केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report
on
AQUIFER MAPPING

Outer Plains of Kishtwar Plateau, Jammu &Kashmir

उत्तर पश्चिम हिमालय क्षेत्र, जम्मू

North Western Himalayan Region, Jammu

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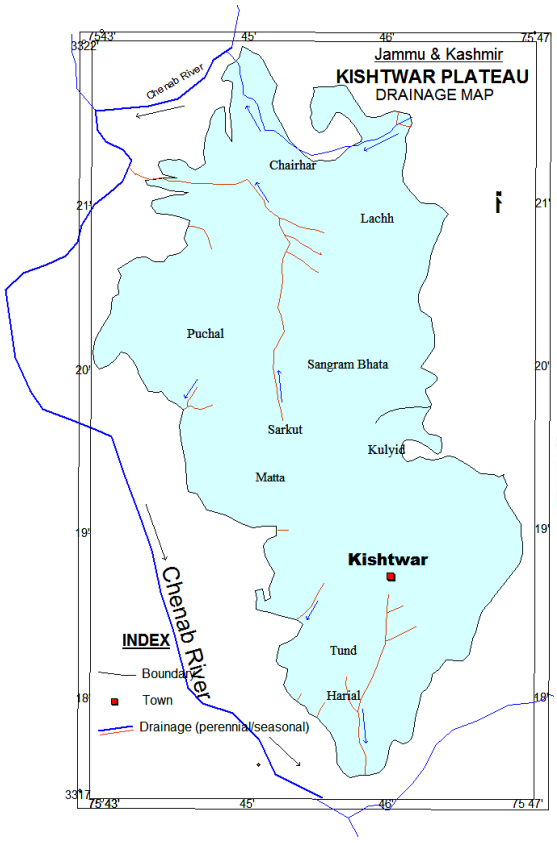
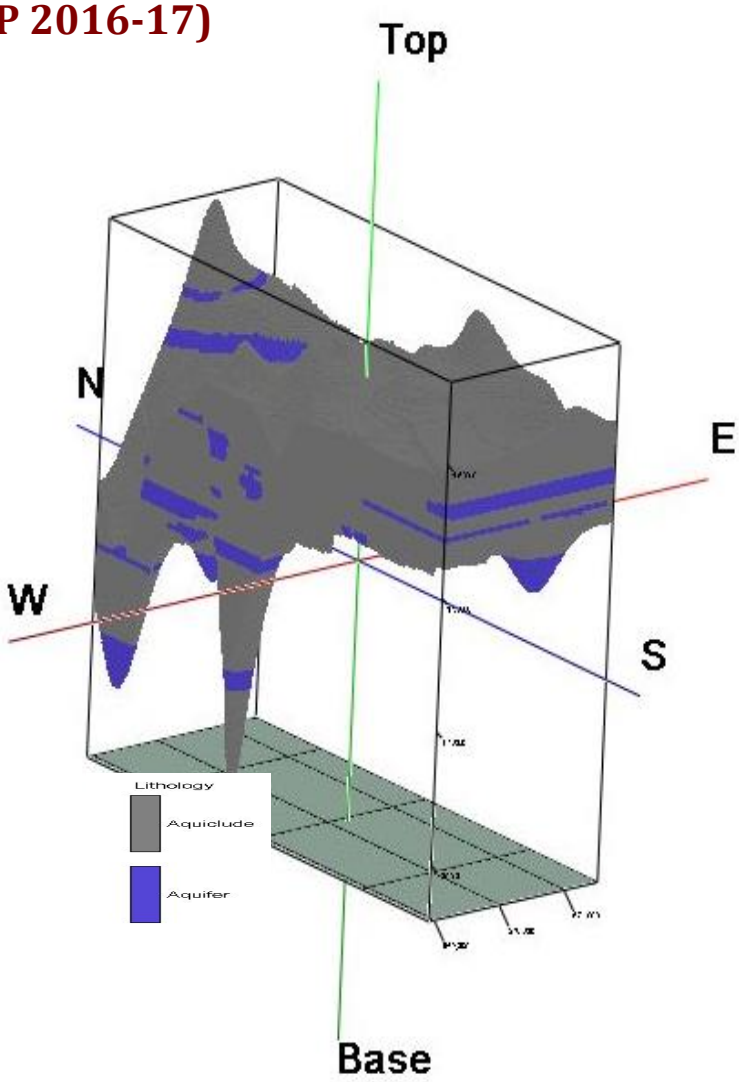
REPORT ON

AQUIFER MAPPING & MANAGEMENT PLAN
OF
KISHTWAR PLATEAU,
KISHTWAR DISTRICT, J&K (20 sq.km)
(AAP 2016-17)





North Western Himalayan Region, Jammu
March 2017

REPORT ON

AQUIFER MAPPING & MANAGEMENT PLAN
OF
KISHTWAR PLATEAU, KISHTWAR DISTRICT, J&K (20 sq.km)
(AAP 2016-17)

Under Overall Guidance of
Dr. Uma Kapoor
Regional Director

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Asstt. Hydrogeologist	**Processing in Rockworks, Preparation of Maps & Power Point Presentations**.

PREFACE

Aquifer mapping studies have been carried out on the Kishtwar Plateau of Kishtwar District that lies in Jammu Province, J&K State with an objective to identify and map the aquifers at micro level, quantify the availability of ground water resource and suggest Aquifer Management Plans to address the basic ground water related issues in the area. Aquifer Mapping study involves integration and analysis of multi-disciplinary scientific aspects including geological, hydrogeological, geophysical, hydrological and hydro-chemical. These studies help to characterize the quantity, quality and ground water movement in the aquifers and devise their optimal management plans. The representative area of the study was in the State of Jammu & Kashmir, forming part of Kishtwar Window spread over an area of 20 Sq. Km. The study area includes the plateau part on which Kishtwar Town is located.

The report on "Aquifer Mapping & Management Plan of Kishtwar Plateau of Kishtwar District. J&K" elaborates the outcome of the Aquifer Mapping Study, in particular, the vertical and lateral extent of the aquifer units, their characteristics and response of the aquifer units to different stress conditions and their redressal through appropriate management plans. Various water stress mitigation options by integrating technical and scientific measures are also recommended for sustainable ground water development and management in the area.

The untiring efforts put forth by a team of Scientists of North Western Himalayan Region, Jammu namely Shri Vinod Sharma, Shri K. P. Singh and Smt. Priya Kanwar, in bringing this report are duly appreciated, as this report would not have seen the light of the day without their hard work and dedication.

The report shall be of immense use for the planners and managers as well as academicians / researchers as a guide and reference volume in the field of Ground Water Resource Management.

Place: Jammu **(Dr. S. K. Jain)**
Date : 31-03-2017 **Regional Director**

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The authors also acknowledge their sincere thanks to various State and Central Govt. Departments like Public Health & Engineering (PHE), Tube Well Irrigation (TWI), Irrigation & Flood Control (I&FC), Department of Geology & Mining (DGM), Indian Meteorological Deptt. (IMD) etc., the local administration from the study area, for providing valuable concerned data.

Last but not the least, the authors express their sincere thanks to every person, who directly or indirectly helped in carrying out this study and bringing out this report in presentable form.

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AQUIFER MAPPING & MANAGEMENT PLAN
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1 INTRODUCTION

The delineation of depth ranges and thickness of aquifers along with their lateral extent and potential, through hydrogeological surveys, geophysical surveys, exploration and monitoring is an on-going activity of Central Ground Water Board. The entire country including the valley areas of Jammu & Kashmir has already been covered under Systematic Hydrogeological Surveys to generate basic hydrogeological data. Reappraisal Hydrogeological Surveys / Ground Water Management Studies have been conducted to study the changes in the groundwater regime over period of time. The hydrogeological map of the entire country was compiled on 1: 2,000,000 scale and was first published in 1984. Subsequently, it was revised and again published in 2002 based on the data collected/generated by CGWB during the course of various scientific studies mainly ground water survey, investigation and exploration programs supported by exploratory drilling, geophysical investigations and hydro chemical studies. The Aquifer Atlas of Jammu & Kashmir State was prepared on 1:250,000 scale in year 2013.

In today's scenario, increasing population, rapid urbanization and industrial development and human interventions in the ecosystem pose a challenge for water resource managers. Any strategy for management of ground water resources on sustainable basis depends on proper understanding of the characteristics of the aquifer system of that very area. In view of the emergent challenges in the ground water sector in the country, an urgent need was felt for comprehensive and realistic information pertaining to various aspects of ground water resources available in different hydro-geological settings through a process of systematic data collection, compilation, data generation, analysis and synthesis.

In view of this, the micro level aquifer mapping programme has been taken up by Central Ground Water Board (CGWB) during the XIIth Five Year Plan. Aquifer mapping is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological, hydro-meteorological and water quality data are integrated to characterize the quantity, quality and movement of ground water in the aquifers. Under the **N**ational **Aqui**fer **M**anagement Programme (NAQUIM) North Western Himalayan Region had undertaken aquifer mapping of Kishtwar Plateau, District: Kishtwar, Jammu & Kashmir.

Objectives

The objective of aquifer mapping is delineation of geometry of the underlying aquifer systems in horizontal as well as vertical domain and their characterization, estimating their yield potential and formulation of aquifer management plans to ensure water availability on sustainable basis.

Scope of the study

The scope of the present study is broadly within the framework of NAQUIM being implemented by CGWB. There are four major components of this activity viz.:

(i) Data collection /compilation
(ii) Data gap analysis
(iii) Data generation, and
(iv) Preparation of aquifer maps and management plan.

Data compilation includes collection of geological, hydrogeological, geophysical, hydrological, hydro-meteorological and water quality data besides agriculture cropping area, irrigation, geomorphology, ground water draft data and wherever required, procurement of related maps / data from concerned agencies, such as the Survey of India, India Meteorological Department, Geological Survey of India, State Governments, etc., Computerization and analyses of all acquired data, and preparation of a knowledge base.

Identification of Data Gap was included to ascertain the requirement for further data generation in respect of hydrogeological, geophysical, chemical, hydrological studies, etc.

Data generation included data pertaining to exploratory drilling and aquifer characteristics, sub-surface geophysics and chemical quality of ground water. Generation of chemical quality data of ground water was accomplished by collection of water samples and their laboratory analyses for all major parameters and heavy metals. Sub-surface geophysical studies incorporated Vertical Electrical Soundings and borehole logging.

Based on integration of data generated from various studies of hydrogeology and geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out characterization of aquifers, which can be termed as Aquifer maps showing lateral & vertical extents of aquifers and water quality. Based on the data available from the strata charts about the saturated thickness of the aquifer on the plateau an attempt has been made to calculate its ground water potential. Finally, a suitable strategy for sustainable development and management of the aquifer in the area has been evolved based on the acquired data.

Approach and Methodology

The study involves collection of existing data from various sources including CGWB records, State Government agencies, available literature and other sources relevant for the purpose of aquifer mapping and management.

In 1963, S. C. Awasthi of Geological Survey of India carried out surveys in Kishtwar Plateau area. The Systematic Geohydrological surveys in 3000 sq. kms of erstwhile Doda District was carried out by G.S.I, before 1971. Geophysical surveys were conducted by GSI in 1969-70. In 1977-78, reappraisal survey of 500 sq. km area was taken up by Sh. P. N. Sarangal. In 1983, Sh. B. L. Kaul, took up the reappraisal surveys of Doda District. In the year 2007-08, Sh. S. K. Mohanty, has carried out the reappraisal surveys of Doda District. Apart from these CGWB has also carried out Short Term Water Supply Investigations for defence and also provided technical assistance to central/state government organizations and recommended sites for ground water development. CGWB under its Ground Water Exploration Program in J&K, has constructed 02 exploratory tubewells in Kishtwar.

The data from available sources was compiled, analysed, examined, synthesized and interpreted. Since, these sources had predominantly non-computerized data, all the data available and collected was converted into computer based GIS data sets, which were used to prepare various thematic layers. These layers were integrated to generate aquifer maps. Finally an attempt was made to formulate aquifer management plans.

Location

Kishtwar District is a newly formed district of Jammu and Kashmir. Prior to 2007, it was a part of Doda District. Commonly known as the 'Land of Sapphire and Saffron‟, it is also very rich in forest products. Kishtwar is surrounded by the District Anantnag, District Doda and also touches the boundary of Himachal Pradesh State.

The District has derived its name from "Kishat Rishi" who stayed here. It is the modified version of earlier name of Kishaswar. Kishtwar in its ancient form Kashthavata, is first referred to in the Rajatarangini during the empire of Raja Kalsa of Kashmir, when "Uttamaraja", the ruler of Kashthavata visited the court of Kashmiri king in company with several other hill chiefs to pay their respects to the Raja.

As of 2011 census, it is the third least populous district of Jammu and Kashmir State (out of 22), after Kargil and Leh districts.

The canoe shaped Kishtwar Plateau area measuring about 20 sq.km lies within the Longitude 75°43’30” and 75°47’00” E; Latitude 33°17’30” and 33°22’15” N and forms a part of the SOI’s toposheet numbers 43O/11 and 15 on 1; 50,000 scale. Kishtwar town is located at a distance of 230 km from Jammu on National Highway 1-B, on the left bank of Chenab River. The district headquarter is located in this ancient town. The location map of the area is shown in Fig. 1.

