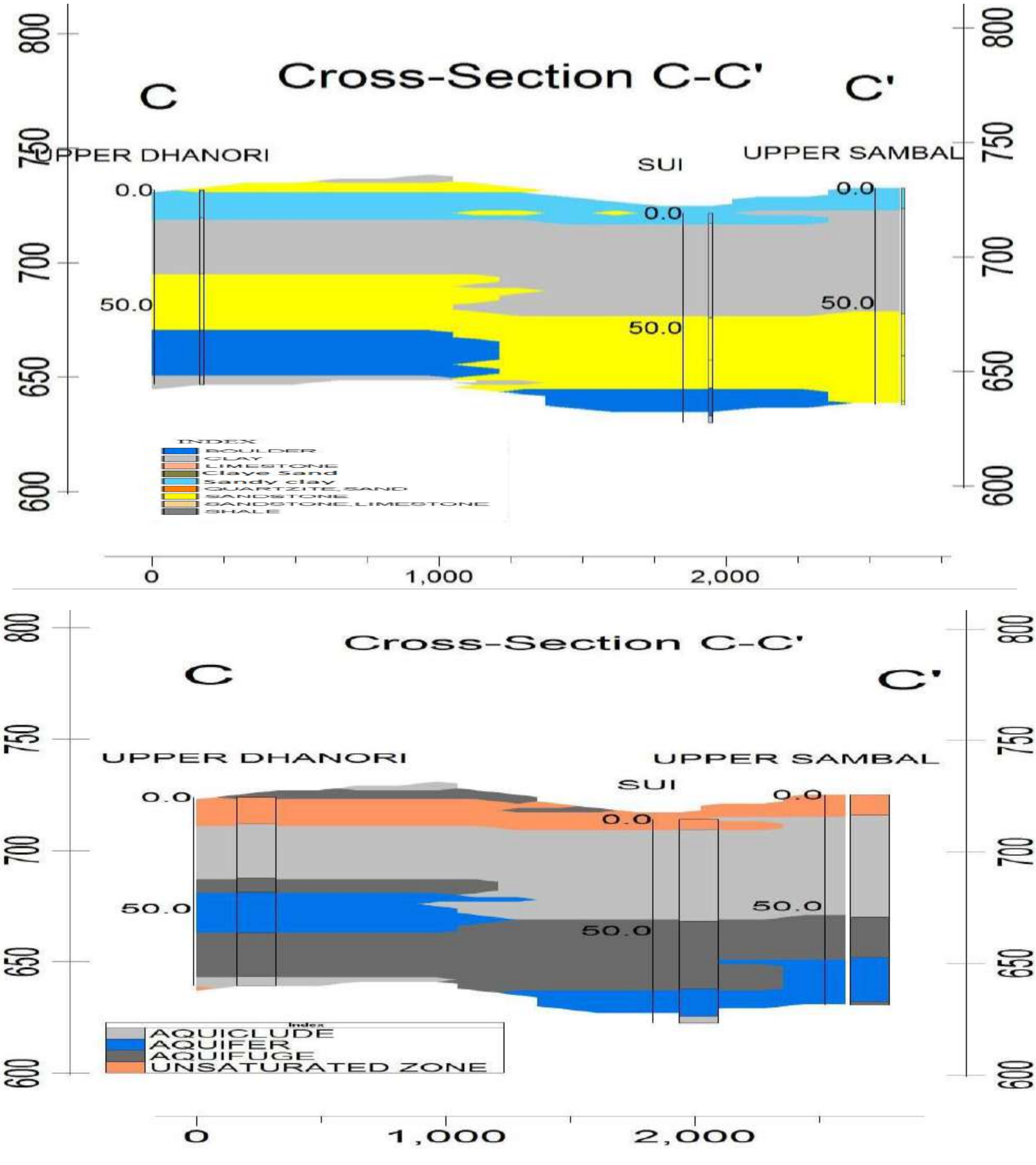


Figure 25: Cross Section depicting Lithological and Aquifer disposition along C-C'

The **cross section D-D'** drawn along Sailan Talab to Barial (Figure 26) depicts the occurrence of Sandy clay, Clay, Sandstone and Boulder. At Barial clay lenses separates the Bouldery formation horizon at depths, small lens of 1m thickness of clayey sand also seen. Water level at Doodha Dhari Ashram is at great depth 36 m bgl and at Sailan Talab is 32.29 m bgl while the Bore well at Barial is dry as the formation here is Clayey and Boulders behave as aquifuge.

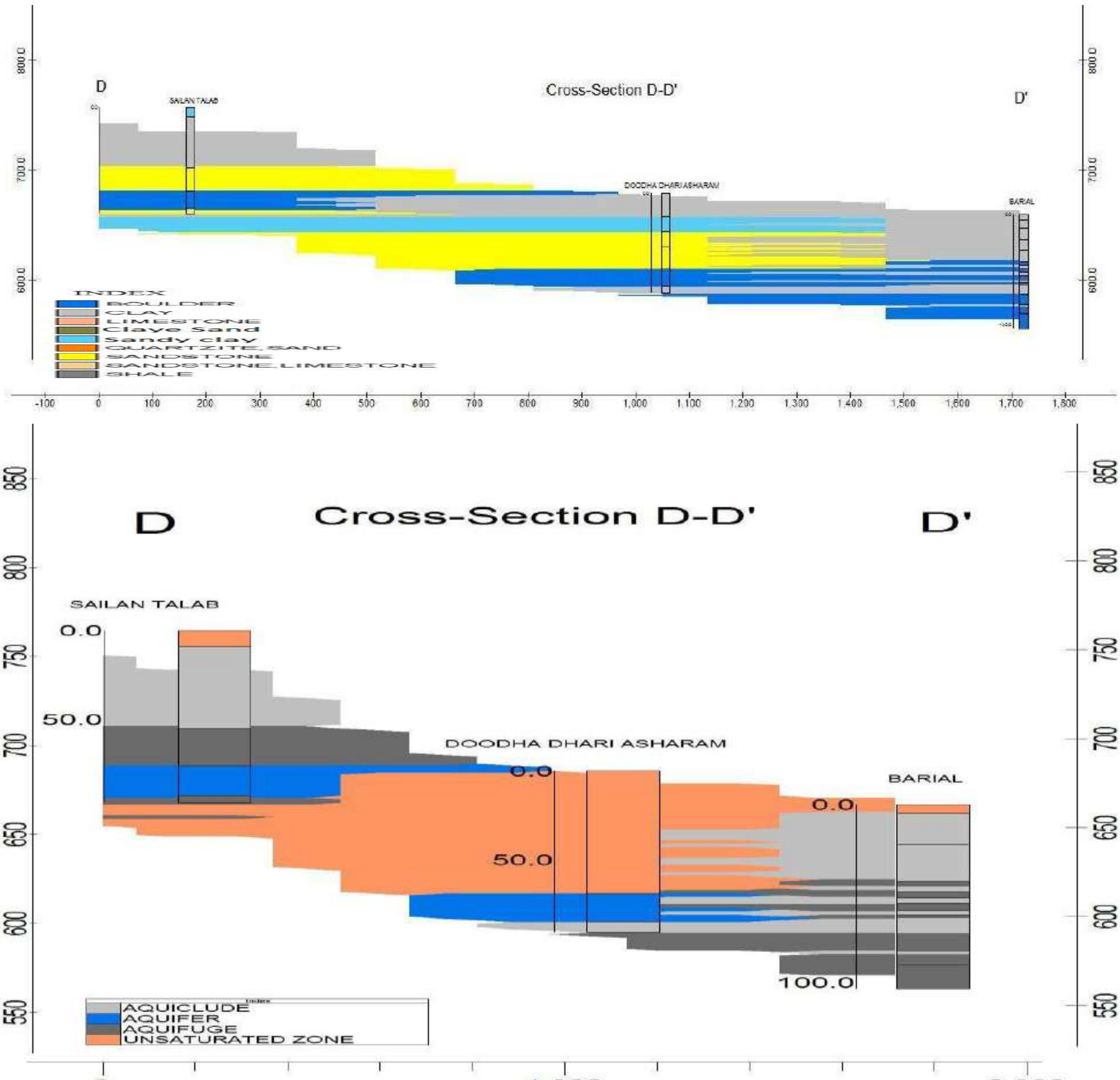


Figure 26: Cross Section depicting Lithological and Aquifer disposition along D-D'

The **cross section E-E’** drawn along Barial to Airforce Station, Udhampur (Figure 27) depicts the occurrence of Sandy clay, Clayey sand, Clay, Sandstone, Boulder and a small lens of Shale at Airforce Station, Udhampur. Water level at Airforce Station, Udhampur is at great depth 35 m bgl and at Kashirah Sandy clay and Boulder behaves as aquifer and the water level is 18.29 m bgl while the Bore well at Barial is dry as the formation here is Clayey and Boulders behave as aquifuge.