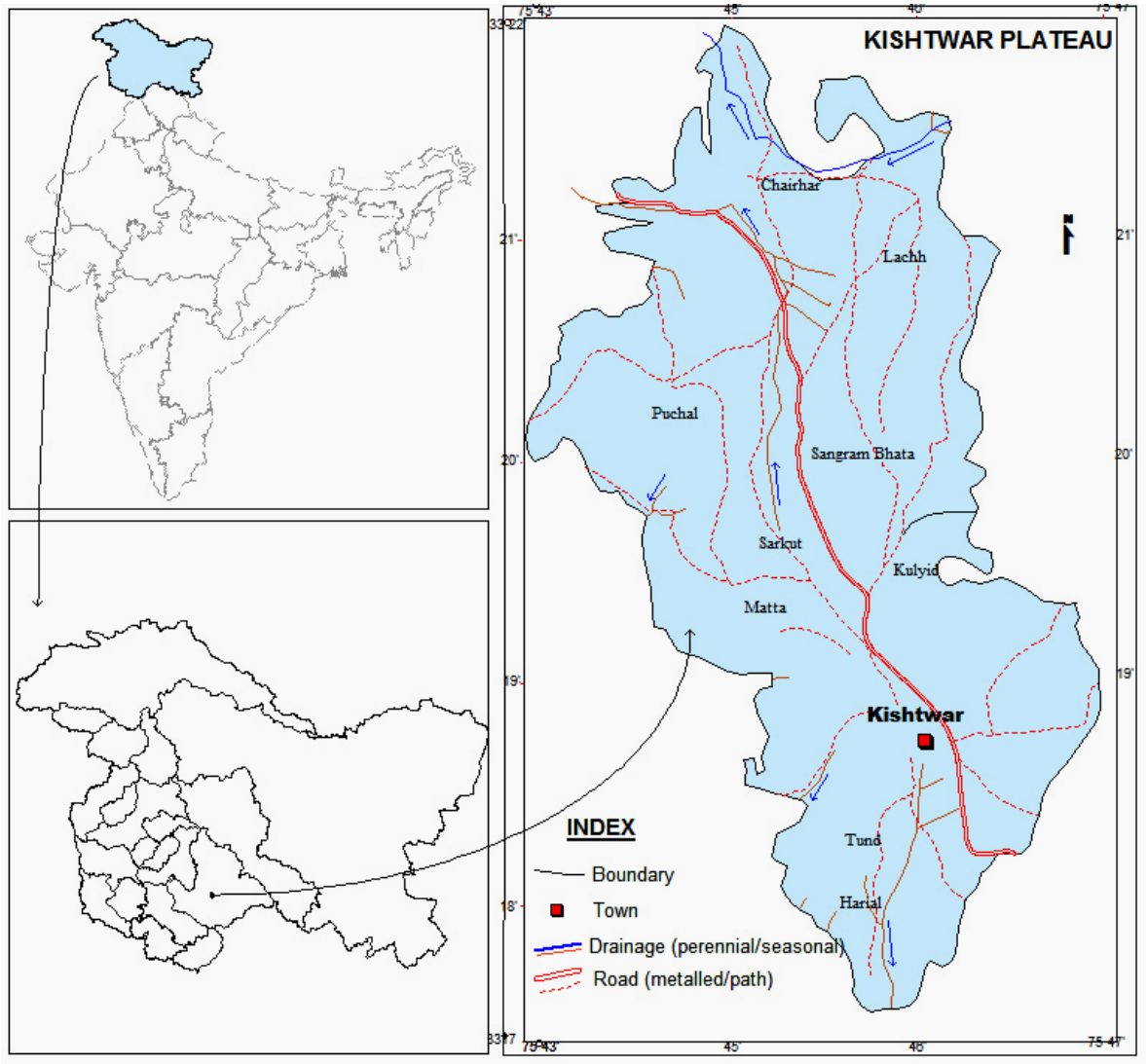

Figure 1: Location Map of Kishtwar Plateau.

Physiography

The Plateau area is bounded by high mountains on the eastern side. These mountains rise to an altitude of 2,700 m above mean sea level and about 1,000 m above the Plateau area. Elevation of the Plateau in general, is about 1,590 metres above mean sea level. A whale back shaped low east-west running ridge with alluvial covering passing through the Kishtwar town, and divides the Plateau area into two unequal segments. The area lying north of this ridge has table spoon shaped topography with an outlet towards north. The area, on the south of this ridge is having soup spoon, topography and it drains towards south. Except for the eastern boundary, the Plateau area stands on steep slopes. The river Chenab flows in a very narrow steep gorge about 60 metres below the Plateau elevation. The western boundary of this tract is characterised by detached mounds aligned along the

course of the river Chenab. These mounds range in height from about 40 to 90 metres above the general elevation of the Plateau.

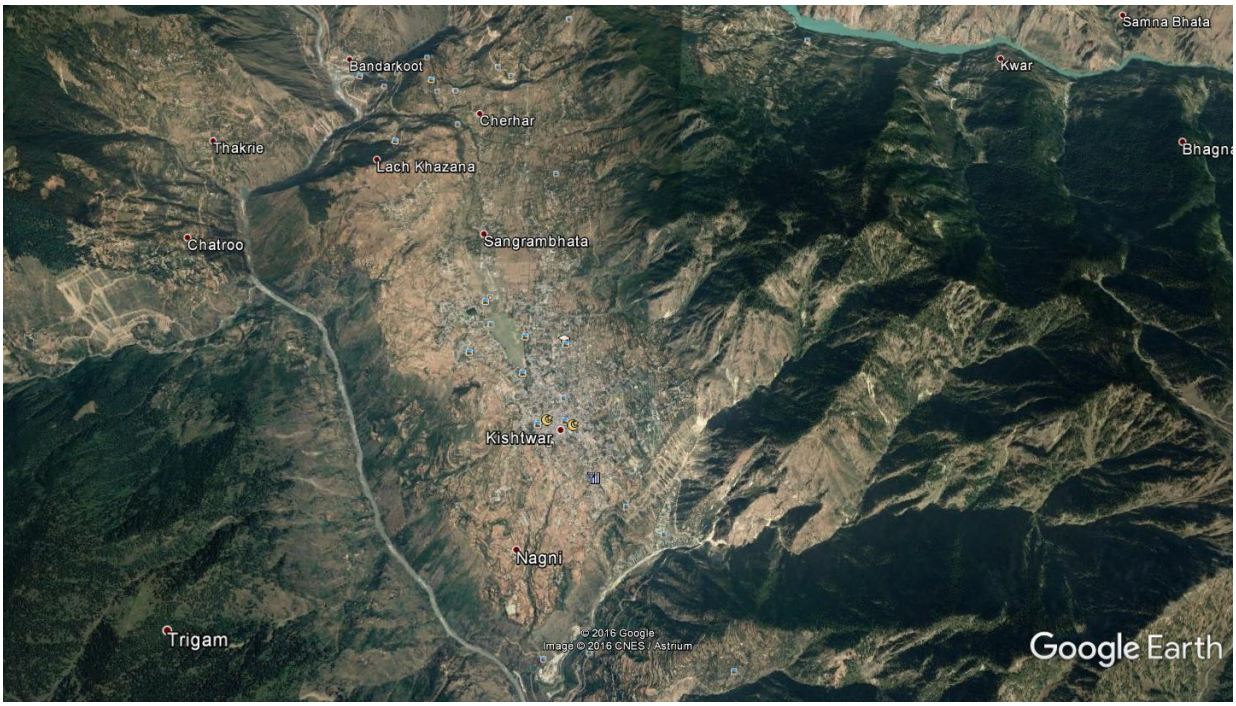

Figure 2: Google earth Image showing Physiography of Kishtwar Plateau

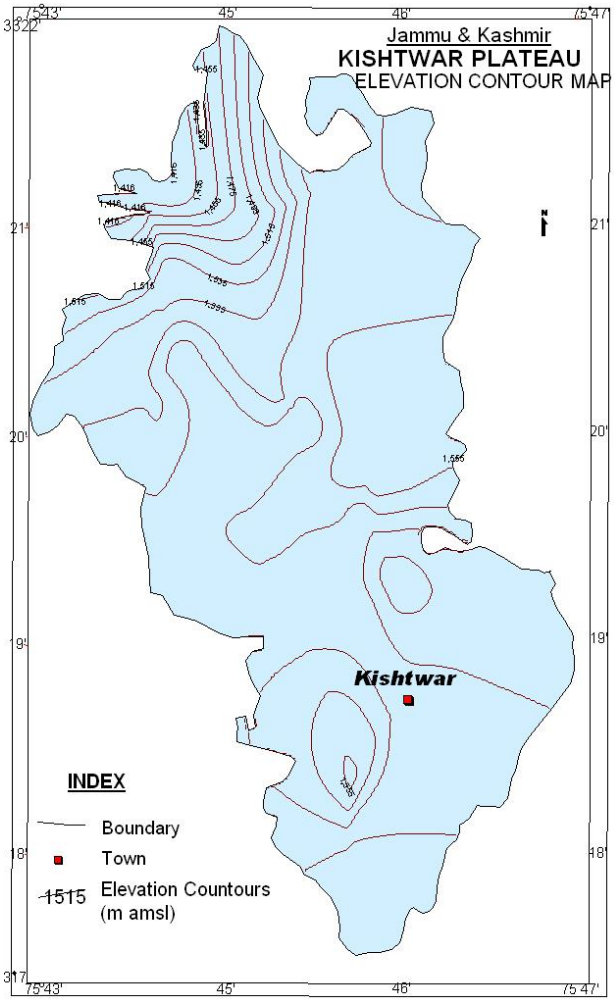

Figure 3: Elevation Contour Map of Kishtwar Plateau

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. The Chenab River surrounds the northern, western and southern part of the Kishtwar Plateau taking a round around the Plateau. Around Kishtwar the river flows through deep gorge and near Banzawar (about 8 km north of Kishtwar Town) the river makes a sharp bend for about 32 kms due south, upto Thatri. Gurdesh Nag forms the southern boundary of the Plateau. It merges into Chenab River on the southern end of the Plateau. On the Plateau very little seasonal drainage are seen mostly draining towards Chenab River. The one on the south of Kishtwar drains into Gurdesh Nag.

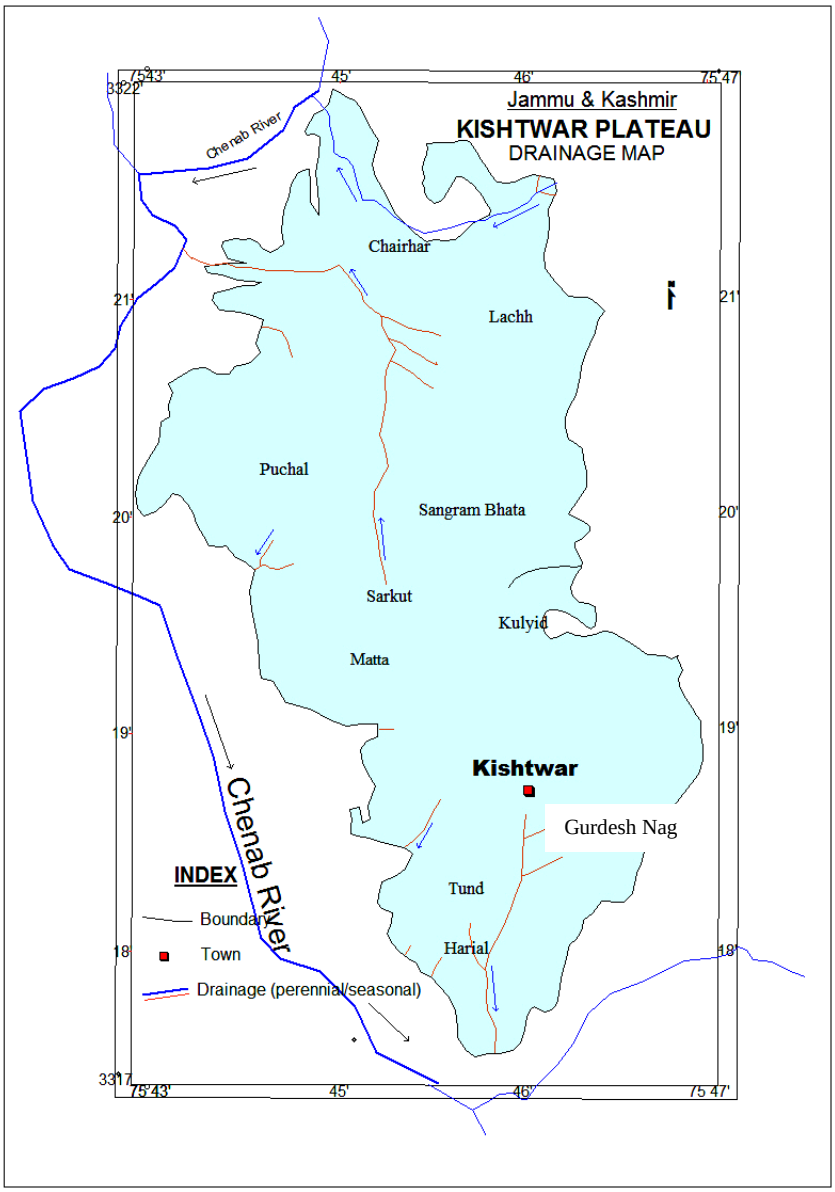

Figure 4: Drainage Map of Aquifer Mapping Area.

Climate

The area, in general has temperate to sub-tropical type of climate. Though the rainfall is spread almost throughout the year, the wettest months are July to September. The lowest rainfall is recorded in the month of November. Average rainfall in District Kishtwar has been recorded as 994 mm per year which is lowest as compared to other districts of Jammu Division. The areas having altitude of 2,000 m amsl experience heavy snowfall in winters viz. from November to April. It is cold in summer also. Average temperature in Kishtwar is 15.4 °C. The highest average temperature is around 23.8 °C, which is observed in June and lowest in January, at around 3.9 °C. The graph showing average monthly rainfall and temperatures on the Plateau is shown in figure 3 and data is given in Annexure I.

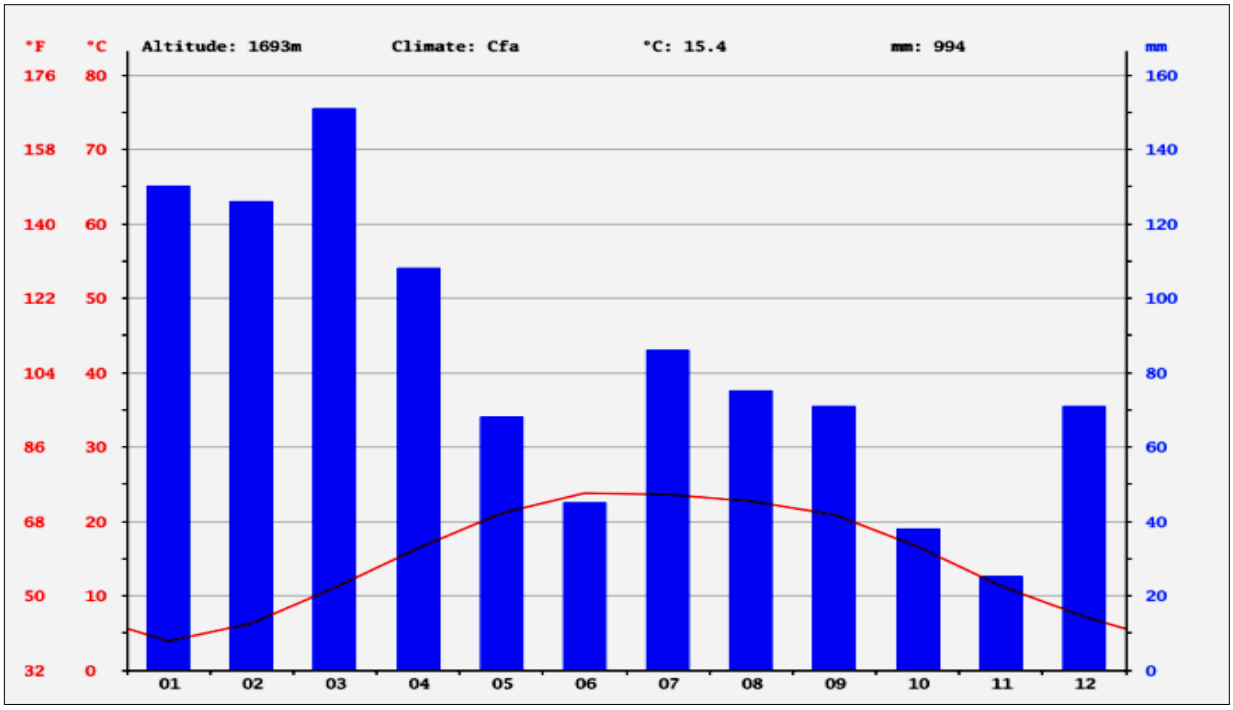

Figure 5: Average Rainfall and Temperatures in Kishtwar.

Soil

Soil is spodosolic, undulating and prone to erosion. Most of the soils of the district Kishtwar are sandy loam to clayey loam in nature with high rate of soil loss due to erosion. Saffron of purest quality is produced in the iron rich soil at Puchhal, Matta, Lachdayaram, Berwar and Hidyal.

Irrigation and Water Supply

As such there is no irrigation scheme on the Plateau. The agriculture here is mainly rain fed. As per Digest of Statistics 2013-14, there are no tubewells or dugwells constructed by State Government for water supply scheme in Kishtwar.

Cropping Pattern

Agriculture is the main source of livelihood in the area, as in the rest of the State. Villages of Puchhal, Matta and Hidyal produce saffron of best quality. The rural households are also abundantly gifted by nature through cash crops of eatable mushrooms and morchella called *guchhi* in local language. Due to dry nature of the climate, the village peasant population usually grows wheat and barley in Rabi season and kidney bean and maize in Kharif season.

Ground Water Recharge and \Discharge

The Chenab River is entrenched deep and the plateau stands on steep slopes on all sides except the eastern boundary and as such there is no possibility of the groundwater reservoir in the Plateau area being recharged from any other side except from the eastern end and the downward percolation, of the rainwater and the snow melt in the area. On the basis of the topography, disposition and nature of springs, it is felt that the direction of ground water movement in the area is westwards. Occurrence of springs in the central tract near Sangram Bhata is due to interception of the water table by the surface slope. The tank near Sarkut is also possibly being fed by groundwater. The spring water on the emergence in the central tract is drained by a nala flowing northwards in accordance with the surface topography.

Discharge of ground water occurs both by natural and artificial ways. Natural discharge is through spring flow and sub surface ground water flow to effluent surface water bodies. Withdrawals of groundwater from the hand pumps for domestic uses contribute to the artificial discharge.

Water Level Scenario

As there are no dugwells or tubewells on Kishtwar Plateau, so hydrograph monitoring network can not be established here. There is no water level data available for Kishtwar Plateau. But the final water level data for the handpumps taken for preparing the aquifer maps are used and water level contours are drawn for the plateau and shown in figure 6.

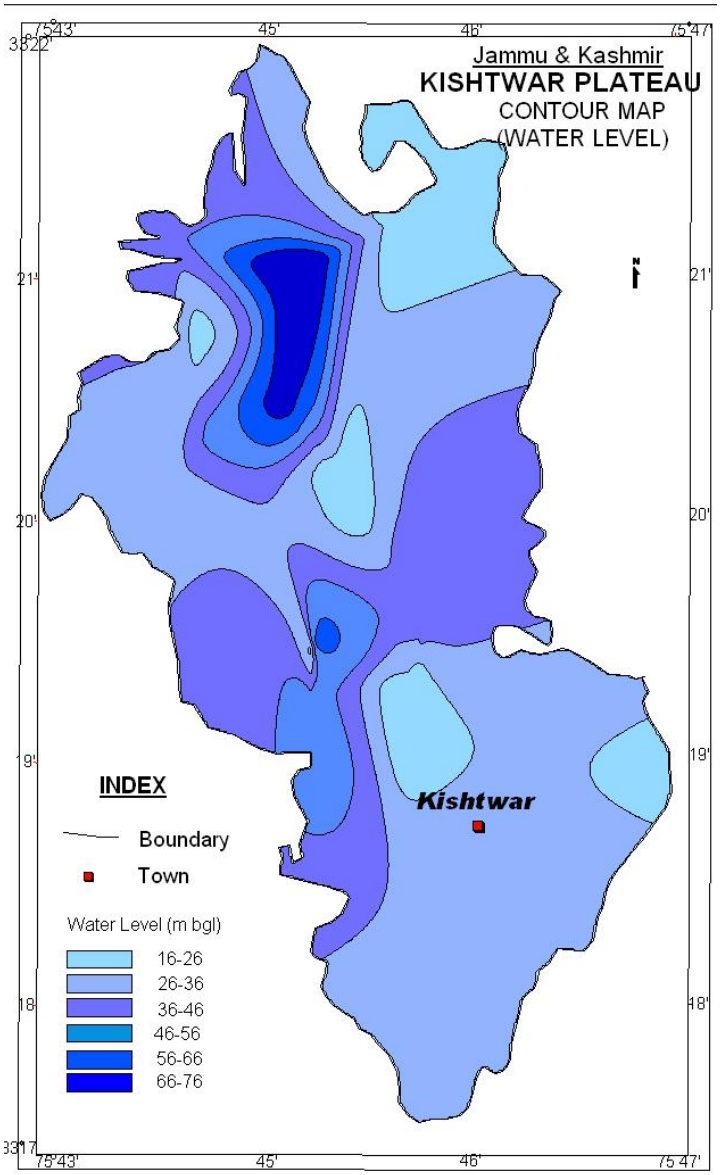

Figure 6: Water Level Contour Map of Kishtwar Plateau

Geology

Kishtwar Plateau lies in Higher Himalayas. The Kishtwar formation occupying the Plateau surface is an assemblage of silty material at the top (10-12m. thick) underlain by silt and angular fragments of mainly quartzites and schists (80m thick) mixed in varied proportions (P. C. Nawani; S. A. Khan, 1980-81). The silty material at top is of darker shade and of Quaternay age. The underlying Pre-Cambrian Schist is of micaceous nature and covers the eastern boundary of the Plateau. The schist lying to the west and south of Kishtwar dips at an angle of 75 to 80° towards the west and 50° towards south-west respectively. The Dul Quartzites of middle Proterozoic age, lying in the east of Kishtwar are believed to be separated by a faulted boundary, as the two, schists and quartzites dip in diametrically opposite directions on the either side of the boundary, with no evidence of

folding of the beds. The mounds on Kishtwar Plateau rising to an elevation of about 1596 m above mean sea level are formed of bed rock i.e. schist. The other mounds in between are composed of clayey material. Huge boulders and gravels occur all along the foot of the mountains on the eastern boundary of the Plateau. The geological map of the Plateau is shown in Figure 7.

Structure

A thrust fault known as Kishtwar Thrust, running in NNW-SSE direction, a tectonic contact between Schists and Dul Quartzites, lies across the plateau surface. The Kishtwar Fault is generally known as a left lateral strike slip fault, which has even affected the Main Central Thrust.

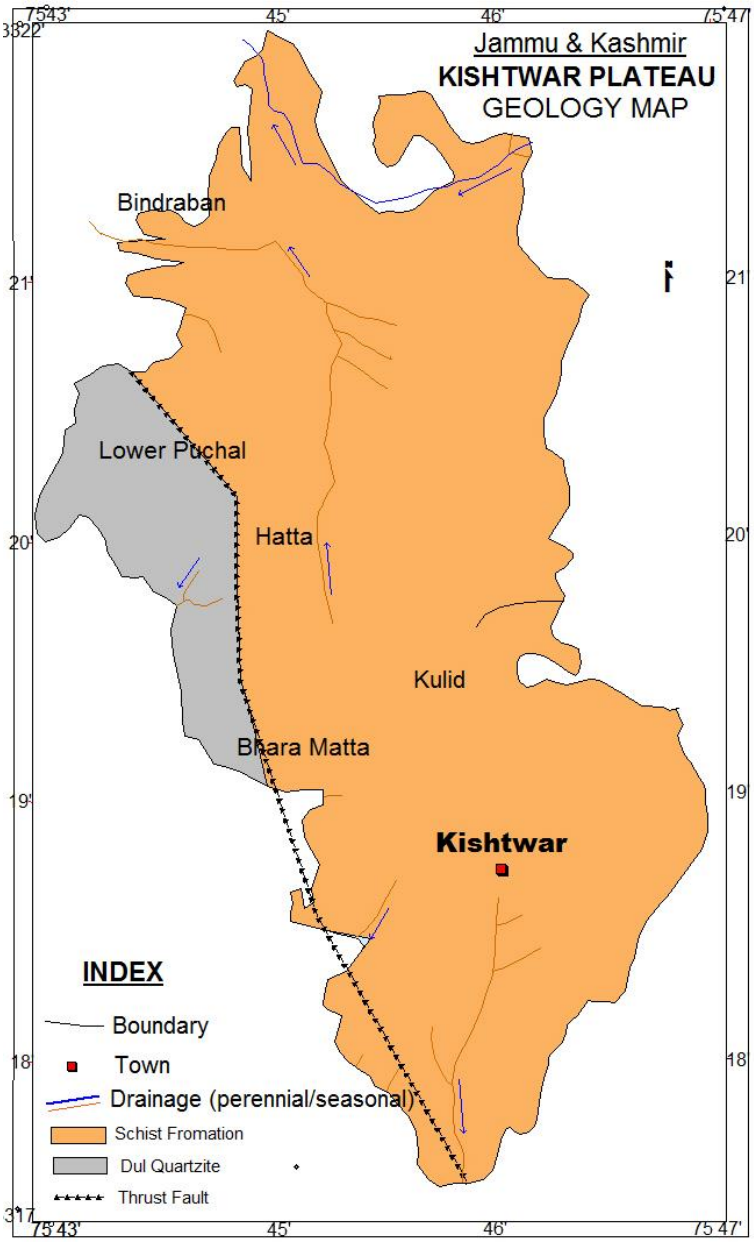

Figure 7: Geological Map of Aquifer Mapping Area

DATA AVAILABILITY

The compiled data were plotted on 1:50000 scale map and data gap analysis was carried out. The summarized table presenting the data requirement, data availability and data gap analysis is presented in table 1.

Table 1. Data Availability and Data Gap Analysis in Aquifer Mapping Area

S. No.	Items	Data Requirement	Data Availability	Data Gap
1.	Rainfall Data	Meterological Stations spread over the project area	Not available	Across study area
2.	Soil	Soil map and Soil Infiltration Rate	Not Available on any Scale	Soil Infiltration Rate across study area.
3.	Land use	Latest Land use pattern	No Land use data available	Latest data required for GIS.
4.	Geomorphology	Digitized Geo-morphological map	Not available	To obtain digitised Geo-morphological map
5.	Geophysics	Geophysical data in each Quadrant	Nil	08 VES
6.	Exploration Data	EW in each Quadrant with Aquifer Parameters	5 EW's	Deep EW's
7.	Aquifer Parameters	Aquifer parameters for all the quadrants	Not available	To be estimated across study area
8.	Recharge Parameters	Recharge parameters for different soil and aquifer types based on field studies	Recharge parameters given in Resources Estimation	To be estimated across study area
9.	Discharge Parameters / Draft Data	Discharge parameters for different GW abstraction structures	Discharge parameters given in Resources Estimation	To be estimated across study area
10.	Geology	All the maps on 1:50,000 Scale. Hard and digitized copies.	Hard copies of only few geological maps	Soft copies of entire study area
11.	Hydrochemistry	Ground Water Quality of the Plateau	Results of some samples from RHS of 2009	To be estimated across study area

2 DATA COLLECTION AND GENERATION

Data on various attributes of Aquifer Mapping has been generated/collected based on the data availability and data gap analysis discussed in previous section. The data generated and data collected from various state government departments is summarized in table 2.

Table 2. Data Generated and Data Collected for Aquifer Mapping Area

S. No.	Items	Data Generated	Data Collected
1.	Rainfall Data	-	https://en.climate-data.org/location
2.	Geophysical data	Carried out 10 VES, conducted one Electrical logging.	Geophysical data is not available with any other department in the State.
3.	GW Exploration	Construction of 4 EWs and Pumping Tests yet to be conducted in the successful EWs for determination of Aquifer parameters	Lithological & discharge details of about 30 handpumps collected from PHE Department.
4.	GW Regime Monitoring	No dugwell/tubewell as NHNS	Monitoring data not available with any other Department
5.	Hydrochemical Studies	Water samples from Handpumps and springs were collected.	-

Water Quality

The basic chemical parameters determined for evaluating the groundwater quality of Kishtwar Plateau are pH, EC, CO_3, HCO_3, Cl, NO_3, SO_4, F, Ca, Mg, TH, Na, K, TDS, Alkalinity and Fe. A total of 12 water samples were collected of which five samples were collected from hand pumps and seven from springs. The chemical analysis results are given in Annexure-II. The water quality distribution maps showing point values of EC, Nitrate and Iron were prepared and it was observed that overall quality of ground water is fresh and potable. The EC values in water samples collected from hand pumps range from 350 ms/cm at 25°C at Bindraban to 830 ms/cm at 25°C at Puchal and in those collected from springs range from 160 ms/cm at 25°C at Semna Colony to 650 ms/cm at 25°C at Hudri. The map showing the point EC values of different handpumps and springs is presented in figure 8.

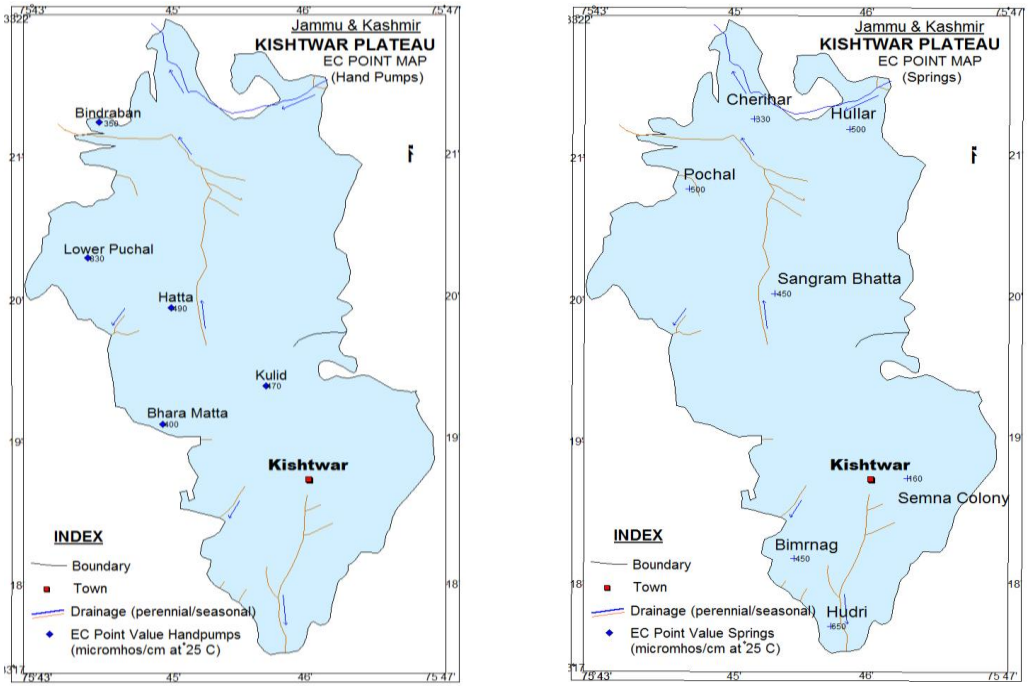

Figure 8: EC Map of Handpumps and Springs at Kishtwar Plateau

Nitrate was observed above permissible limit of 45 mg/l, as set by BIS, for drinking water in one handpump sample viz. 173 mg/l at Lower Pochal and 2 samples from springs viz. 141 mg/l at Hudri and 76 mg/l at Kundali Pochal. The map showing point values of nitrate concentration in Handpump and Spring samples is given as figure 9.