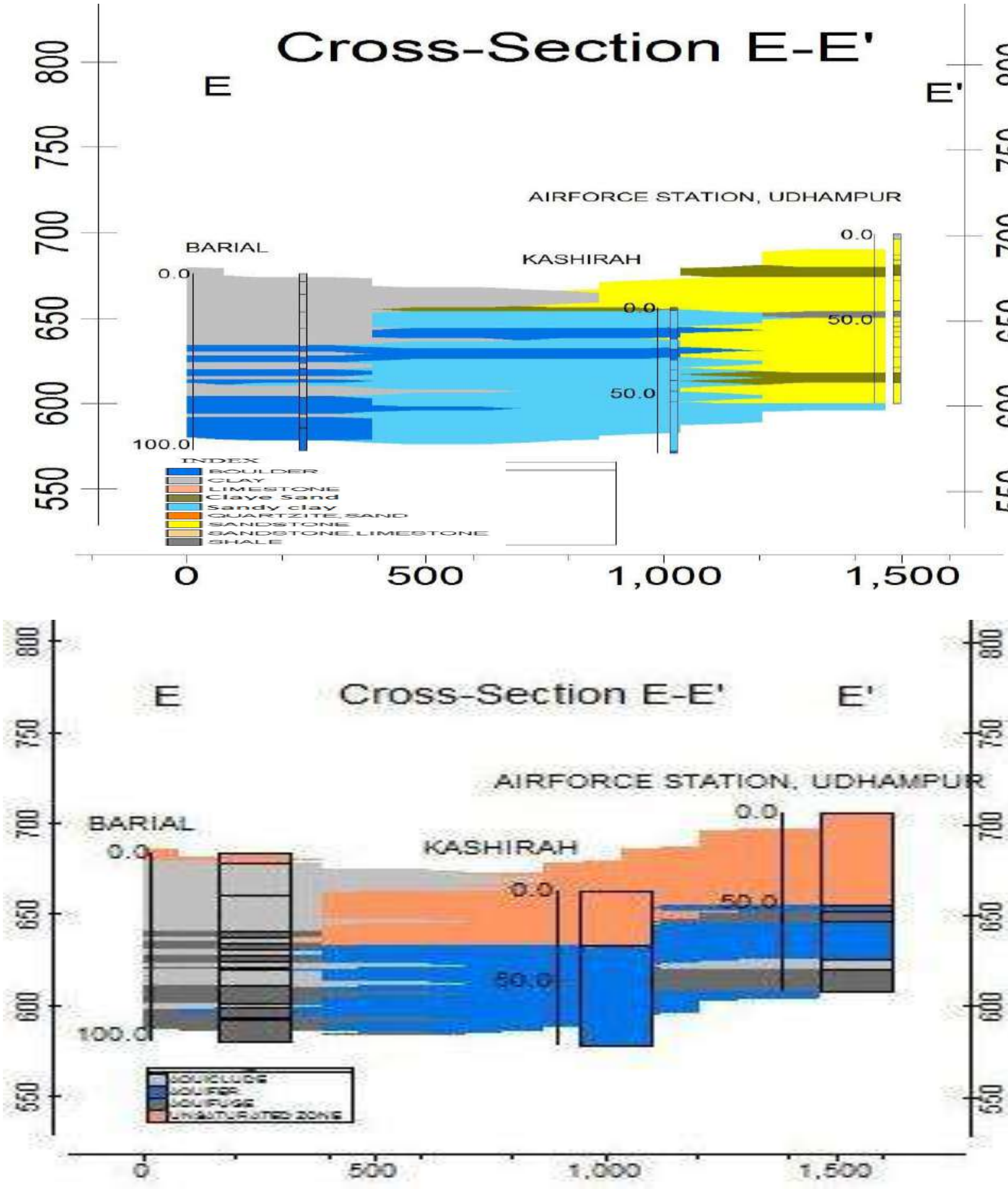


Figure 27: Cross Section depicting Lithological and Aquifer disposition along E-E’

The **cross section F-F'** drawn along Fangial to Battal Kothi (Figure 28) depicts the occurrence of Sandy clay, Clay, Sandstone and Boulder. Water level at Pathli Battal is at great depth 42 m and in other wells water level varies from 28.96 m at Battal Kothi to 18.29 m at Fangial. At Pathli Battal and Fangial only Bouldery formation is acting as an aquifer.

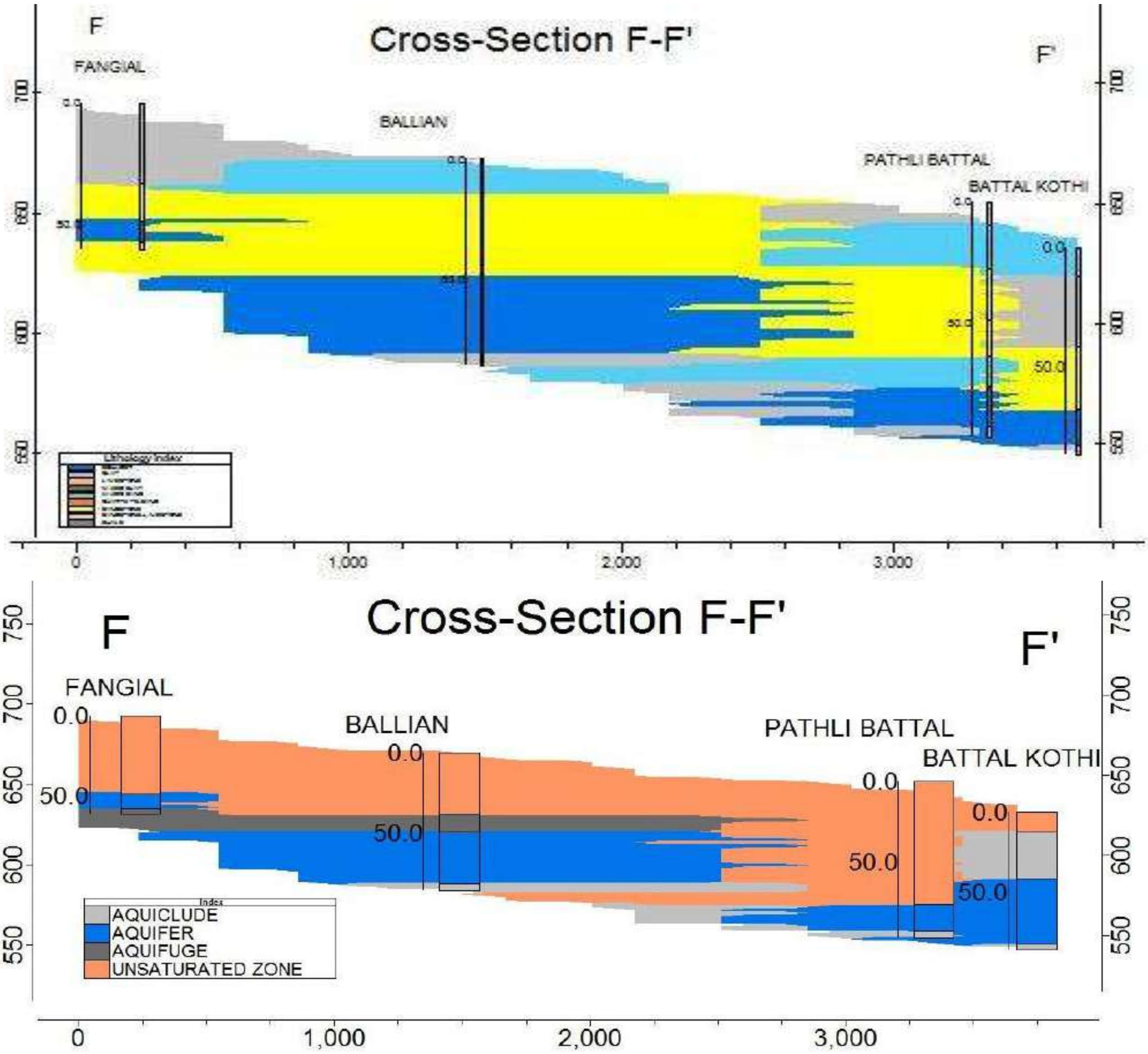


Figure 28: Cross Section depicting Lithological and Aquifer disposition along F-F'

The **cross section G-G’** drawn along Dhanni to Jindrah (Figure 29) depicts the occurrence of Sandy clay, Clayey sand, Clay and Sandstone. Water level varies from 1.5 m at Jindrah to 48 m at Korga-II. The sandy clayy layer is acting as an aquifer at Jindrah at a shallow depth which are separated by Clay and Clayey sand lenses while at Korga-II and Dhanni Sandstone is acting as an aquifer at great depth.