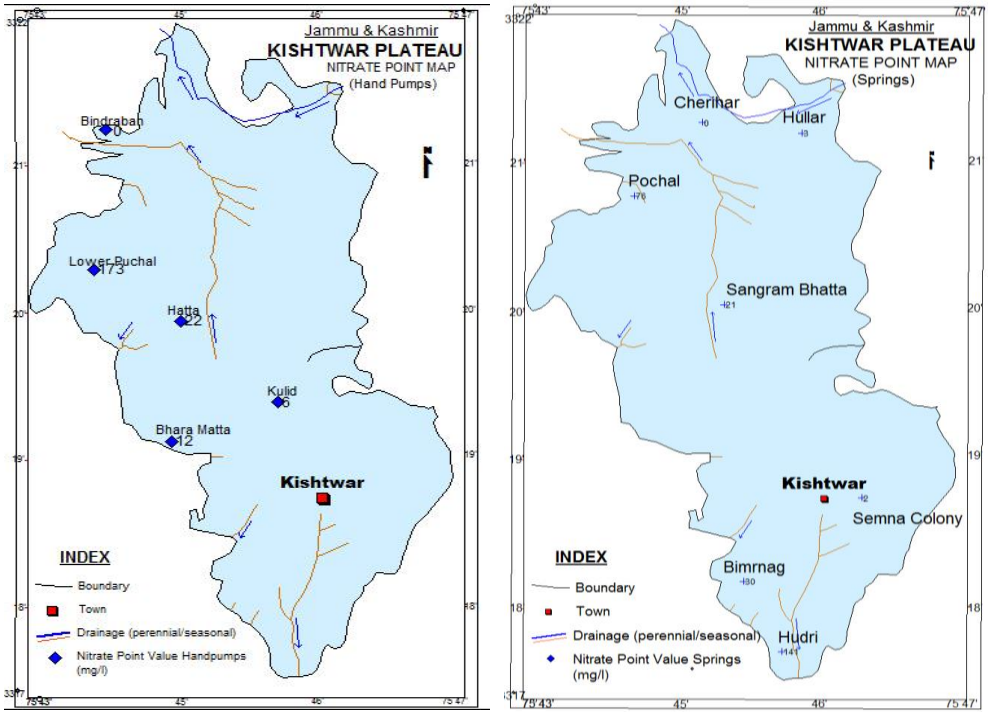

Figure 9: Point Map showing Nitrate concentrations in Handpumps & Springs of Kishtwar Plateau

None of the water samples collected from the Plateau was found to have the Iron concentration within the desirable limit of 0.3 mg/l, as set by BIS for drinking water. All the water samples collected from hand pumps were contaminated by Iron concentration exceeding the permissible limit (1 mg/l) of BIS. Six out of seven water samples collected from springs also contain iron above desirable limits of BIS whereas the sample from Cheriar Spring contains iron (1.6 mg/l) which is above permissible limit. The map showing point values of Iron concentration in Handpump and Spring samples is given as figure 10.

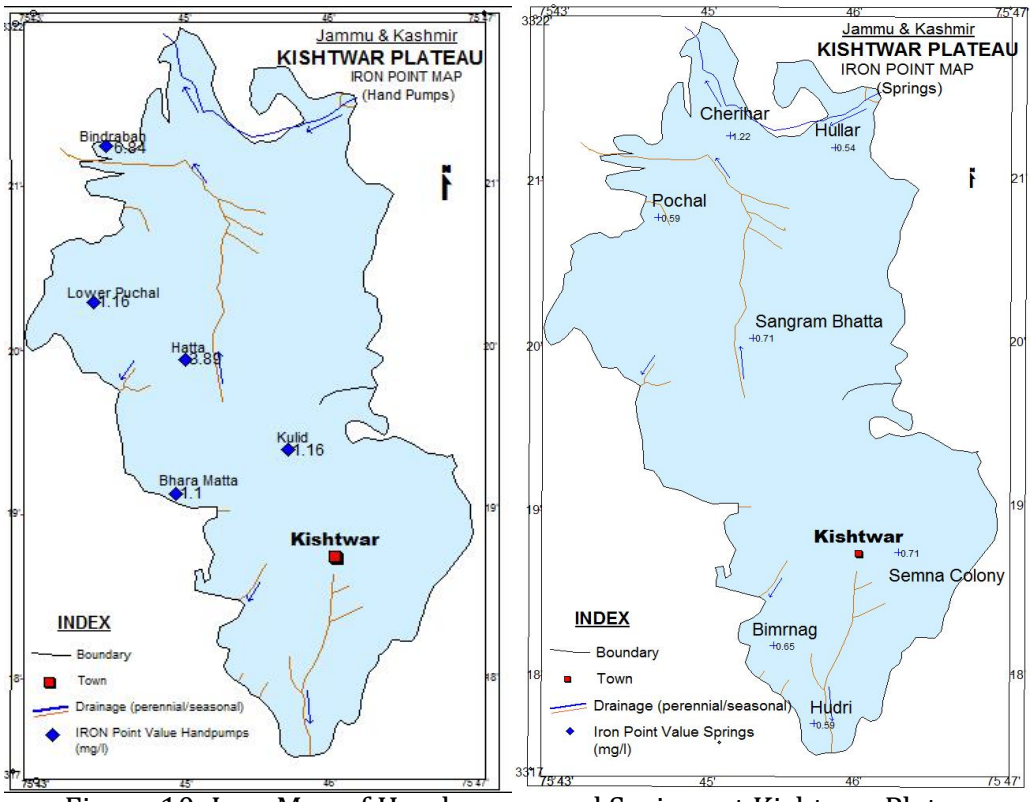

Figure 10: Iron Map of Handpumps and Springs at Kishtwar Plateau

Geophysics

As a part of AAP 2014-15, a total of 10 Vertical Electrical Soundings (VES) were carried out by deploying Schlumberger array with maximum current electrode separations ranging from 130 to 380 m. The VES were conducted by using the DDR-4MP resistivity meter, with an objective of deciphering the depth and thickness of ground water zone/s. The location map of these VES sites is shown in figure 11 and details are given in Annexure III.

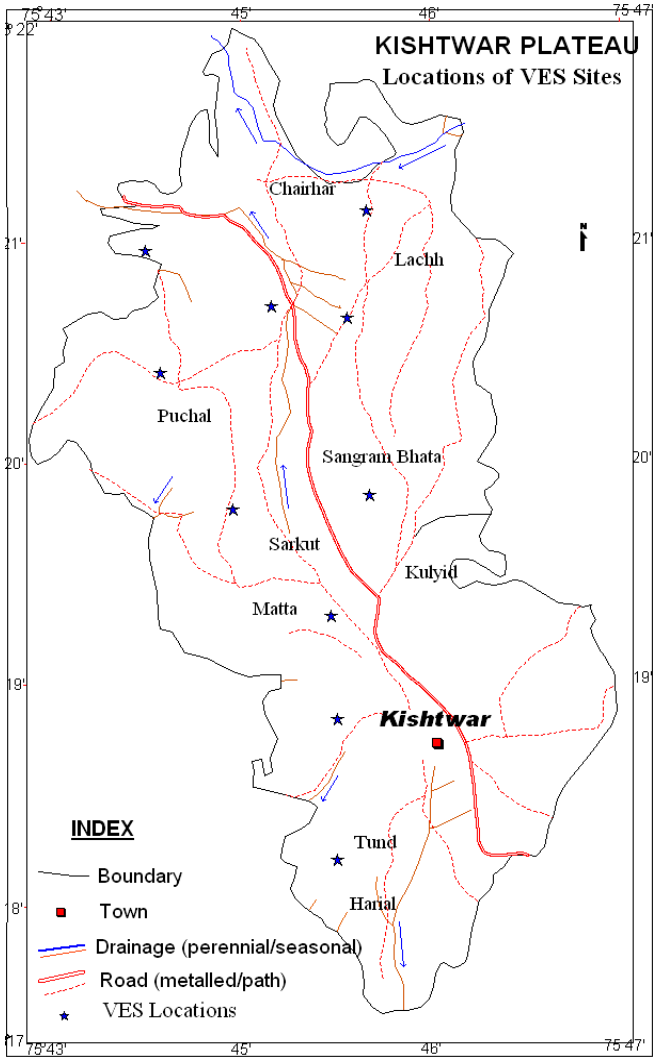

Figure 11: Location Map of VES Sites conducted at Kishtwar Plateau

Using the interpreted results of all the 10 VES carried out at Kishtwar plateau, a 3 D model was prepared using the RockWorks 16 program, for depicting the variations in 'subsurface geo-electrical resistivity', in turn lithology of the plateau (Figure 12). The 3D model reveals that there is hard formation at shallow depths in southern, north-eastern and of central parts (Sangram Bhatta). These mounds are showing high resistivity, which can be inferred as Schist. Where ever there is hard rock formation, the occurrence of ground water is confined to weathered and / or fractured zones. Very thin alluvium layer is seen throughout the plateau but the thickness is more at central part in east-west and north-west orientation. Also, there is a very thick layer of silt and clay, in the central (Chogan) part towards the eastern end, of the depth range more than 300 m, which can be corroborated with 'bowl nature of structural depositional topography' of the plateau. These clayey mounds occur at four places. Very thin alluvium cover is seen on the northern and central part of plateau.

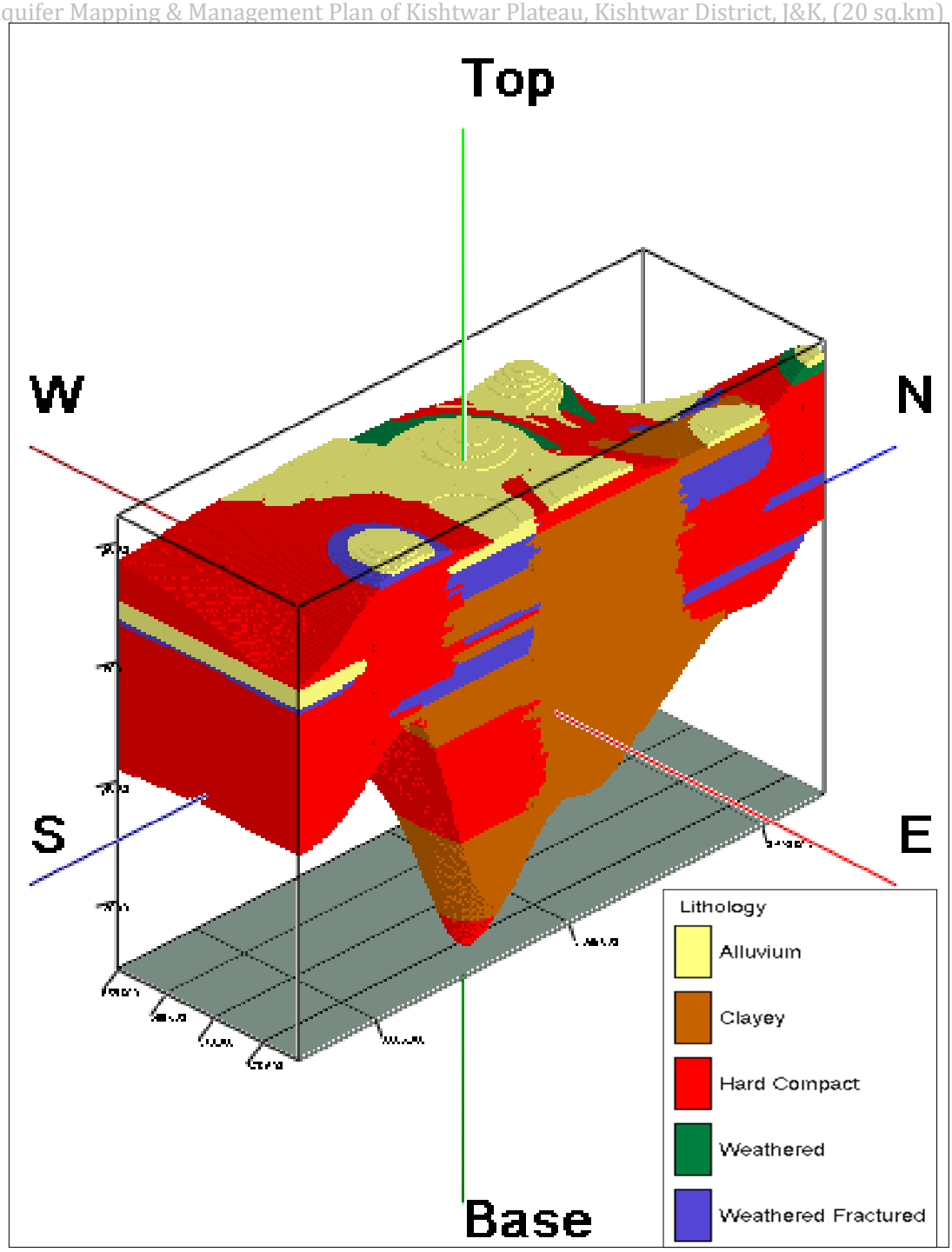

Figure 12: 3 D Model of Kishtwar Plateau by interpretations of Resistivity Surveys.

The fence diagram (figure 13) depicts the 3 dimensional view that shows the alluvium covering the plateau is underlain by weathered zone followed by hard formation at most of the places. The clayey formation which is predominant on the eastern end is not observed in the western part. In the central part viz. Sangram Bhatta, Hatta and Chogan two prominent aquifers can possibly be encountered at varying depths at different places, depending upon their surface elevations. There is a ground water zone following the ground slope from Berwar towards Bindraban.