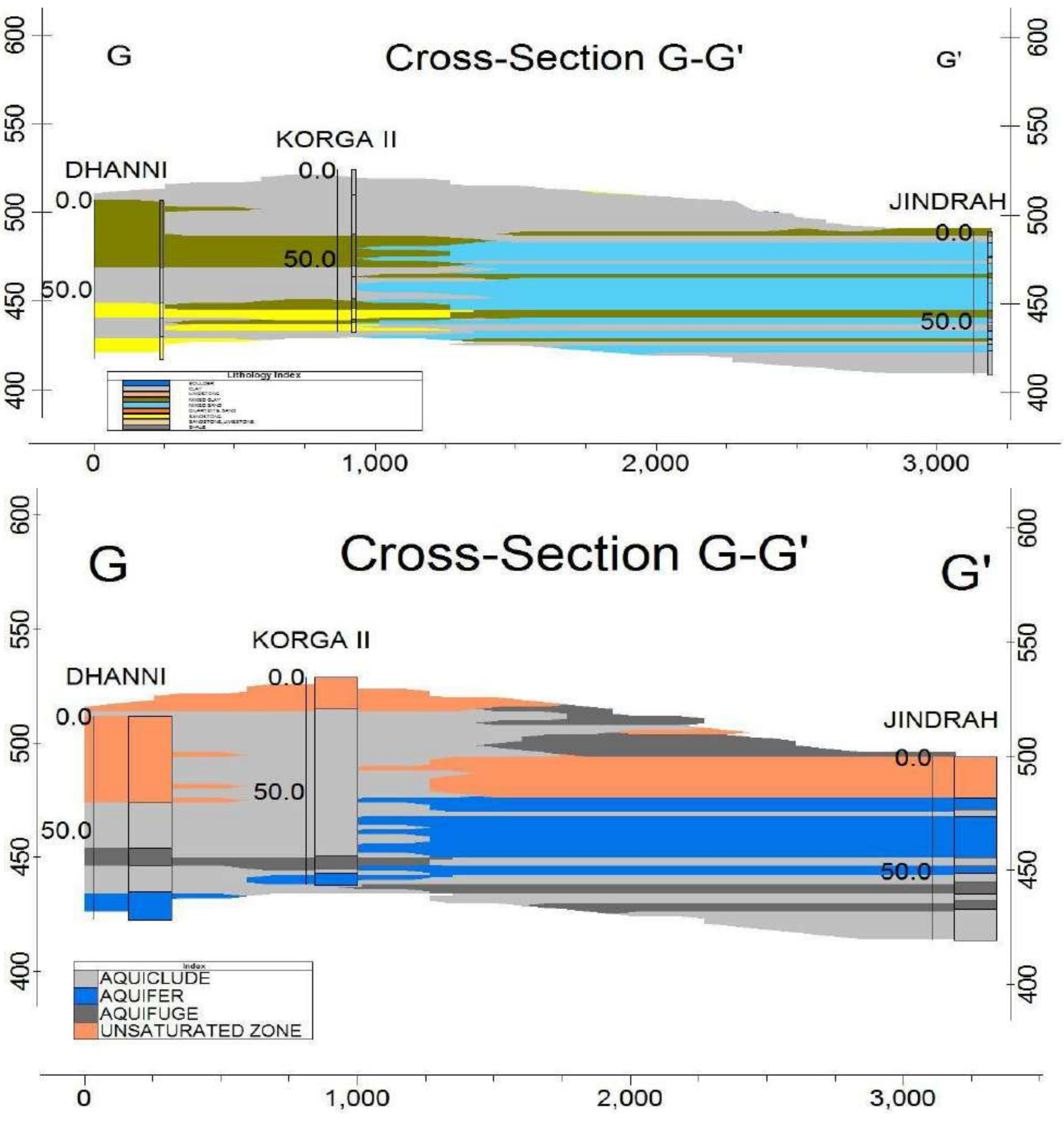


Figure 29: Cross Section depicting Lithological and Aquifer disposition along G-G’

The **cross section H-H’** drawn along Billawar to Surara (Figure 30) depicts the occurrence of Sandy clay, Clayey sand, Clay and Boulder. The water level found at a very shallow depth of 5 m at Billawar and 6 m at Dewal. The borehole at Surara is dry as the small lenses of sandy clay behave as aquifuge and does not allow the percolation of water.

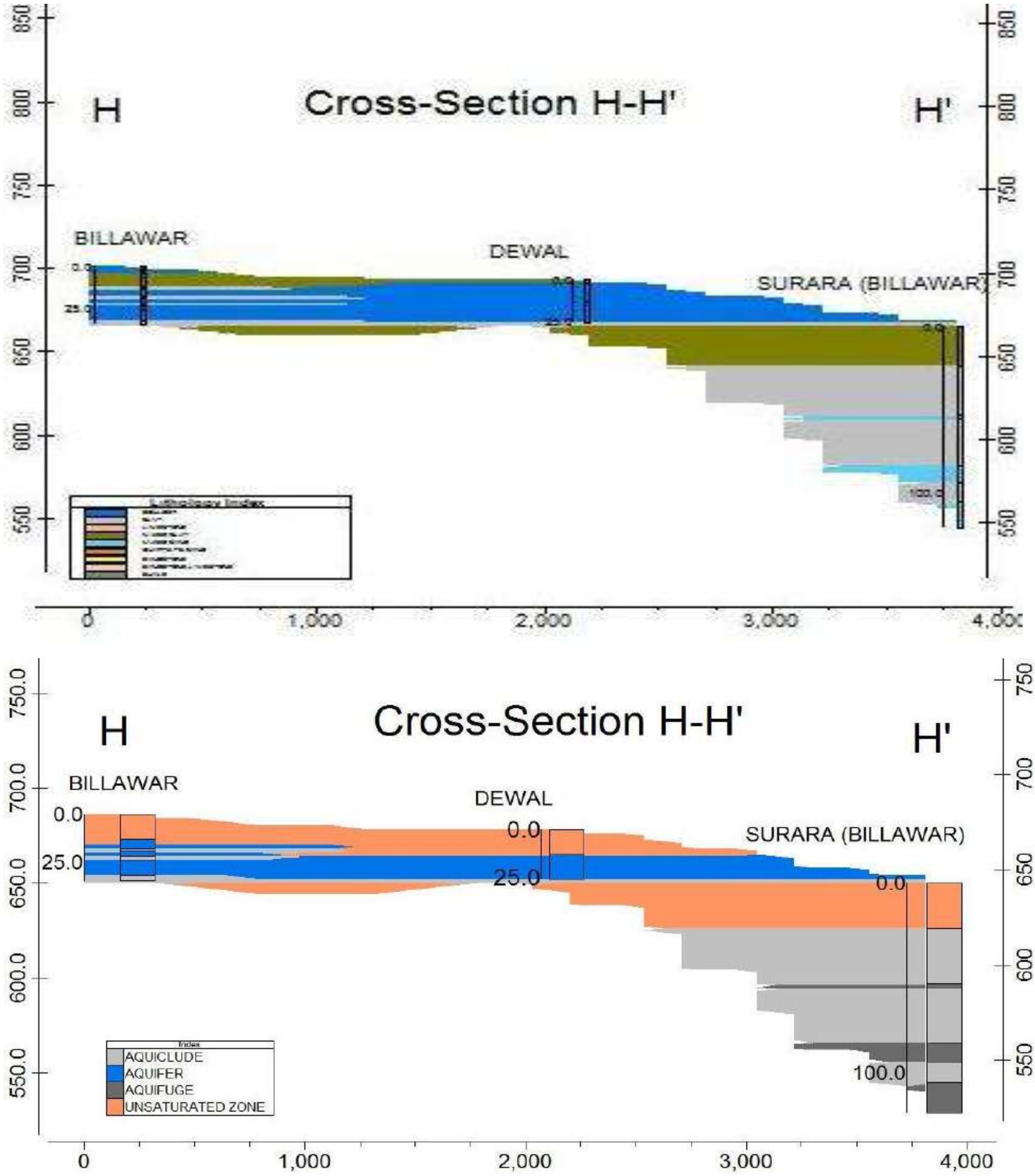


Figure 30: Cross Section depicting Lithological and Aquifer disposition along H-H’

4.0 GROUND WATER RESOURCES

As per the ground water resource assessment of dynamic resources of Udhampur-Rajouri section the net ground water availability is 79240.00 ham The overall stage of ground water development is 29.59 % which falls under safe category the details are given in the table 6

The assessment of total availability of ground water resources encompasses two component namely Dynamic and In-storage resources. The in-storage resources include In-storage unconfined and In-storage confined resources. For unconfined aquifer in-storage resources are computed based on specific yield of the aquifer and of confined aquifer based on the storativity of the confined aquifer

4.1. Ground Water Recharge

Recharge of ground water involves several components and the rainfall being the major one. The other components are return irrigation flow from surface water and ground water irrigation.

4.2. Draft

The ground water draft was estimated based on the number of ground water structures and the unit draft of each structure. The data for ground water structures are taken from 'Digest of Statistics' 2009-2010 a Publication of J&K State and also some of the data taken from concerned state government departments.

4.3. Allocation for Domestic and Industrial Use and the Stage of Ground Water Development

The allocation for domestic and industrial purpose is computed by projecting the existing ground water draft for domestic and industrial use for the year 2035 using population growth rate.

The In-storage resources of unconfined aquifer and confined aquifers were calculated as per above norms and summarised in the table 6 & 7

Table 6 In-storage GW Resources of unconfined aquifer

S. No	Assessment Unit/ District	Command/ Non-command / Total area (ha)	Total Annual Ground Water Recharge	Provision for Natural Discharge	Net Annual GW Availability (ham)	Existing gross GW draft for Irrigation (ham)	Existing gross GW draft for domestic& industrial requirement supply (ham)	Existing gross GW draft for all uses (ham)	Provision for domestic& industrial requirement supply to 2035 (ham)	Net GW availability for future irrigation development (5-6-9)	Stage of GW development % (8/5*100)
	1	2	3	4	5	6	7	8	9	10	11
1	Kathua	23250.00	14890.71	1183.17	13707.54	1640.70	1149.06	2789.76	1379.16	10687.68	20.35
2	Udhampur	15890.00	11139.10	452.31	10686.79	7.50	2956.80	2964.30	4199.40	6479.89	27.74
3	Reasi	5100.00	5773.16	195.97	5577.19	7.50	2442.50	2450.00	2810.76	2758.93	43.93
4	Rajouri	35000.00	11179.66	1179.95	9999.71	235.50	3388.50	3624.00	5694.22	4069.99	36.24
Total Valley Fill area		**79240.00**	**42982.63**	**3011.40**	**39971.23**	**1891.20**	**9936.86**	**11828.06**	**14083.54**	**23996.49**	**29.59**

Table 7 In-storage GW resources of confined aquifer

S. No	Name of Assessment Unit	Total Area (ha)	Type of Formation	Average pre-monsoon Water Level	Depth to bottom of unconfined Aquifer (mbgl)	Total thickness of formation below pre-monsoon water level (m)	Thickness of granular zone below pre-monsoon water level (m)	Average specific yield (%)	In – Storage Ground Water Resources ham (2*7*8)
	1	2	3	4	5	6	7	8	10
1	Kathua	23250.00	Valley Fill						
2	Udhampur	15890.00	Valley Fill	4.07	9	4.93	10	3%	4767
3	Reasi	5100.00	Valley Fill	4.04	9	4.96	10	3%	1530
4	Rajouri	35000.00	Valley Fill	3.86	10	6.14	10	3%	10500
Total		**79240.00**				**16.03**	**30**		**16797**

The total ground water availability in the area is calculated by adding dynamic and in-storage resources and the total ground water resources are 201510.58 ham or 20.15 BCM (Table 9)

Table 8 Availability of Total Ground Water Resources in the area

S. No	Name of Assessment Unit	Total Area (ha)	Type of Formation	Depth to bottom of unconfined Aquifer (mbgl)	Average Explored depth (mbgl)	Total thickness of confined aquifer down to explored	Thickness of granular zone in confined aquifer down to	Average value of storativity (%)	In – Storage Fresh Ground Water Resources ham (2*7*8)
	1	2	3	4	5	6	7	8	9
1	Kathua	23250.00	Valley Fill						
2	Udhampur	15890.00	Valley Fill	9	70	61	10	0.00001	1.59
3	Reasi	5100.00	Valley Fill	9	70	61	10	0.00001	0.51
4	Rajouri	35000.00	Valley Fill	10	50	40	10	0.00001	3.50
Total		**79240.00**		**28**	**190**	**162**	**30**	**0.00003**	**5.60**

Table 9 Assessment of Availability of Total Ground Water Resources in the area (as on March 2011)

S. No	Name of Assessment Unit	Total Area (ha)	Net GW availability Dynamic GW Resources as on 31st march 2013 (ham)	Fresh in-storage GW resource (ham)		Total Fresh in-storage GW Resource ham (4+5)
				Confined	Unconfined	
	1	2	3	4	5	6
1	Kathua	23250.00	14491.24	212.78	192547.2	192759.98
2	Udhampur	15890.00	5834.65	1.59	4767	4768.59
3	Reasi	5100.00		0.51	1530	1530.51
4	Rajouri	35000.00	10619.62	3.5	2448	2451.5
Total		**79240.00**	**30945.51**	**218.38**	**201292.2**	**201510.58**

5.0 GROUND WATER RELATED ISSUES & PROBLEMS

The area being hilly and mountainous, most of the rainfall goes waste as surface runoff. This has resulted in varying degree of recharge to ground water. In such hard rock terrain, since aquifers are discontinuous and having different geological/hydrogeological setup, the ground water scenarios are different in various parts of the area.

- Most of the ground water issues and problems so far noted in the area are localized and need to be treated independently by taking micro level studies in a particular area.
- Water level fluctuation which is very high in some of the areas and in few areas some dug wells gets dried up in the lean periods, poor ground water potential and heavy drawdown as most of the area comprises of Murrees, Siwaliks and hard rocks are some of the common issues
- As far as overall quality of ground water is good except at few places whereas Fluoride, Iron and Nitrate and pH values have been detected more than permissible limits at some places in the area.
- Slope is rugged, undulating and steep
- Soil run off, gully erosion and degradation of land
- Aquifer thickness is very small.
- Springs and dug wells in few areas are dried up during pre-monsoon periods
- Thrust on Open Dug Wells for water supply.
- Ground water contamination by improper disposal of domestic and industrial wastes.
- Natural sources of water like rivers, streams and ground water have dried up in the area because of climate change.
- The water sources in the area are rain-dependent and mostly dried up during summer.

6.0 MANAGEMENT STRATEGIES

6.1. Ground Water Conditions:

Ground water in the area occurs under water table condition in the shallow valley fill areas and in weathered sediments in the low-lying valleys, along streams and rivers. Shallow open wells, springs & hand pumps are the main ground water structures in the area. The lateral extent and dug wells capable of fulfilling small water supplying needs. The lateral extent and thickness of such saturated zones are potential sites of high yielding dug wells, large quantities of base flows are generated in the stream/khads during and after rains. Ground water exploration in Siwalik formation down to about 90m depth had not revealed promising water bearing horizons in the area.

6.2. Management Plan for Ground Water Development

The Ground Water Resource of the 1286 Sq km of NAQUIM (Rajouri, Udhampur, Dun belt of J&K) is around 400 mcm and Ground water draft is 100mcm as per the GEC resource estimation 2013. Present Ground Water development is 27%. So, It is recommended to develop the area upto 50%. The study area falls in Murree and Siwalik formation of tertiary period with steep slope having poor ground water potential. The surface run off is high due to steep slopes and base flow is also high in lean periods. Hence it is recommended to construct number of water retaining structure (subsurface dyke, check dam, Nalla Bunds, Gully Plugs) across the rivers and nallas that will enhance the retention period of the ground and surface water, in order to achieve 50% Ground water development by constructing ground water abstraction structures. In the water deficit areas it is recommended to construct Conservation/Artificial recharge structures in the area.

6.3. Dug Well Rejuvenation And Management:

Salient Observations and Recommendations

The observations of individual water supply sources vis-a vis recharge structures recommended are presented below:

1. **Galak Water Supply Scheme** ($32^0$37’34” & $75^0$37’34” E, 43 P/6)

<u>Observations:</u>

The water supply source is a dug well located east of road near Triveni nallah. This water supply scheme caters to population of 2400 souls of Galak, Challan, Part of Ramkot, Talhar, Jashyal, Nanad, Kanth villages of Billawar block. The present requirement of water as reported by PHED is 2800 m3/day. As per PHED there is a short fall of water supply and efforts to sustain this source are required. Water source of this scheme is an open well situated on the right bank of Triveni nallah and reportedly taps shallow alluvium and weathered sedimentary formation. The depth to water level is 3.8m bgl while the well depth is 10.0 m bgl and diameter of well is 6.0m & it is reported to yield about 180 m3/day.

Recommendations:

- Yield of existing source may be tested to exactly know the water supply gap in this scheme.
- Two low height check dams/gabion (height maximum 1 or 1.5m above the bed level) across the nallah are proposed to impound water to recharge the source at the following locations:

a. About 50m upstream of the well near exposed rock with site protection.
b. About 100m downstream the existing source well.