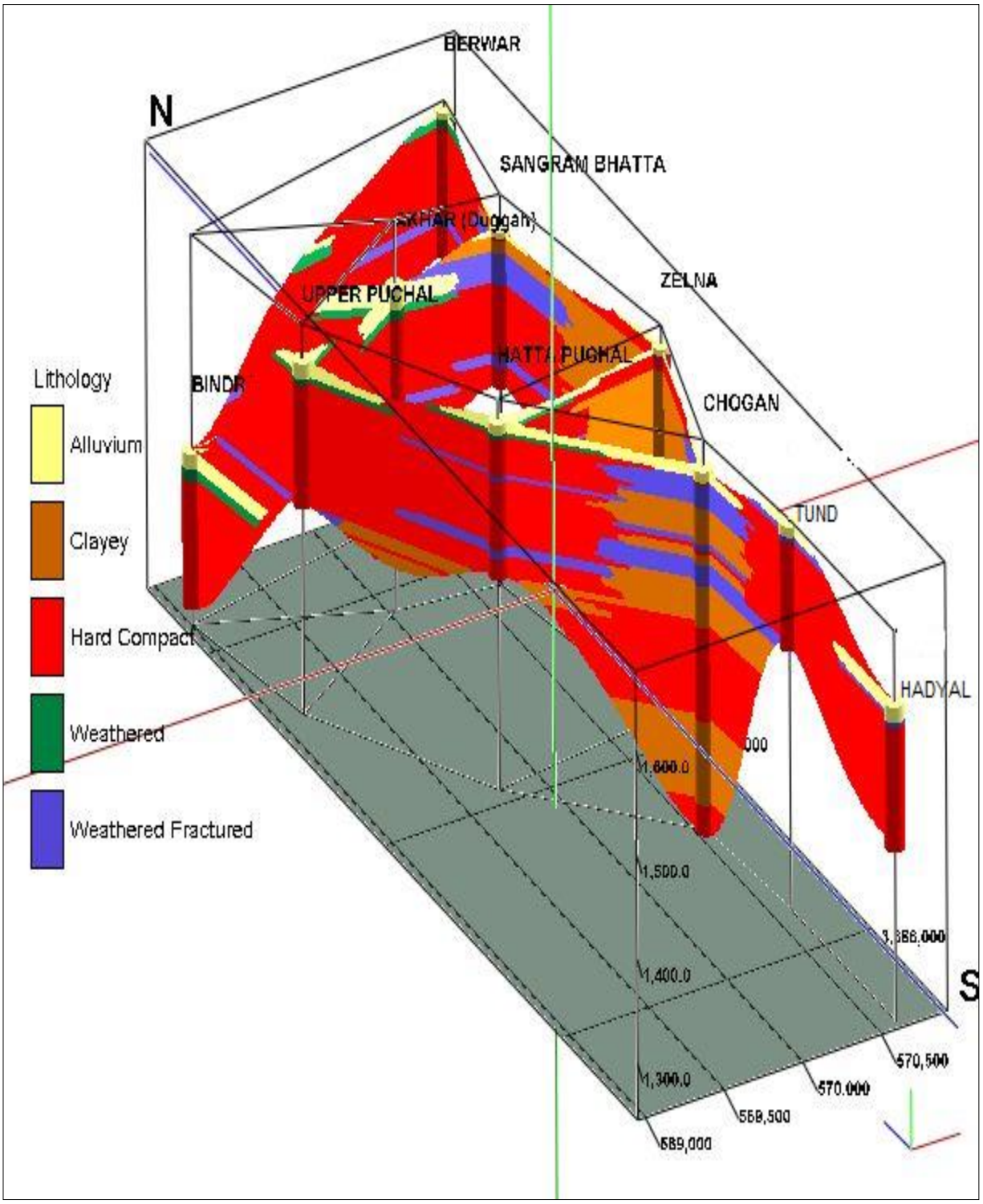

Figure 13: Geo-electrical Fence Model of Kishtwar Plateau based on interpretations results of Resistivity Surveys.

The pseudo geo-electric cross sections between VES points are drawn using the Surfer and Rockworks Softwares. The map showing the section lines is given in figure 14.

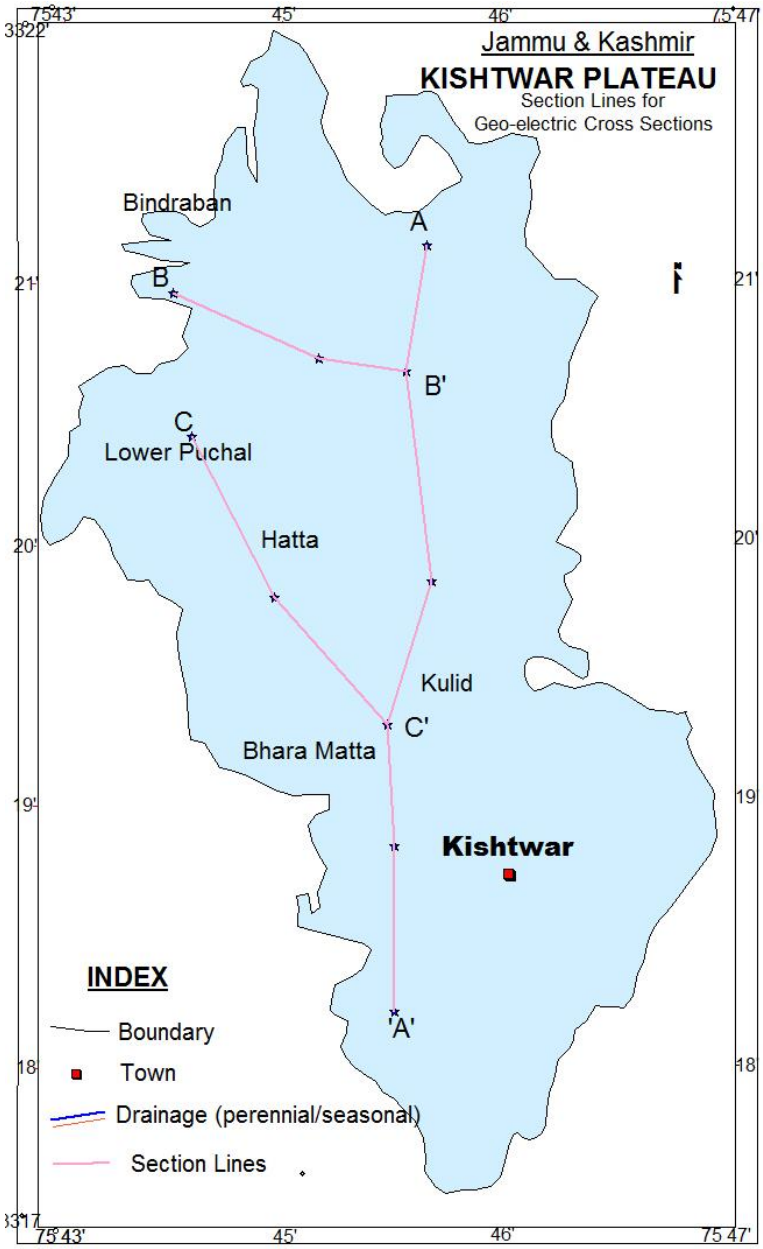

Figure 14: Map showing profiles along which Pseudo Geo-electric Cross Sections are drawn.

The pseudo geo-electric cross section drawn in the north-south direction along Berwar – Sangram Bhatta – Zelna –Chogan – Tund and Hadyal reveals that at Sangram Bhatta the higher resistivity values are indicative of hard rock formation throughout its depth from the ground level itself (figure 15). No weathered/ fractured formation is encountered here which can act as a conduit for water. This hard formation further extends at Berwar and is encountered at deeper levels, restricting the potential zone to the shallower depths. In the southern end at Hadyal, this hard formation is found to extend on the inner side towards Tund. The softer silty clayey formation is found to occur in the central part of the plateau viz. Zelna, Chogan and Tund.

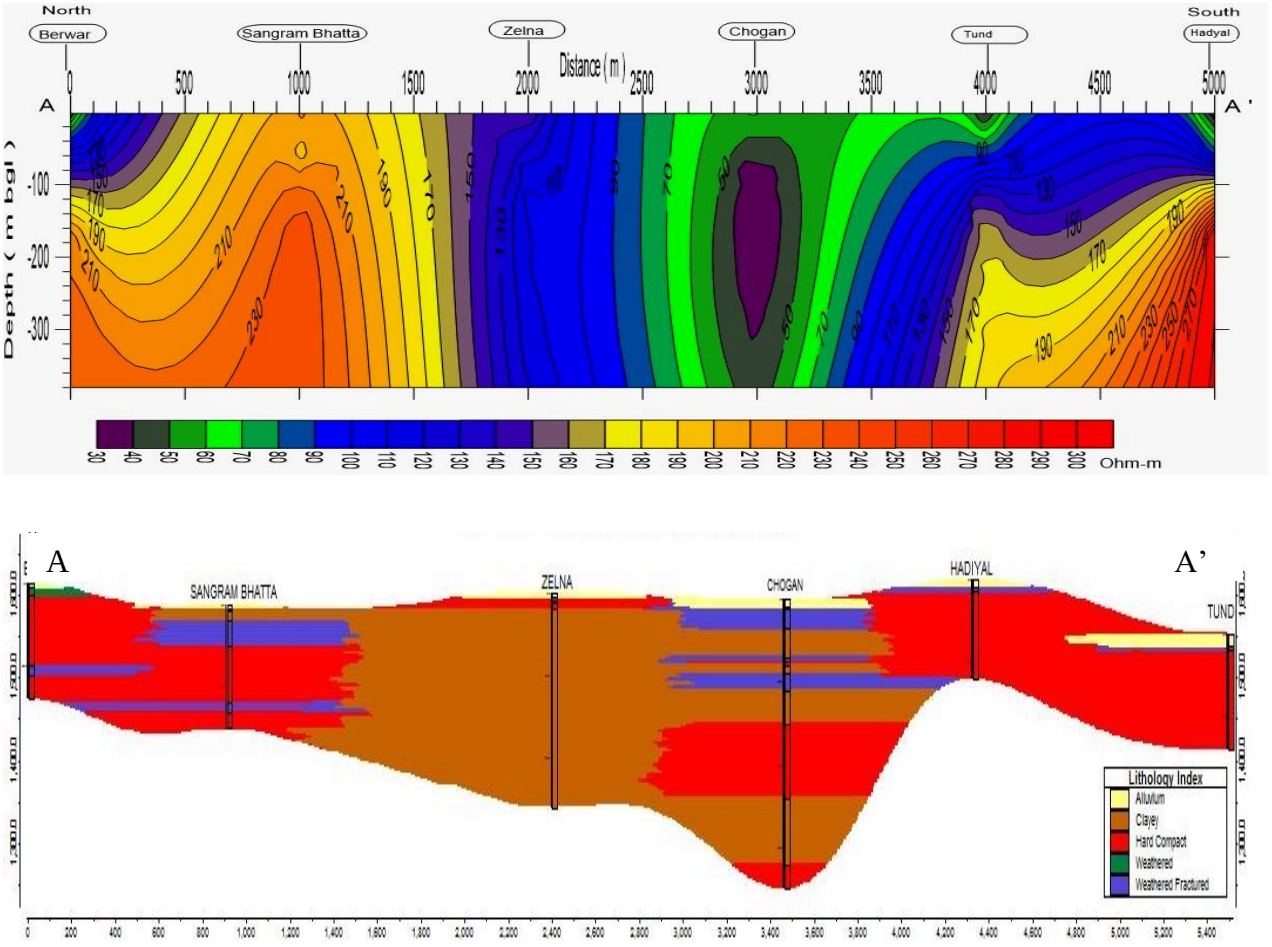

Figure 15: Pseudo geo-electric cross section between Berwar – Sangram Bhatta – Zelna – Chogan – Tund and Hadyal

The cross section drawn from west to east along Bindraban – Akhar to Sangram Bhatta depicts that the soft rock formation occurs at very shallow depths at Bindraban and Akhar. At deeper depths schist and hard formations extends throughout the section from west to east.

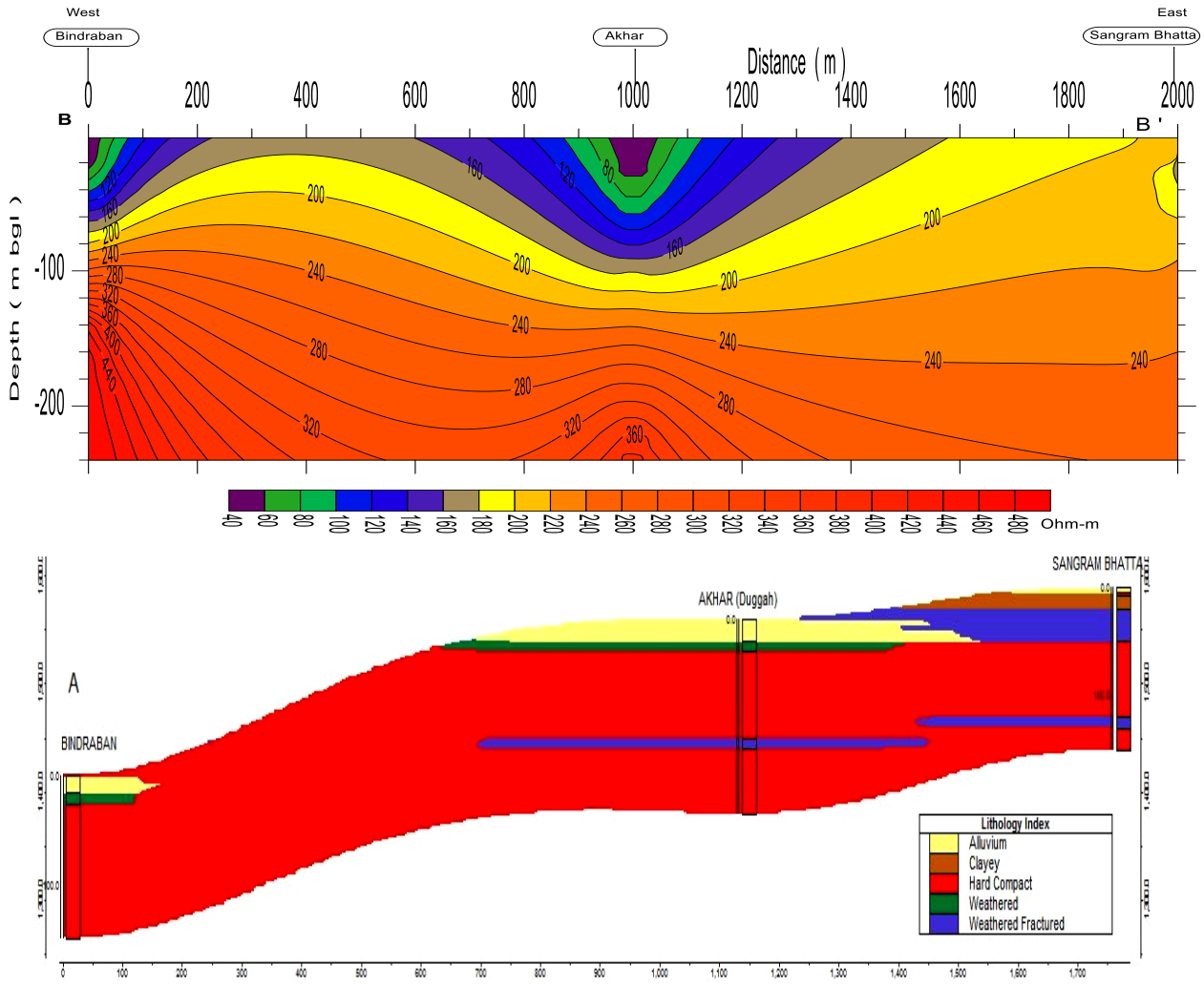

Figure 16: Pseudo geo-electric cross section between Bindraban – Akhar - Sangram Bhatta.