2. **Ucha Pind Water Supply Scheme** ($32^0$38’14.9” N, 75.$2^0$27’12” E, 43P/6)

<u>Observations:</u>

This scheme supply water to Ucha Pind, Thara, Kalyal, Derli, Morha Bhabuna lower & upper Chakhanu, Badu, Allarh, Trapada Kawari, Thana Lehd, Thand Badal Bhed, Dodain, Gari, Patyari, Darokari, Molan, kala & Dabbar having population of 13000 souls. The present requirement of water as reported by PHED is 7900m3/day. As per PHED authorities there is a short fall of water supply and efforts to sustain this source are required water source of this scheme is an open well situated near the confluence of two Uchapind Khads and is reported to yield 144m3/day. The source well taps shallow alluvium and weathered sedimentary formation. The Depth to water level is reported to be 4.8m bgl while the total depth is 9.0 m bgl and diameter of well is 6.0m.

These streams or khads have broad channels, very high gradient and is reported to have flash floods of high velocity wherein big boulders come rushing or rolling with flash floods. The area, thus, do not appear feasible for check dam or other water harvesting surface structures.

Recommendations:

- Yield of the existing source may be tested to exactly know the water supply gap in the scheme.
- Since the check dams or other water harvesting structures are not feasible in this area.
- A sub-surface infiltration gallery is proposed for tapping sub-surface flow in the stream-beds and connecting this gallery with the existing source well to enhance its yield. This would increase the availability of water in the well making it a sustainable source.

3. **Tanari Water Supply Scheme** (32^{0}36’11.4” N 75^{0}31’42.5” E, 43 P/10)

Observations:

This water supply scheme is yet to be put to operation and would supply water to Dewal Tilla, Rampur & Malti villages having population of 3200 souls.

As per PHED there may be short fall of water supply in future and efforts to sustain this source may be required. Water source of this scheme is an open well situated near a perennial streambed and area around the w/s source is having undulating topography and terraced fields. As reported Well taps shallow alluvium and weathered sedimentary formation. The well has 6.0m diameter and its depth and depth to water level as 10.0m and 2 m bgl respectively. Because of effluent seepages and base-flow in the streambed, de saturated aquifer do not exists and the scope for artificial recharge is limited.

Recommendations:

- There is need to test the existing source to exactly know the water supply gap in this scheme.
- A low height (1.0 m above the bed level) check dam or Nalla-bund is proposed across the Tunari nallah about 20 m downstream of dug well. This would impound the water/base flow making water available for recharge.

4. **Didwara Water Supply Scheme** (32^{0}33’35.2” N 75^{0}32’30.9” E, 43 P/10)

Observations:

This scheme has been framed to supply water to Bala Sundri, Chlar Safain and Narda having population of 4000 souls. Water source of this scheme is an open well situated on the left bank of Bhini River bed and is reported to yield 495 m3/day. As per PHED there may be short fall of water supply in future and efforts to sustain this source are required.

The area around the w/s source is having undulating topography and water supply well is located in the river bank/terrace of a perennial river Bhini. The source well taps shallow river alluvium. The Depth to water level is near ground level while the total depth is reported to be 6.50 m bgl. The well diameter is 6.0m

As per the site conditions aquifer potential is very high very shallow water level with seepage of water and thus there is no need to have any recharge measure.

Recommendations:

- Yield of the existing source may be tested to exactly know the water supply gap in this scheme.
- Area is not feasible for recharge structures as there are seepages in the area, sustainability measures are not required.

5. **Gurnal-Billawar Water Supply Scheme** ($32^0$36'47" N, $75^0$35'53.4" E, 43 P/10)

Observations:

This scheme supplies water to Dewal Tilla, Sarman, Garh, Part of Malti, Rampur Sarda, Billawar town having population of 7000 souls. As per PHED there is a short fall of water supply and efforts to sustain this source are required. Water source of this scheme is an open well situated near the streambed and is reported to yield 360m3/day.

The main source of water supply to this area is the groundwater wells or springs located in favourable locations. The area around the w/s source is having undulating topography and water supply well is located near the bank of stream bed. The source well taps shallow alluvium and weathered sedimentary formation. The Depth to water level is in 1.0 m bgl while the total depth is 10.0 m bgl and diameter is 6.0 m. The site is near the spring sources having water level near ground level and seepages or minor flow in the streams is observed. Therefore the de-saturated aquifer thickness for accepting the recharge is not available here.

Recommendations:

- Yield of the existing source may be tested to exactly know the water supply gap in this scheme, if any.
- The structures like check dam etc., are not feasible here.
- In case of shortfall in future, it is proposed that a recharge trench should be constructed to the south of the well, across the direction of ground water flow and connecting it with the existing well. The trench may be filled by inverted filter from boulders material very coarse at the top of medium size material at the bottom. Southern wall of the trench could be provided with 250 micron polyethylene film so as to arrest sub-surface flow so that it could flow along the gradient to contribute to the source well.

6.4. Springs

Springs occur wherever groundwater flows out from the earth's surface. Springs typically occur along hillsides, low-lying areas, or at the base of slopes. A spring is formed when natural pressure forces groundwater above the land surface. When water flows out slowly on the surface without distinct outlets, the term seepage is used. Springs are formed where the water springs are formed where the water table is intercepted by the topography. In the study area, the springs are widely distributed, occurring in the different formations at varying altitudes. These springs play important role to fulfil the requirement of the local people for drinking, irrigation and domestic purposes especially in the study area because of scarcity of other fresh water sources or water supply facilities. These springs are also tapped by the PHE Department to supply drinking water.


In the study area, occurrence of spring is controlled by lithological and structural character of rock formation. In Katra and Reasi area majority of the springs occur along fracture zones. Main Boundary Thrust, Mudun Thrust, Kishanpur-Mandli Thrust are some major fractures along which spring are located at Tanori, Latori etc. are major springs occurring along Kishanpur-Mandli thrust.

In Sunderbani and Nowshera area, water mostly emerges as seepages which are protected by making box like structures around them that are locally called as 'Bowli'.

The discharge of the spring varies from a trickle to a stream. Springs located at Kunian and Chamba in Katra area have considerable discharge of 15 lps to 5 lps and at Siyad Baba near Talwara the spring has fall of about 70 m with considerable discharge.

Kunian Spring

Siyad Baba Water Fall

Discharge of the spring becomes meagre during pre-monsoon period (April-June).

Spring originated from Sirban limestone have generally considerable discharge Pei Khad and Banganga are fed by springs emerging from limestone rock at Mata Vaishno Devi Shrine.

In Bowli's the discharges can not be measured because of improper drain channel to put a v notch or apply any other method. As Dun Belt in general is water scarce not only observed by less number of abstraction structures but also by the dry bowli's in the area.

Bowli near Sagoon

Bowli at Manwal

The discharge and temperature of the springs fluctuate throughout the year depending upon its recharge and discharge factor. During pre-monsoon season the temperatures of water in springs or bowlis varies from 21° to 26°C with the exception of "Tattapani Spring" of Rajouri district which is a hot water spring emerging Kalakote Anticline has temperature of 43°C in summers and 42°C in winters. This is the highest recorded temperature of the spring water in the study area and the lowest temperature recorded was 21°C in summers and 19°C in winters.

Tattapani Hot Spring

During the rains the favorable geological structures get recharged and resulting in higher discharge of spring monsoons. After the post-monsoon period spring discharge reduces gradually with time and is meagre in Pre-monsoon period. In general the discharge of spring's increases after monsoon while during summer season the discharge reduces considerably. This clearly indicates that monsoon recharge has a direct bearing on the spring discharge.

As discussed large number of springs and seepages also occur in the study area that need consideration while planning the water resources of the study area. They can be a reliable and relatively inexpensive source of drinking water if they are developed and maintained properly.

6.4.1. Spring Development and Rejuvenation

A spring can be developed into a drinking water supply by collecting the discharged water using pipe and running the water into some type of sanitary storage tank. Protecting the spring from surface contamination is essential during all phases of spring development. Springs can be developed in two different ways and the method you choose will depend on whether it is a concentrated spring or a seepage spring.

Spring Development Procedures: Concentrated Springs

A concentrated spring typically occurs when groundwater emerges from one defined discharge in the earth's surface. Concentrated springs are visible and are often found along hillsides where groundwater is forced through openings in fractured bedrock. This type of spring is relatively easy to develop and is usually less contaminated than other types of springs.

Steps for Developing a Concentrated Spring

- Excavate the land upslope from the spring discharge until three feet of water is flowing.
- Install a rock bed to form an interception reservoir.
- Build a collecting wall of concrete or plastic down slope from the spring discharge.
- Install a pipe low in the collecting wall to direct the water from the interception reservoir to a concrete or plastic spring box.
- Remove potential sources of contamination and divert surface water away from the spring box or collection area.
- Alternative types of interception reservoirs and collecting walls can be constructed.

Spring Development Procedures: Seepage Springs

Seepage springs occur when shallow groundwater oozes or "seeps" from the ground over a large area and has no defined discharge point. This type of spring usually occurs when a layer of impervious soil redirects groundwater to the surface. Seepage springs can be difficult to develop (see Figure 3). They are also highly susceptible to contamination from surface sources and they need to be monitored before development to ensure that they will provide a dependable source of water during the entire year. Flow is often lower from seepage springs, making them less dependable.

Steps for Developing a Seepage Spring.

- Dig test holes upslope from the seep until you locate the point where the impervious layer is 3 feet underground.
- Create a trench approximately 18 to 24 inches wide across the slope. Trench should be extended 6 inches into the impervious layer (below the water-bearing layer) and should extend 4 to 6 feet beyond the seepage area. Install 4 inches of collection tile and surround the tile with gravel.
- Installation of a collecting wall will help prevent water from escaping the collection tile. This collecting wall should be constructed of 4 to 6 inches of concrete.
- Collection tile should be connected to 4-inch pipe that leads to the spring box. Box inlet must be below the elevation of the collector tile.
- Remove potential sources of contamination and divert surface water away from spring box or collection area.

6.4.2. Proper Management of springs.

Remove Sources of Contamination. No matter what type of spring you have developed, it is critical that you remove potential sources of contamination from the spring's drainage area (the area upslope of the spring discharge point). Surface water draining into that area should be redirected and all activities should be limited within the drainage area. If livestock are present, fences should be used to keep animals from contaminating the drinking water supply.

Water Testing and Disinfection. Once the spring is developed and nearby sources of contamination are eliminated, it is important to submit a water sample to a water testing chemical laboratory for water quality analysis. If a water test indicates any contamination, check the water supply location and construction of the system for potential pollution pathways. Any roadside spring that is being used as a drinking water supply should be tested and these springs should only be used as a source of drinking water if they have been tested and found of desired drinking water specifications.

However, if springs are to be protected and restored, the solutions occur on the land where recharge water first starts the path to the aquifer. Three general approaches are available – avoiding activity that damages or threatens the aquifer, the springs themselves, and the springs runs and other features of the spring system; minimizing the impact of development and use of springs and related features; and, where necessary, mitigating the effects of the impact to the springs. The springs are located in different hydrogeologic settings, with a variety of land uses within their basins. The spring can be developed and rejuvenated as follows:

- Identify and enforce existing regulations that can be used and should be amended to protect groundwater that flows to springs, Identify pertinent existing groundwater standards that could be amended to increase protection of the surface water quality in springs.
- The suitable engineering measures (artificial recharge structures) may be constructed in the recharge areas of springs such as check dams, gully plugs, gabions and bushwood check dams and contour trenches may be designed for suitably selected sites to increase its discharge and to reduce the surface run off and protect non-consumptive uses, such as recreation, through the establishment of minimum flows for threatened springs.
- Vegetation measures as the permanent solution of the spring rejuvenation/ sustainability be sought out
- Establish minimum flows for springs or minimum levels for aquifers threatened by groundwater withdrawals. Once the minimum flow for a spring has been established; implement a recovery or revention strategy if needed to achieve the established flow or level.
- Conduct hydrogeologic investigations to determine the relationships between groundwater levels and spring flows so that groundwater withdrawals can be managed to avoid impacts to spring flows.
- Review existing conservation requirements used in consumptive use permitting. Develop and implement improvements that will result in increased water-use efficiency.

6.5. Construction of Canal Network system

The area can be developed and managed by constructing of canals in the feasible areas. The construction of canal should not be made concrete so that the canal irrigates the area as well as some amount of water percolates and adds to the ground water. Hilly areas does not have well developed irrigation network and as e.g. in case of Rajouri district where in most of the cultivable lands are located in the slopes where irrigation network is not possible. Rajal Canal is the only surface water irrigation system in the district and irrigates about 660 ha of the land. There are 12 No. of distributions taking off from the main canal at various locations as per the command area requirement. Similarly some more canals should also be constructed in the feasible areas in such a way that the canal acts both for irrigation and ground water purposes.

Delivery tank of Rajal Lift Irrigation scheme

Rajal Canal in Rajouri

ANNEXURE – I

Result of Chemical Analysis of water samples of National Hydrograph Stations collected during May 2015

S. No	Longitude	Latitude	Location	PH	EC	Concentration (mg/l)											
						TH	Ca	Mg	Na	K	Fe	CO3	HCO3	CL	S	N	F
1	74.5806	33.05	Bhamla	8.27	580	85	22	7	96.0	1.3	0.19	0	171	89.0	19	13.0	0.15
2	74.6367	33.0686	Dadua	8.54	390	165	36	18	21.0	2.6	3.30	12	165	25.0	30	3.2	0.08
3	74.6489	33.0708	Garan Jagir	8.5	250	95	16	13	15.0	0.6	0.00	6	122	3.0	3	0.1	16.00
4	74.6319	33.1306	Nanora	8.28	630	185	28	28	61.0	3.7	0.00	0	165	74.0	50	37.0	0.10
5	74.5861	33.1417	Thangrot	8.25	450	165	24	26	25.0	1.5	0.00	0	207	25.0	28	5.0	0.01
6	74.5528	33.1667	Aliyah	7.73	290	140	28	17	6.3	0.6	0.00	0	165	11.0	0	6.0	0.23
7	74.4819	33.0903	Marchola	9.09	1120	70	10	11	225.0	5	0.00	12	421	46.0	139	1.0	0.68
8	74.4611	33.0903	Channi Parat	8.54	390	120	14	21	43.0	1.8	0.00	6	177	21.0	30	6.0	0.23
9	74.4867	33.0672	Thanda Panni	8.24	380	140	24	19	26.0	0.8	0.00	0	98	35.0	57	11.0	0.23
10	74.4583	33.0333	Banpari	8.42	510	145	14	27	58.0	2.7	0.00	6	128	46.0	76	25.0	0.18
11	74.4167	33.0319	Dhok Baniar	8.61	290	125	16	21	30.0	0.7	0.00	6	140	21.0	34	7.0	0.17
12	74.3972	33.0583	Kangri (Grid Station)	8.41	290	110	20	15	20.0	0.45	0.00	6	159	11.0	0	9.0	0.25
13	74.3342	33.0681	Jabah	8.56	390	135	20	21	31.0	1.01	4.68	6	177	14.0	31	1.0	0.62
14	74.3167	33.0722	Sail	8.6	350	120	14	21	31.0	1	0.00	6	116	39.0	31	1.0	0.95
15	74.2917	33.0806	Seri	8.28	450	120	20	17	49.0	1.08	0.00	0	128	35.0	65	6.2	0.31
16	74.2733	33.0903	Gagrote	8.48	540	150	22	23	50.0	10	0.00	6	165	28.0	82	6.2	0.36
17	74.2761	33.0878	Ding	8.54	390	120	20	17	37.0	1.8	0.00	6	140	36.0	20	14.0	0.15
18	74.2333	33.0806	Kalal	8.1	930	50	14	4	187.0	3	0.64	0	310	36.0	149	1.0	2.75
19	74.2167	33.1361	Rumli Dara	8.28	310	130	18	21	14.0	0.5	0.00	0	159	14.0	10	1.0	0.22
20	74.1944	33.1042	Bareri	8.21	990	280	42	43	107.0	5	0.00	0	140	184.0	76	80.0	0.00
21	74.2083	33.175	Nouniyal	8.6	550	175	20	30	47.0	1.3	0.14	6	183	35.0	53	24.0	0.28
22	74.1917	33.1722	Chowki Handa	8.56	360	145	14	27	19.0	0.5	0.00	6	146	21.0	30	0.4	0.31
23	74.1417	33.1861	Kalsian	8.43	290	105	16	16	19.0	0.5	0.00	6	128	25.0	1	1.0	0.40
24	74.0472	33.2417	Jhangar	8.42	310	125	16	21	19.0	0.5	0.09	6	146	25.0	6	0.3	1.20