The cross section drawn from north-west to south-east along Upper Pochal – Hatta Pochal and Chogan reveals that soft formation extends throughout the section and proves to be potential except for Upper Pochal where hard and compact formation has encountered below 100 m of depth, which extends towards Hatta Pochal. In this hard formation only the secondary porosity will act a potential aquifer if encountered.

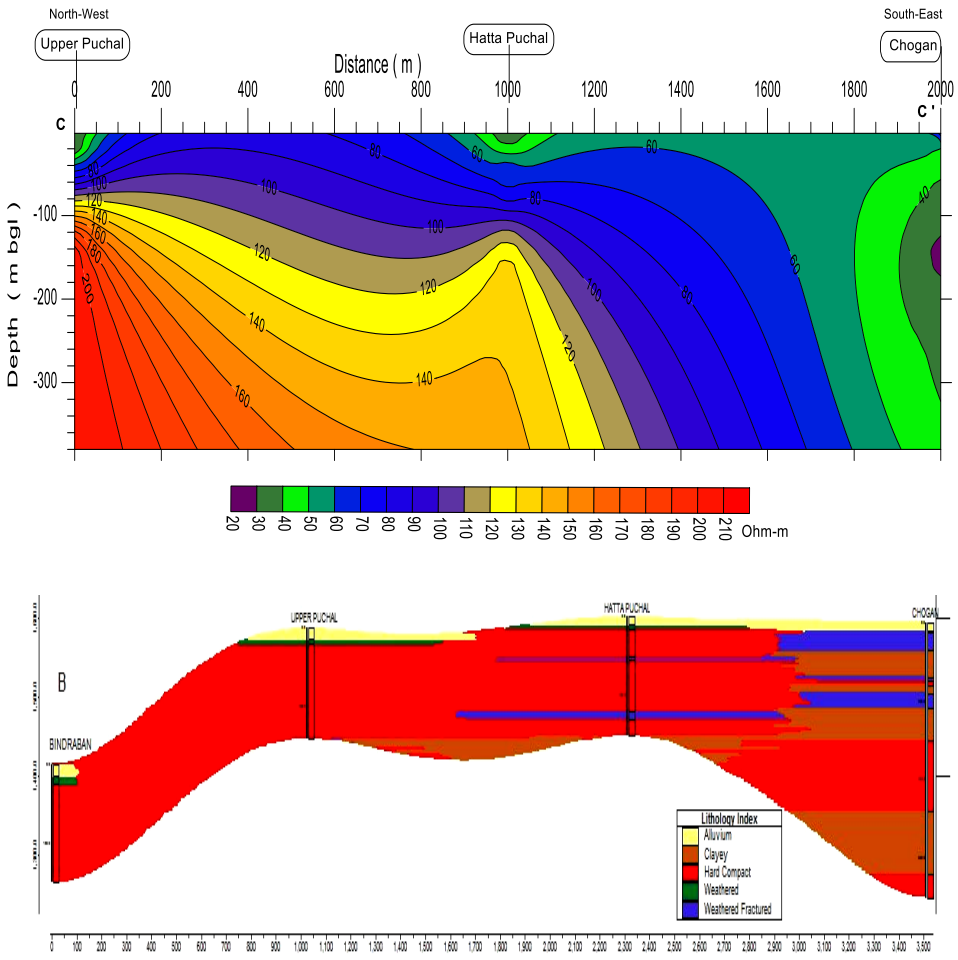

Figure 17: Pseudo geo-electric cross section between Upper Pochal – Hatta Pochal - Chogan

The tubewell drilled at Pochal during Aquifer Mapping study was electrically logged through Uptron logger. The electrical log is shown in figure 15. The analysis of the Electrical log of the borehole reveals that there are no such prominent aquifer zones beneath. But the ground water lies in the weathered/ fractured part of the rock formation. Based on this borehole log the potential zones were deciphered in the depth range of 108 – 119, and 202 - 218 m bgl.

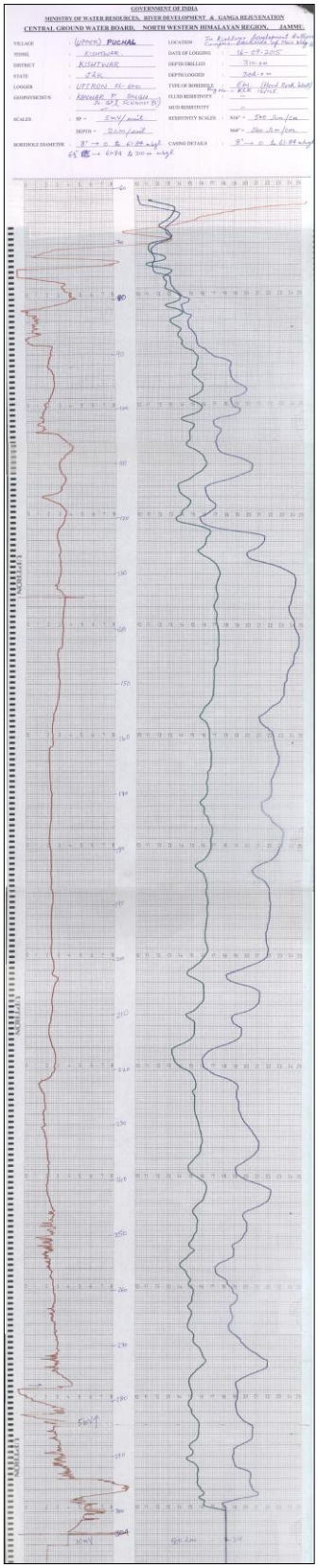

Figure 18: Electrical Log of Pochal

GROUND WATER EXPLORATION in AQUIFER MAPPING AREA

The knowledge about the hydrogeology of the Kishtwar Plateau is very limited because of limited availability of drilling data in the area. CGWB took up the drilling in 1972 under, ground water exploration program. Two exploratory boreholes were drilled in 1972, and as no potential zone was encountered both the boreholes had to be abandoned. During Aquifer Mapping work in Kishtwar in 2014-15, three exploratory tubewells were drilled at Lach Khazana, Pochal and Sarkoot. Of these three wells the EW drilled at Pochal down to 310 m bgl was successful, rest of two boreholes were abandoned due to non availability of potential zones.

The Public Health Engineering Department of Government of J&K has constructed many handpumps for drinking water supply on the plateau. Strata charts of these handpumps were collected and combined with the data obtained during ground water exploration, to prepare the lithological model and cross sections depicting the formations underneath the plateau area.

Aquifer 3D models and cross sections

To generate 3D model, fence and cross sections in Rockworks, the strata-charts of 27 handpumps / tubewells were used. Map showing the locations of these structures is presented in figure 19.

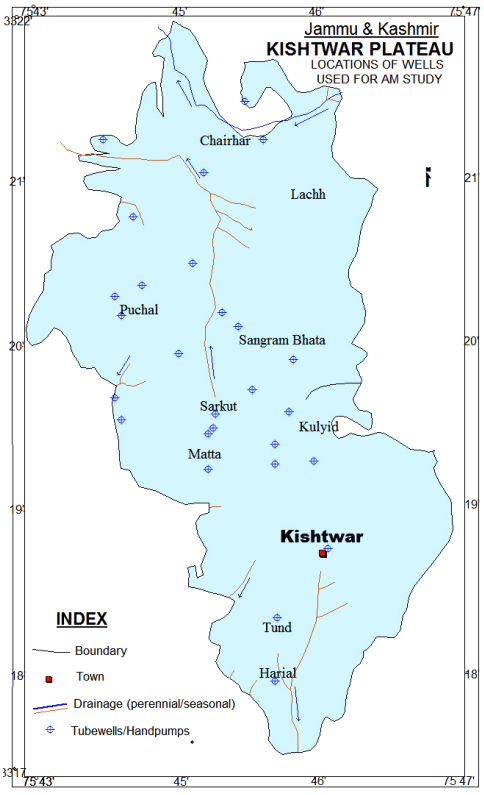

Figure 19: Location Map of Tubewells and Handpumps used for Aquifer Mapping.

The 3 D Aquifer Model of Kishtwar Plateau (figure 20) depicts that the plateau is not a plain table land like structure, instead there are several mounds on it, resulting in undulating topography. It is sloping sharply towards west and gently towards south. It is divided longitudinally into two unequal halves. The eastern half is underlain by schist formation and the western half by Dul Quartzite. Mostly the handpumps and tubewells are drilled in the schist formation. The deepest well drilled on the plateau is a borewell drilled by CGWB's KLR Rig down to a depth of 310 m bgl at Pochal. The handpumps are installed up to a maximum depth of 110 m bgl, restricting the extension of lithology down to this depth only. The secondary porosity developed in the schist due to its weathering and fracturing is acting as conduit for water. These weathered/ fractured zones are encountered at different depths in different parts of the plateau. In the central part viz. Chogan, Kulid etc. the aquifer is encountered at a depth range of 18-35 m bgl.

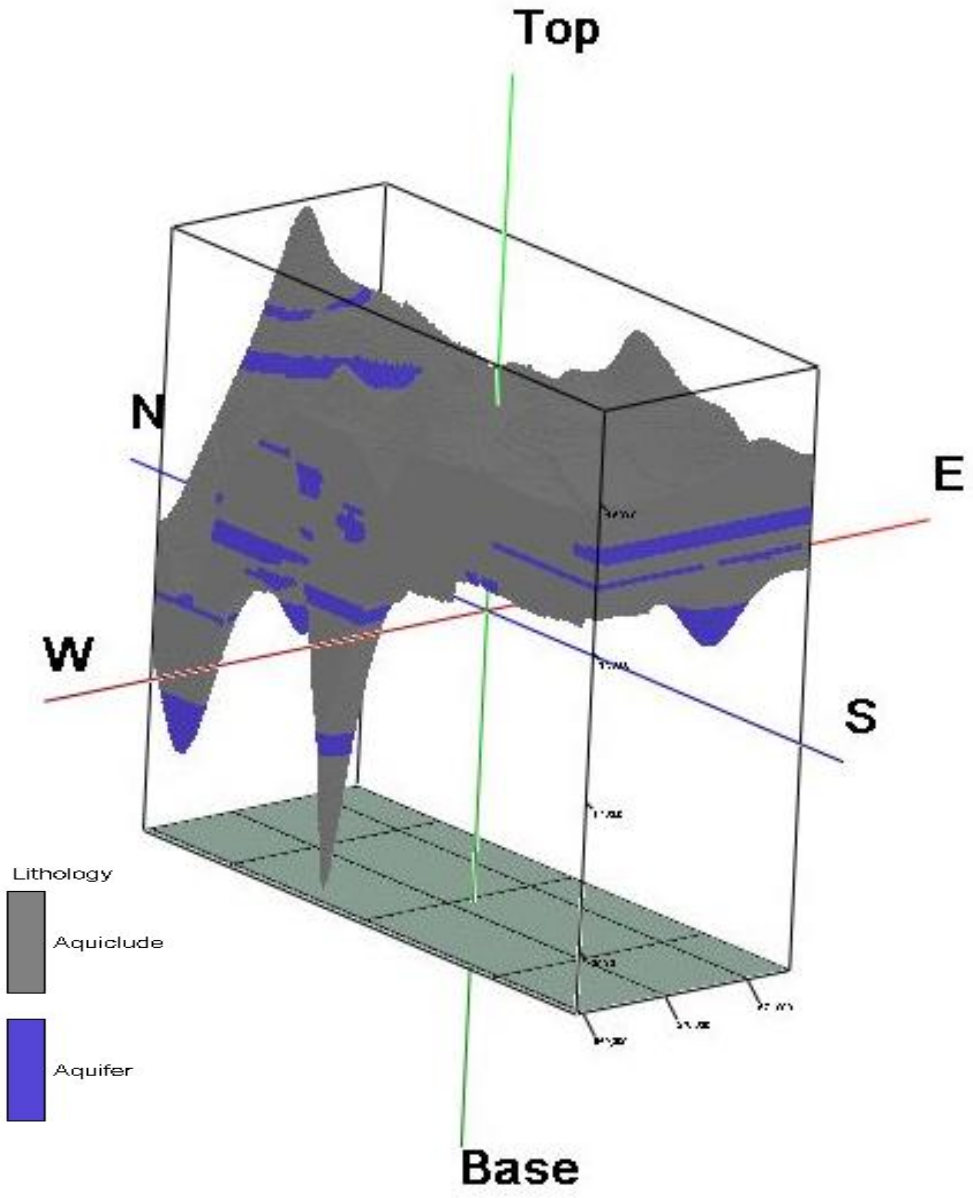

Figure 20: 3 D Aquifer Model of Kishtwar Plateau.

The strip logs are plotted in a 3 D view of all the strata charts used for creating the 3D model, fence and cross sections of the plateau, and is shown in figure 21.

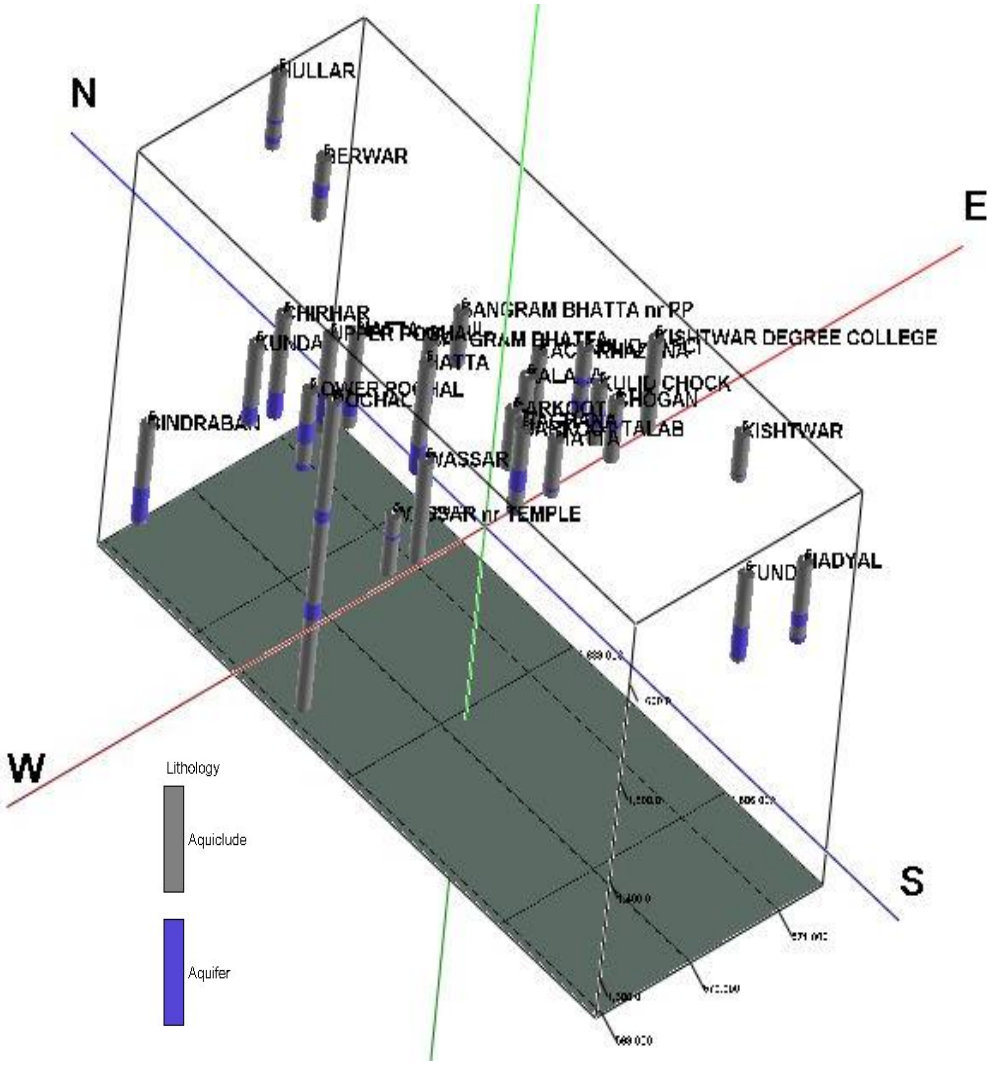

Figure 21: Strip Log Aquifer Model of Kishtwar Plateau.

Fence Diagram of Kishtwar Plateau

The fence diagram (figure 22) prepared by extending and combining the strata charts to the nearest well log, depicts that the aquifers are encountered on the longitudinal eastern side of plateau which is underlain by Schists of Pre-Cambrian age. There is very thin veneer of alluvium on the plateau; the aquifers are encountered in the secondary porosity developed due to weathering/ fracturing in the formation. In the south- central part of the plateau the aquifer is encountered at a shallower depth (at Chogan 18 to 24 m bgl), while on the southern side the aquifer is encountered at deeper level (at Tund and Hadyal 49 m bgl.), and on the northern side viz. at Kulid 27 m bgl, Sangram Bhatta 44 m bgl., Hatta 68 m bgl. and in further north at Chirhar 76 m bgl.

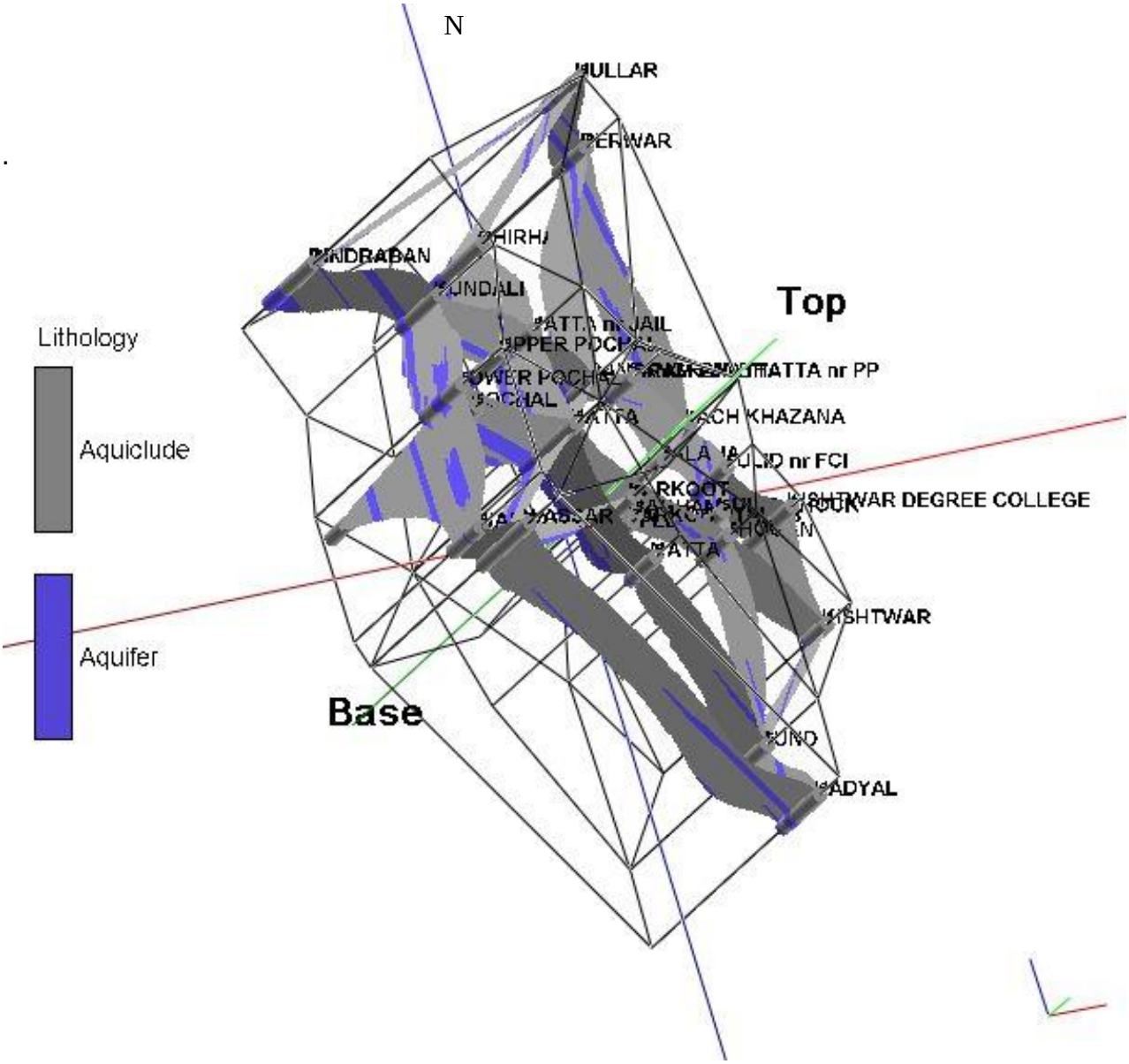

Figure 22: 3 D Aquifer Fence of Kishtwar Plateau.

The west to north, diagonal (north-west to southeast) and longitudinal (north south) sections had been prepared by joining the strata charts of the wells drilled. The figure 23 shows the cross section lines.

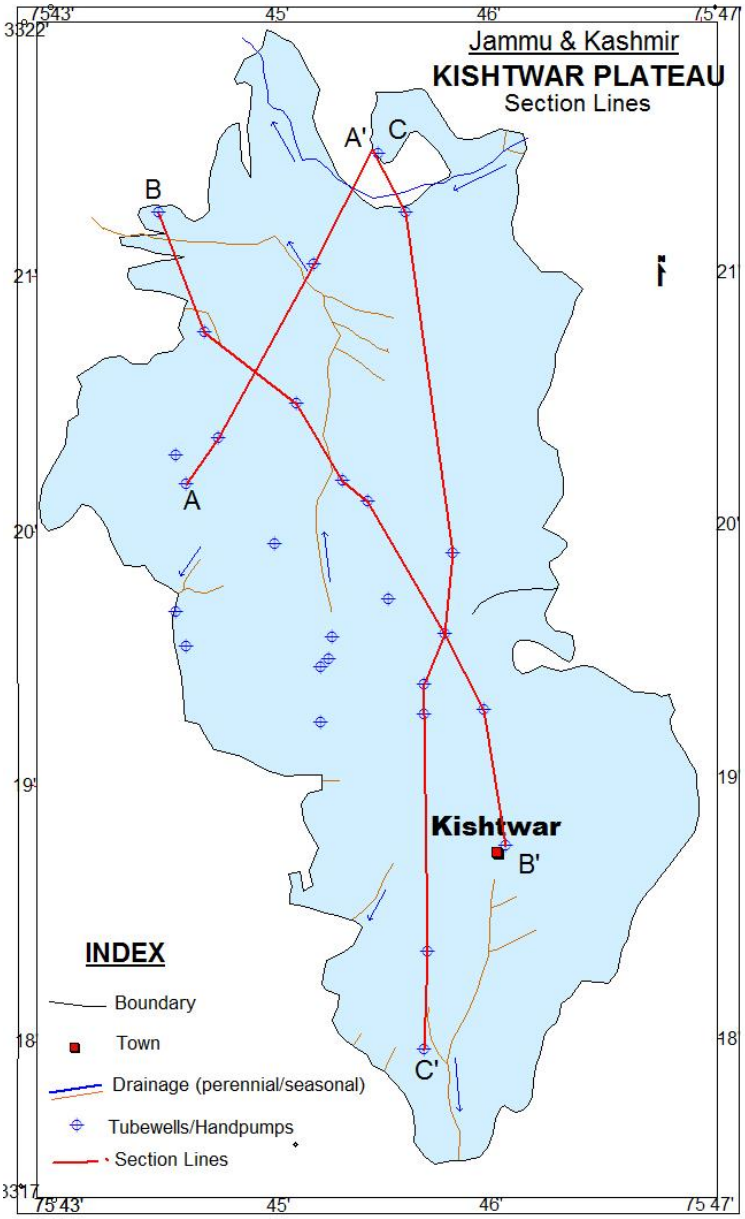

Figure 23: Map showing lines along which aquifer cross-sections are drawn.

The cross section A-A' drawn along Pochal - Upper Pochal –Cheriar -Hullar (figure 24) depicts that Pochal is the deepest well drilled on the plateau down to the depth of 310 m bgl and the aquifer zones are encountered at a depth of 108 and 202 m bgl. Upper Pochal lies at quite higher elevation of 1603 m amsl as compared to Pochal (1573 m amsl). The depth of the well drilled at Upper Pochal is restricted only to 94 m bgl. The potential zone is encountered at 54.70 m giving a discharge of 17 lpm. Cheriar lies at a lower elevation of 1495 m amsl. The formation drilled through is schist and the zone has been encountered at about 76 m bgl. The handpump installed at Hullar lies on a clay mound. Two weathered/fractured zones has been encountered here lies at 45 m and 62 m. bgl.

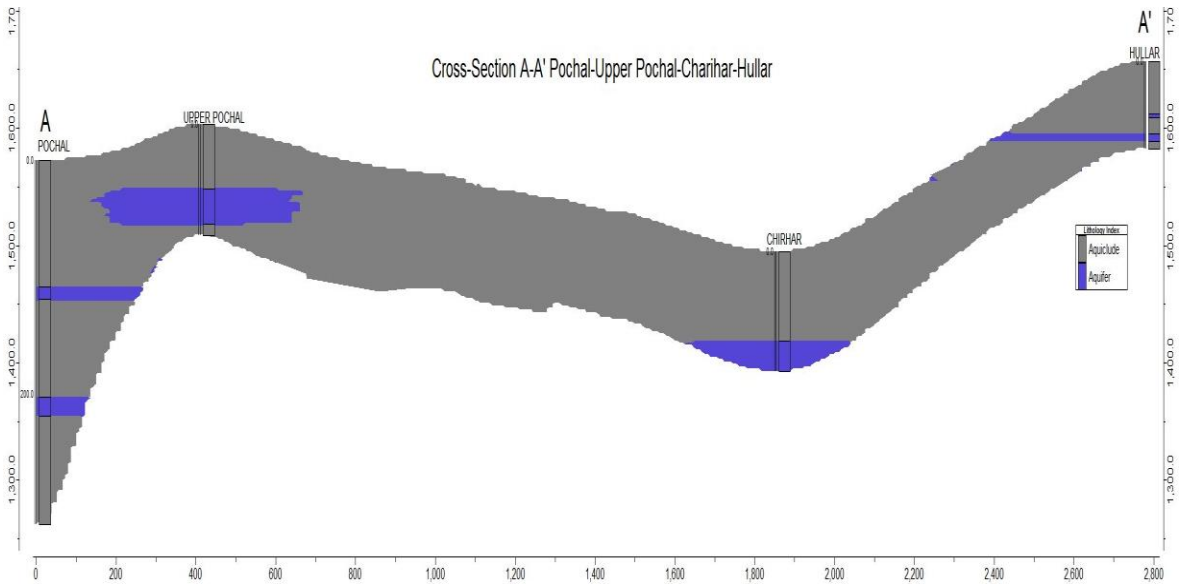

Figure 24: Cross Section between Pochal - Upper Pochal –Cheriar -Hullar

The cross section B-B' drawn from north-west to south-east along Brindaban - Kundali - Hatta near Jail - Sangram Bhatta -Sangram Bhatta near Petrol Pump- Kulid near FCI - Kishtwar Degree College – Kishtwar is depicted in figure 25. Brindaban lying at the extreme north-western edge of the section line is at the lowest elevation of 1416 m amsl. This well is drilled in Dul Quartzite and the weathered/fractured zone has been encountered at a depth of 60 m bgl. The handpumps installed at Kundali, Hatta and Sangram Bhatta located at similar elevations. At Kundali and Hatta near FCI the water bearing zones had been encountered at similar depths of 60 and 68 m bgl, seem to share same aquifer. At Sangram Bhatta the potential zone has been encountered at 44 m bgl. The well drilled at Sangram Bhatta near petrol pump has encountered a very thin weatherd zone at a depth of 43 m bgl. The well Kulid near FCI was drilled down to a depth of 66 m bgl where two fractured zones were encountered at 27 m and 73 m bgl respectively. The handpump drilled in the campus of Kishtwar Degree College that lies on a clay mound at an elevation of 1641 m amsl was drilled down to a depth of 91.46 m bgl, but did not hit any water bearing zone. In the well drilled at Kishtwar at 1610 m amsl water bearing zone was encountered at a depth of 45 m bgl.

This section depicts that the weathered fractured zone lies at different depths, revealing a discontinuous aquifer and the occurrence of ground water zones follow the topography, as the western edge of the plateau heads towards the steep slopes into Chenab River.