S. No	Longitude	Latitude	Location	PH	EC	Concentration (mg/l)											
						TH	CA	MG	NA	K	FE	CO3	HCO3	CL	S	N	F
25	74.0972	33.2361	Laroka	8.94	460	160	20	27	31.0	2.8	0.00	6	177	21.0	44	6.0	0.24
26	74.1131	33.2703	Phukarni	8.7	1150	80	18	9	227.0	2.5	0.00	6	476	35.0	137	5.0	0.00
27	74.15	33.2194	Darhal Quilla	8.73	340	115	14	19	24.0	3.00	0.00	6	116	25.0	25	12.0	0.48
28	74.2014	33.2028	Bhatta Morh	9.09	160	70	10	11	7.4	0.45	0.00	12	55	18.0	2	5.0	0.54
29	74.28	33.5031	Narina	8.46	250	105	22	12	11.0	1.2	0.00	6	110	18.0	8	3.0	0.24
30	74.2806	33.2889	Chittiar	8.26	340	140	24	19	16.0	0.80	0.00	0	134	21.0	17	22.0	0.23
31	74.3181	33.2808	Potha	8.26	260	110	24	12	10.0	2.90	0.00	0	98	25.0	1	23.0	0.27
32	74.3686	33.2369	Dyala	8.25	460	145	19	17	39.0	2.14	0.00	0	134	28.0	61	23.0	0.16
33	74.4158	33.18	Panja	8.65	425	135	54	0	37.0	2.20	0.00	6	201	25.0	1	14.0	0.25
34	74.4306	33.1639	Solki	8.7	430	165	20	28	23.0	1.50	0.38	6	220	14.0	1	13.0	0.29
35	74.4164	33.1494	Lower Kharak	8.04	360	140	20	10	19.0	0.50	0.00	0	153	39.0	1	1.0	0.27
36	74.4139	33.1347	Dharamsal	8.84	860	255	20	50	82.0	2.40	0.00	6	354	57.0	39	25.0	0.14
37	74.3	33.1417	Bagnoti	8.57	465	100	22	11	62.0	4.40	0.00	6	116	21.0	102	5.0	0.27
38	74.3806	33.1167	Siot	8.6	410	130	18	21	38.0	0.80	0.00	6	165	35.0	21	3.0	0.20
39	74.4275	33.0881	Bakhar	8.05	490	200	36	27	28.0	2.20	0.00	0	153	50.0	45	27.0	0.24
40	74.5244	33.05	Salote	8.3	520	205	22	36	29.0	0.50	2.18	6	275	25.0	2	2.0	0.33
41	74.4467	33.0422	Ainpur	8.56	270	115	14	19	13.0	0.50	0.00	6	122	25.0	0	5.0	0.21
42	74.925	32.9083	Katra	8.23	440	190	12	39	12.0	1.3	5.40	0	207	25.0	0	15.0	0.14
43	74.7944	33.0917	Talwara	8.05	720	345	60	47	6.0	8.5	2.27	0	354	14.0	1	71.0	0.62
44	74.8333	33.0917	Riasi	8.16	260	125	22	17	4.8	1.02	5.11	0	146	7.0	4	2.3	0.23
45	75.0378	32.9131	Seen Thakaran	8.44	350	135	30	15	21.0	0.9	7.13	6	116	29.0	31	11.0	0.18
46	75.0825	32.905	Garhi (Udh)	8.27	490	160	28	22	40.0	1	0.12	0	128	43.0	63	21.0	0.26
47	75.1256	32.8797	Battal Ballian	7.92	460	210	34	30	10.0	1.2	0.12	0	128	28.0	74	14.0	0.18
48	75.1353	32.8956	Phangyal	8.41	380	170	30	23	10.0	1.7	0.12	6	116	43.0	9	30.0	0.14
49	75.1819	32.8503	Kuperlah	8.43	300	135	34	12	7.5	0.6	0.12	12.00	140	14.0	6	0.0	0.21
50	75.1633	32.8417	Retti	8.05	260	110	20	15	10.0	0.7	3.54	0	116	18.0	12	0.0	0.23
51	75.2728	32.7814	Dehari	8.24	590	100	6	21	92.0	3	0.12	0	299	21.0	26	2.3	0.67
52	75.31	32.8064	Ramnagar	9.08	520	175	42	17	37.0	4.4	0.28	12	146	32.0	66	21.0	0.18

S. No	Longitude	Latitude	Location	PH	EC	Concentration (mg/l)											
						TH	CA	MG	NA	K	FE	CO3	HCO3	CL	S	N	F
53	75.2317	32.7956	Jallow	8.55	590	110	14	18	86.0	6.1	6.59	12	214	57.0	22	21.0	0.48
54	75.1986	32.8594	Talpad	8.12	910	65	8	11	182.0	2.6	5.62	0	409	21.0	95	0.2	0.45
55	75.0858	32.8131	Jindrah	8.21	470	165	30	22	30.0	3.6	2.64	0	134	22.0	21	90.0	0.23
56	75.1083	32.7989	Kotka Swal	8.21	290	100	12	17	26.0	0.51	5.83	0	128	35.0	0	2.3	0.30
57	75.0333	32.9039	Kunihala	8.09	265	105	34	5	14.4	0.4	0.23	0	92	35.0	3	10.0	0.44
58	75.0417	32.8344	Kah Pathala	8.39	280	95	24	9	21.0	0.8	0.21	30	79	21.0	21	0.2	0.23
59	75.0186	32.8525	Badso	8.16	230	100	32	5	10.0	1.3	2.19	0	122	14.0	2	1.3	0.22
60	74.8619	32.8656	Dansal	8.2	530	185	27	30	43.0	0.95	0.26	0	134	53.0	76	19.0	0.63
61	75.1089	32.9147	Birhma	8.25	260	115	28	11	10.0	1.6	0.12	0	122	18.0	13	0.2	0.28
62	75.1233	32.9464	Jakhar	8.36	240	110	38	4	6.3	1.2	0.12	6	134	7.0	0	1.0	1.00
63	75.3125	32.8189	Dalsar	8.36	240	95	20	11	13.0	0.91	0.23	6	116	14.0	3	1.0	0.37
64	75.175	32.7167	Salabra	8.22	250	115	20	16	9.0	0.32	1.01	0	140	11.0	4	0.0	0.35
65	75.15	32.7556	Manwall	8.2	250	105	24	11	11.0	0.71	0.12	0	98	25.0	4	13.0	1.10
66	75.1644	32.6972	Chhani Mansar	8.22	270	105	18	15	17.0	0.6	0.12	0	146	14.0	2	0.0	0.28
67	75.2425	32.6794	Sunal	8.49	390	145	20	23	39.0	1.80	2.59	12	189	28.0	16	15.0	0.12
68	75.3361	32.6417	Ramkot	8.29	480	180	24	29	27.0	7.00	1.41	0	183	25.0	59	1.0	0.23
69	75.3939	32.6464	N. Gujroo	8.24	1010	210	20	39	120.0	11.00	0.58	0	134	209.0	2	96.0	0.20
70	75.4153	32.6561	Lakri	8.28	260	95	14	15	18.0	1.10	1.53	0	133	14.0	0	7.0	0.27
71	75.5083	32.6356	Mandli	8.76	550	115	6	24	81.0	3.00	0.83	12	134	64.0	81	0.4	0.27
72	75.5444	32.5828	Phinter	8.33	400	185	12	38	12.0	1.80	9.50	6	160	39.0	0	29.0	0.33
73	75.5658	32.5564	Pallan	8.49	690	170	24	27	87.0	2.20	0.12	6	201	103.0	28	22.0	0.44
74	75.6083	32.6131	Billawar	8.19	150	55	12	6	10.0	1.20	0.16	0	70	14.0	0	0.0	0.24
75	75.0875	32.7417	Sagoon	8.47	260	110	18	16	8.5	1.50	2.49	12	122	14.0	0	1.0	0.25
76	74.8964	32.7506	Rangoora	8.41	390	145	20	23	21.0	2.50	2.36	6	146	39.0	2	14.0	0.39
77	75.0431	32.7728	Surinsar	8.52	430	130	14	23	43.0	2.00	0.11	6	128	39.0	48	14.0	0.21
78	75.2708	32.8358	N. Panjgrahian	8.56	290	85	8	16	31.0	2.70	2.61	6	134	14.0	15	5.0	0.23
79	75.5292	32.3639	Kathua	7.88	930	275	60	30	107.0	11	5.23	0	159	177.5	133	4	0.9