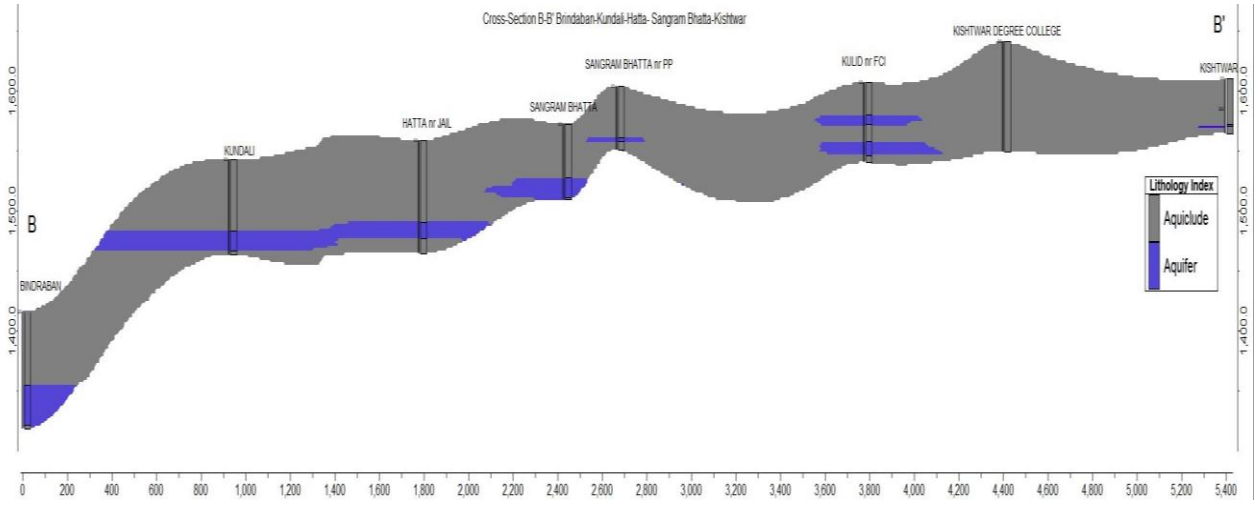

Figure 25: Cross Section between Brindaban – Kundali - Hatta near Jail - Sangram Bhatta - Sangram Bhatta near Petrol Pump- Kulid near FCI-Kishtwar Degree College - Kishtwar

The cross section C-C' drawn along Hullar- Berwar- Lach Khazana- Kulid near FCI- Kulid Chowk- Chogan- Tund- Hadyal (figure 26) from north to south depicts that the two extreme ends of Hullar in north and Hadyal in south are at mounds of 1657 and 1619 m elevations amsl. At both of these ends the water bearing zones are encountered at a depth of 45 m bgl. From both these end the slope is towards each other forming depression at the centre. The occurrence of aquifer is observed to follow the surface slope and at Berwar it is found to encounter at 24 m bgl. Lach Khazana in the centre and Tund towards Hadyal are depressions lying at elevetions of 1557 and 1553 m amsl respectively. At both of these depressions the first aquifers might have got eroded. There is no water bearing zone encountered at Lach Khazana and at Tund it was encountered at 49 m bgl. In the central part, at Kulid and Chogan the potential zones are encountered at shallower depths of 12 and 18 m bgl respectively.

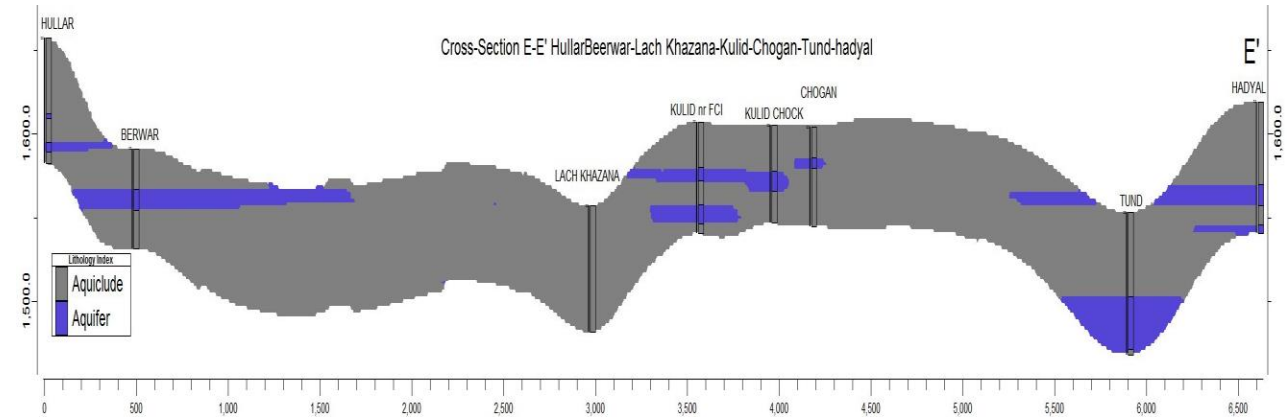

Figure 26: Cross Section between Hullar –Berwar -Lach Khazana –Chogan –Tund -Hadyal

Ground Water Resource Estimation

An attempt has been made to estimate the water availability of Kishtwar Plateau based on the limited available aquifer information. There are no dugwells or tubewells ever drilled in this area to be fixed for water level monitoring or draft estimation, required for estimating the ground water resources of the Plateau. The water supply for drinking purpose is met from the springs and nallas and irrigation is rainfed. The ground water occurs in the secondary porosity developed as weathering and fracturing of the rock formations underneath which is being tapped by construction of handpumps by the State Government. The saturated thickness of the aquifer is taken from the strata charts of these handpumps that are also used for preparation of aquifer maps.

The recommended values provided by norms of GEC 97 were used for the specific yield and rainfall infiltration factor for schist with significant clay content. The ground water availability is estimated by both the factors as below

As per GEC 97 norms, the specific yield of the schist with significant clay content is considered to calculate the aquifer potential of the plateau area.

Area of Plateau (A) = 20 sq. km or 2000 hectare meter
Average Saturated thickness of the aquifer (T) = 13.86 m
Specific Yield of Schist with Significant Clay Content (Sy) = 0.015

Net Ground Water Availability = A x T x Sy = 2000 x 13.86 x 0.015
= 415.877 ham.

The aquifer on the plateau area can hold the amount of 415.877 ham of ground water.

As per GEC 97 norms, the rainfall infiltration factor of the schist with significant clay content is considered to calculate the aquifer potential of the plateau area.
Area of Plateau (A) = 20 sq. km or 2000 hectare meter
Average Saturated thickness of the aquifer (T) = 13.86 m
RIF of Schist with Significant Clay Content (RIF) = 0.08
Net Ground Water Availability = A x T x RIF = 2000 x 13.86 x 0.08
= 2218. 015 ham.
The aquifer on the plateau area can hold the amount of 2218.015 ham of ground water.

ISSUES

Drinking water

The total requirement of drinking water of Kishtwar Plateau is: **16 lakh gallons/day. Present** water availability for water supply to the plateau area with Public Health Engineering Department is **8 lakh gallons/day**, i.e shortfall of another **8 lakh gallons/day.** The details of the available 8 lakh gallons per day is as under:

- Lahlla spring source located at a distance of about 2.5 Kms from Kishtwar suffice the requirement of **2.5 lakh gallons / day**
- HRT Shalimar, the Head Race tunnel of the Dul Hasti Hydro-electric Project fulfils the requirement by tapping it for **4 lakh gallons/day.**
- Naigad spring source located at a distance of 32 Kms from Kishtwar caters the requirement by providing **1.5 lakh gallons/day.**

Irrigation

Presently there is no irrigation infrastructure in Kishtwar Plateau area and all agriculture activity is rainfed.

Catchments of Spring

As per an earlier study, there were many springs on the Kishtwar Plateau and also on the higher elevations on its eastern hilly part. Some of these springs have either disappeared or their discharges have been reduced to a considerable amount due to encroachments/ alterations in their catchment areas.

Untapped Springs

The available spring sources are not tapped to their full extent. Even at HRT Shalimar, after lifting of 4 lakh gallons/day, much more discharge is flowing out of the HRT.

Iron in Ground Water

The results of chemical analysis of ground water samples indicate the presence of iron in it. The source of this iron is geogenic.

MANAGEMENT PLAN OF KISHTWAR PLATEAU

Drinking Water

The shortage of drinking water supplies of 8 lakh gallons/day can be met from the discharge available at Shalimar HRT, which will be economical also keeping in view its proximity to Kishtwar Plateau area.

Irrigation

keeping in view the climate of the area, irrigation facilities are required for only about two months i.e. from 15th May to 20th July, these can also be met from the HRT, where sufficient discharge is available and especially during the summer months wherein the discharge increases due to snowmelt.

Springs

Kishtwar Plateau area is not devoid of groundwater potentialities. It is highly probable that the high level springs viz. Kani Nag Spring, Chop Nal, Marhpiyar Nag, Kaisar Nag etc., are not tapping the entire flow in the vicinity. It seems some water is passing away as subsurface flow along the spring line where, another series of springs occur in the centre of the plateau, along north-west south-east direction. It is therefore, recommended to open up the orifice of the major springs like Marhpiyar by putting shallow trenches. These trenches are likely to provide greater infiltration surface and storage area. The water collected in these trenches may be distributed to different villages situated at lower level through pipes by gravity.

Gurdesh Nag which is a substantial source of water supply in the Kishtwar area needs further development. This particular source is not tapped to its full capacity. If properly and fully developed, this source alone can provide about 3 to 4 cusecs of water.

Protection of Catchments of Spring

The catchments of springs which have been encroached upon should be reclaimed and further strictly prohibited.

Geogenic Iron

The iron removal plants should be installed with the handpumps and tubewells drilled on the plateau.

Capacity Building

People should be made aware of water management practices, modern agricultural and irrigation techniques, changing climate etc.

Solid Waste Disposal/Land fill site

Such site should be decided in consultation of Central Ground Water Board, so that the quality of ground water does not get contaminated.

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ANNEXURE I

Monthly Average Rainfall and Temperature Data of Kishtwar

Month	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Rainfall in mm	130	126	151	108	68	45	86	75	71	38	25	71
Temperature Min ˚C	-0.1	1.7	6.3	11.0	5.4	18.0	19.0	18.4	15.7	10.6	5.3	2.3
Temperature Max ˚C	7.9	10.9	15.9	21.9	26.9	29.7	28.2	27.1	26.2	22.7	17.4	12.1

ANNEXURE II

Chemical Quality Data of Handpumps of Kishtwar Plateau.

S.No	Location	Longitude	Latitude	Date of collection	Temp °C	pH	Sp Cond ms/cm 25 °C	CO3	HCO3	Alkalinity	Cl	SO4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
1	L. Pucchal	75.73944	33.33833	19/09/2013	18	6.91	830	0	189	155	85	4	173	0.18	114	16	30	3	350	432	1.2
2	Hatta	75.7675	33.29083	20/09/2013	16	7.69	490		237	194	21	4	22	0.42	16	46	6	3	230	255	3.9
3	Bhara Matta	75.74889	33.31889	22/09/2013	16	7.21	400		208	170	7	19	12	0.55	26	30	7.2	3	190	208	1.1
4	Brindaban	75.735	33.34833	22/09/2013	17	7.5	350		171	140	14	29	0	0.4	28	22	11	5.4	160	182	6.8
5	Kulid	75.76194	33.32333	21/09/2013	15	7.78	470		171	140	14	72	6	0.85	14	41	12	7	205	244	1.2

Chemical Quality Data of Springs of Kishtwar Plateau.

S.No	Location	Longitude	Latitude	Date of collection	Temp °C	pH	Sp Cond ms/cm 25 °C	CO3	HCO3	Alkalinity	Cl	SO4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
1	K. Pucchal	75.74444	36.34639	19/09/2013	16	7.12	500		171	140	28	2	76	0.46	48	26	7	3	225	260	0.6
2	Sangrambhata	75.75528	36.33417	20/09/2013	16	7.18	450		220	180	28	4	21	0.18	16	44	9	1	220	234	0.7
3	Semma Colony	75.77194	36.0125	21/09/2013	18	7.86	160		79	65	14	22	2	0.2	22	12	1.2	1.21	105	83	0.7
4	Hudri	75.76278	36.00694	23/09/2013	17	7.45	650		104	85	64	50	141	0.26	44	39	29	6	270	338	0.6
5	Hullar	75.765	36.50639	23/09/2013	16	7.59	500		134	110	18	119	3	0.51	46	29	9	5.3	235	260	0.5
6	Chehriar	75.75139	36.51083	23/09/2013	19	7.71	330		165	135	14	21	0	0.35	26	32	12	4.6	145	172	1.2
7	Bimarang	75.75778	36.00944	22/09/2013	18	7.36	450		201	165	25	4	30	0.42	18	41	6	0.3	210	234	0.7

ANNEXURE III

List of VES locations carried out at Kishtwar Plateau.

S. No.	Location	District	Date	Latitude	Longitude
1.	AKHAR (Duggah)	Kishtwar	14/10/2014	33°20'43"	75°45'10"
2.	BERWAR	Kishtwar	14/10/2014	33°21'09"	75°45'40"
3.	BINDRABAN	Kishtwar	15/10/2014	33°20'58"	75°44'30"
4.	UPPER PUCHAL	Kishtwar	15/10/2014	33°20'25"	75°44'35"
5.	HATTA PUCHAL	Kishtwar	16/10/2014	33°19'48"	75°44'58"
6.	ZELNA	Kishtwar	16/10/2014	33°19'52"	75°45'41"
7.	SANGRAM BHATTA	Kishtwar	16/10/2014	33°20'40"	75°45'34"
8.	CHOGAN	Kishtwar	17/10/2014	33°19'19"	75°45'29"
9.	HADIYAL	Kishtwar	17/10/2014	33°18'51"	75°45'31"
10.	TUND	Kishtwar	17/10/2014	33°18'13"	75°45'31"

ANNEXURE IV

List of Tubewells and Handpumps used for Aquifer Mapping Study.

BORE	LONGITUDE	LATITUDE	TOTAL DEPTH	ELEVATION
BAGHANA	75.75417	33.325	90.21	1590
BINDRABAN	75.74083	33.35417	97.56	1416
CHIRHAR	75.75306	33.35083	102.13	1495
HADYAL	75.76167	33.29944	78.67	1619
HATTA	75.75	33.3325	108.23	1609
KISHTWAR	75.76806	33.31278	45.41	1610
KUNDALI	75.74444	33.34639	79.26	1543
LACH KHAZANA	75.76389	33.33194	75.54	1557
LOWER POCHAL	75.74222	33.33833	77.97	1573
MATTA	75.75361	33.32083	54.87	1609
POCHAL	75.74306	33.33639	310.50	1573
SANGRAM BHATTA	75.75528	33.33667	62.45	1572
SARKOOT	75.75444	33.32639	57.00	1590
SARKOOT TALAB	75.75361	33.32444	79.27	1589
TUND	75.76194	33.30583	85.02	1553
UPPER POCHAL	75.74556	33.33944	94.20	1603
WASSAR	75.74306	33.32583	100.60	1599
KULID nr FCI	75.76333	33.32667	66.67	1607
KULID CHOCK	75.76167	33.32333	58.32	1605
SANGRAM BHATTA nr PP	75.75722	33.33528	53.37	1604
ZALANA	75.75889	33.32889	82.31	1581
BERWAR	75.76028	33.35417	59.45	1591
HATTA nr JAIL	75.75167	33.34167	94.5	1559
HULLAR	75.75806	33.35806	74.69	1657
WASSAR nr TEMPLE	75.74222	33.32806	57.93	1530
CHOGAN	75.76167	33.32139	59.45	1604
KISHTWAR DEGREE COLLEGE	75.76639	33.32167	91.46	1641