ANNEXURE – II

Location of VES sites

S. No.	Site	District	Date	VES	Profiles	Line-M	Latitude	Longitude
1.	Badsu ew	Jammu	31-03-2012	4	0	0	32° 51' 13"	75° 00' 44"
2.	Bain bajalta	Jammu	21-03-2014	1	0	0	32° 45' 50"	74° 56' 03"
3.	Bamiyal ew	Jammu	18-04-2012	3	0	0	32° 56' 29"	74° 52' 59"
4.	Chilla	Jammu	27-03-2014	1	0	0	32° 47' 36"	75° 01' 06"
5.	Dhok wazira - nagrota	Jammu	18-03-2013	1	0	0	32° 47' 29"	74° 54' 33"
6.	Jari (nagrota)	Jammu	18-03-2013	1	0	0	32° 48' 18"	74° 53' 00"
7.	Kana charkal	Jammu	22-03-2014	1	0	0	32° 44' 59"	74° 57' 56"
8.	Kathel-batal	Jammu	11-03-2000	22	0	0	32° 46' 59"	74° 57' 48"
9.	Kotli tanda	Jammu	05-02-2015	1	0	0	32° 58' 32"	74° 42' 37"
10.	Lohara lehar	Jammu	20-04-2012	3	0	0	32° 52' 22"	74° 59' 59"
11.	Malhori	Jammu	28-03-2003	5	0	0	32° 47' 10"	74° 56' 37"
12.	Noor	Jammu	30-01-2015	1	0	0	32° 59' 48"	74° 47' 05"
13.	Panjoda bridge	Jammu	21-03-2014	1	0	0	32° 45' 18"	74° 57' 46"
14.	Sujan di garhi (athem)	Jammu	22-03-2014	1	0	0	32° 46' 11"	74° 58' 52"
15.	Surinsar-sangar rd.	Jammu	27-03-2014	1	0	0	32° 46' 05"	75° 03' 06"
16.	Tutan ki kuhi	Jammu	21-03-2014	1	0	0	32° 45' 45"	74° 58' 32"
17.	Phinter billawar road	Kathua	28-01-2009	45	0	0	32° 35' 01"	75° 32' 48"
18.	Baja bain	Rajouri	18-12-2013	1	0	0	33° 02' 57"	74° 25' 41"
19.	Berari (pukka makan	Rajouri	19-12-2013	1	0	0	33° 08' 07"	74° 14' 12"
20.	Berri pattan	Rajouri	18-12-2013	1	0	0	33° 04' 04"	74° 21' 05"
21.	Bhajnowa	Rajouri	13-12-2013	1	0	0	33° 08' 02"	74° 12' 30"
22.	Chowki	Rajouri	12-12-2013	1	0	0	33° 09' 55"	74° 11' 56"
23.	Drahal qila	Rajouri	20-12-2013	1	0	0	33° 13' 15"	74° 09' 22"
24.	Ganya	Rajouri	14-12-2013	1	0	0	33° 09' 24"	74° 09' 14"
25.	Inayatpur ew	Rajouri	06-04-2011	1	0	0	33° 11' 25"	74° 15' 50"
26.	Jhanger	Rajouri	12-12-2013	1	0	0	33° 14' 31"	74° 02' 47"
27.	Kalsian	Rajouri	14-12-2013	1	0	0	33° 11' 12"	74° 07' 57"
28.	Lamberi	Rajouri	15-12-2013	1	0	0	33° 07' 12"	74° 21' 35"
29.	Nowshera (nonihal)	Rajouri	13-12-2013	1	0	0	33° 09' 03"	74° 13' 51"
30.	Phukarni	Rajouri	20-12-2013	1	0	0	33° 16' 07"	74° 06' 52"
31.	Sayal	Rajouri	19-12-2013	1	0	0	33° 04' 29"	74° 18' 47"
32.	Sunderbani - 52 bn bsf	Rajouri	12-11-2009	14	1	100	33° 02' 41"	74° 28' 56"
33.	Choua	Udhampur	26-03-2014	1	0	0	32° 43' 42"	75° 06' 23"
34.	Garan	Udhampur	24-01-2002	8	3	240	33° 03' 20"	74° 37' 32"
35.	Jeenthly	Udhampur	26-03-2014	1	0	0	32° 45' 29"	75° 03' 52"
36.	Katra	Udhampur	26-03-2000	1	0	0	32° 59' 56"	74° 56' 52"
37.	Kishanpur	Udhampur	08-08-2002	2	0	0	32° 46' 51"	75° 08' 08"
38.	Kotli	Udhampur	27-01-2002	1	0	0	33° 02' 16"	74° 54' 15"
39.	Letar	Udhampur	18-03-2001	8	3	1510	33° 02' 47"	74° 35' 46"
40.	Manwal	Udhampur	10-08-2002	1	0	0	32° 45' 19"	75° 08' 19"
41.	Mari	Udhampur	16-03-2004	6	0	0	33° 05' 50"	74° 51' 42"
42.	Northen command hq	Udhampur	12-05-2014	6	7	490	32° 54' 30"	75° 05' 11"
43.	Numbel	Udhampur	17-03-2004	2	0	0	33° 06' 00"	74° 49' 10"
44.	Padhanu 2000	Udhampur	19-06-2000	2	0	0	32° 53' 55"	75° 03' 01"
45.	Smvd university katra	Udhampur	15-05-2014	4	0	0	32° 57' 02"	74° 57' 30"
46.	Sunthan (satain)	Udhampur	06-08-2002	2	0	0	32° 52' 43"	75° 08' 40"
47.	Thande da padden	Udhampur	05-08-2002	1	0	0	32° 54' 28"	75° 08' 21"
				VES	**Profiles**	**Line-M**		
			Total	**167**	**14**	**2340**		

ANNEXURE – III

Exploratory drilling – CGWB and private tube wells

NO.	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH
1	Airforce Station, Udhampur	75.14	32.90	682	99.00
2	Badsoo	75.01	32.85	426	60.00
3	Ballian	75.12	32.88	664	85.94
4	Bambla	74.58	33.06	662	91.46
5	Banganga	74.94	32.99	882	103.70
6	Barakh	74.64	33.12	625	70.00
7	Barial	75.14	32.91	659	103.65
8	Barsoo	75.02	32.86	486	88.00
9	Barsoo – II	75.02	32.86	473	86.52
10	Battal Kothi	75.11	32.87	627	85.96
11	Bhabbar Chobian	74.81	33.03	372.4	70.00
12	Beri Pattan	74.36	33.07	493	91.46
13	Billawar	75.60	32.61	701	35.00
14	Chain Pur Kalakote	74.42	33.21	1302	60.30
15	Chakhar	75.12	32.95	737	97.55
16	Channi Mansar	75.15	32.70	646	84.98
17	Chounkian Pathwad	75.32	32.85	1122	97.79
18	Dadooa	74.64	33.07	598	92.50
19	Dera Baba Ashram	74.82	33.02	366	95.46
20	Dewal	75.58	32.60	693	26.00
21	Dhanni	75.11	32.79	507	89.50
22	Dharmani	75.48	32.63	658	56.00
23	Dharam Kot	75.53	32.60	637	37.00
24	DFO Billawar	75.56	32.59	700	40.65
25	Doodha Dhari Asharam	75.14	32.91	678	90.79
26	Fangial	75.13	32.89	687	60.96
27	FPF Gamma Unit Billawar	75.56	32.59	707	43.50
28	Galak	75.35	32.63	683	68.00
29	Garan Jagir	74.65	33.08	597	101.10
30	Gujroo Nagrota	75.40	32.65	786	105.50
31	Gurah Kalyal	75.45	32.64	695	37.70
32	Independent R+O FLT, Udhampur	75.09	32.90	617	100.59
33	Itbp Udhampur	75.08	32.91	640	209.00
34	Hamdhana	75.41	32.65	751	86.54
35	Jagti Tanda	74.89	32.81	379	71.50
36	Jindrah	75.09	32.81	489	80.50
37	Kashirah	75.14	32.90	639	85.36
38	Khanpur	74.89	32.78	299	201.00
39	Khapote	75.04	32.83	463	122.00
40	Kishanpur	75.15	32.78	468	122.00
41	Korga II	75.11	32.80	524	91.45
42	Kothia	74.65	33.09	612	88.41

NO.	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH
43	Krimchi Mansar	75.12	32.96	700	60.97
44	Kuperalla	75.18	32.85	581	97.55
45	Ladera	75.50	32.65	654	56.42
46	Lam	74.13	33.24	904	118.00
47	Lansi	75.10	32.94	723	66.77
48	Laiter	74.58	33.06	658	103.65
49	Lakhiri	75.41	32.65	755	148.00
50	Mansar Yard	75.12	32.97	813	78.35
51	Marhi	74.86	33.10	654.6	86.00
52	Megain	75.08	32.92	665	88.40
53	Nadore	74.94	32.80	494	95.00
54	Narian Alory	74.93	32.80	371	99.50
55	Northern Command Udhampur	75.09	32.91	631	122.17
56	NCH Udhampur	75.10	32.95	741	105.00
57	Nelay (Katra)	74.92	33.02	1064.2	112.00
58	Nowshera	74.24	33.16	550.5	37.00
59	Numbal	74.82	33.10	399.6	44.00
60	Pathli Battal	75.12	32.87	646	97.56
61	Peoni	75.20	32.73	610	92.98
62	Sailan Talab	75.13	32.92	757	96.94
63	Salmairi	75.10	32.94	775	96.94
64	Sarni	75.48	32.64	712	55.50
65	Seen Brahmna	75.02	32.97	817.2	80.00
66	Seen Thakran	75.05	32.90	640	99.08
67	Sui	75.12	32.94	714	91.46
68	Surara (Billawar)	75.56	32.60	665	121.00
69	Thangriot	74.58	33.14	795	86.26
70	Thanda Pani	74.45	33.08	561	74.16
71	Tutan Wali Khui	74.98	32.76	408.7	300.00
72	Upper Dhanori	75.10	32.92	724	84.74
73	Upper Sambal	75.12	32.94	725	94.50
74	Upper Siot	74.41	33.10	575	112.80