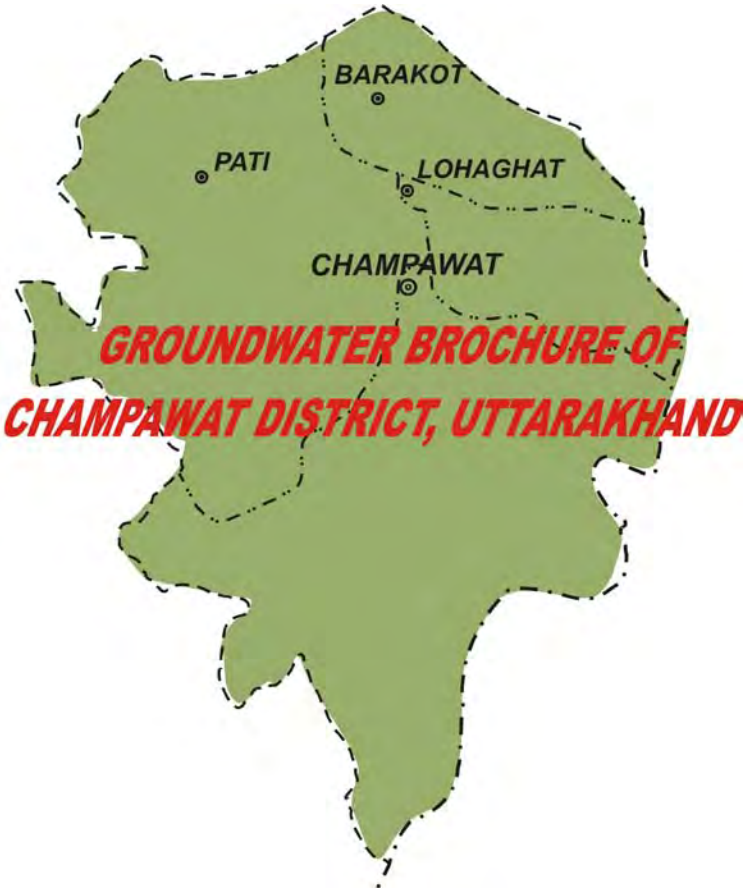
For Restricted/Official Use only

Government of India
Ministry of Water Resources
Central Ground Water Board



GROUNDWATER BROCHURE OF CHAMPAWAT DISTRICT, UTTARAKHAND

Uttaranchal Region *May 2009* *Dehradun*

GROUNDWATER BROCHURE, CHAMPAWAT DISTRICT
CHAMPAWAT DISTRICT AT A GLANCE

S.No	Items	Statistics
1	**GENERAL INFORMATION**	
	(i) Geographical area (Sq km)	1955.26
	(ii) Population (as on 2001 census)	224542
	(iii) Average Annual Rainfall (mm)	1085.62
	(iv) Annual Rainfall (mm) for the year 2007	1747.00
2	**GEOMORPHOLOGY**	
	Major physiographic units	High denudational mountains, river valleys and Bhabar zone.
	Major drainage	Ladhiya, Sarju, Kali river and tributaries like Lohawathi, Panar, Ratiya, Gandhak etc.
3	**LAND USE (ha)**	238636
	(a) Forest	122200
	(b) Net Sown area	27362
	(c) Area Sown more than once	17206
	(d) Cultivable Barren area	15273
4	**MAJOR SOIL TYPES**	Dystric Eutrochrepts, Typic Udorthents, Lithic Udorthents, Typic Dystrochrepts
5	**AREA UNDER PRINCIPAL CROPS (ha)**	54359.0
6	**IRRIGATION BY DIFFERENT SOURCES** (numbers of structures and area)	Hydrums: 12 Hauz: 349 Guls: 235
	Tube wells/bore wells	Deep TW: 06, Shallow TW: 628
	Tube wells/bore wells (Govt.)	12/728
	Tanks/Ponds (ha)	488
	Canals (Length km)/irrigated area (ha)	229.7/759
	Other sources	196
	Net Irrigated area (ha)	2171
	Gross Irrigated area (ha)	3541
7	**NOS OF GROUNDWATER MONITORING WELLS OF CGWB**	
	No. of Dug wells	One (Tanakpur)
	No. of Hand Pumps	Two (Banbasa and Bastia)
	No. of Piezometers	Nil
8	**PREDOMINANT GEOLOGICAL FORMATIONS**	Rocks of Siwalik Group, Ramgarh Group, Almora Group, and Bhabar formation.
9	**HYDROGEOLOGY**	
	Major water bearing formations	Weathered rocks of Siwalik Group, Ramgarh Group, Almora Group, and Bhabar formation.

	Depth to Water Level Range: Pre-monsoon: (2007) m bgl Post-monsoon: (2007) m bgl	(Different hydrogeological terrain) 5.48 to 73.78 m bgl 4.63 to 71.26 m bgl
10	**GROUNDWATER EXPLORATION BY CGWB (As on 31/03/2008)**	
	No. of wells drilled (EW, OW, PZ, SH, Total)	Six EW-02 (Tanakpur, Chandni), OW-02, (Abandoned-02)
	Depth Range (m)	74.98 to 88.39
	Discharge (lpm)	2683 to 3100
	Transmissivity (m^2/day)	7484 to 14140
11	**GROUNDWATER QUALITY**	Overall Groundwater quality is good for domestic and irrigation purpose.
	Presence of Chemical constituents more than permissible limit	All the parameters well within the permissible limits.
12	**DYNAMIC GROUNDWATER RESOURCES (2004) in MCM**	The water resources could not be estimated as the groundwater table is not continuous and groundwater abstraction is mainly done through hand pumps.
	Annual Replenishable Ground water Resources	--
	Net Annual Groundwater Draft	--
	Projected demand for domestic and industrial uses up to 2005	--
	Stage of Groundwater Development	--
13	**AWARENESS AND TRAINING ACTIVITY**	--
	Mass Awareness Programmes Organized	Not yet organized
	Water Management Training Programmes Organized	Not yet organized
14	**EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING**	14 Nos, undertaken by Social Welfare Research Centre (SWRC), Champawat, constructed Rooftop rainwater storage tanks in the premises of Govt. Primary Schools in the vicinity of Chalthi Village, Champawat Bock.
	Projects completed by CGWB (No. & amount spent)	Nil
	Projects under technical guidance of CGWB (Numbers)	14
15	**MAJOR GROUNDWATER PROBLEMS AND ISSUES**	There is no groundwater problem and issues except the shortage of water in villages situated at higher reaches. Proper management of springs is required, as they are main source of water for all uses.

DISTRICT GROUNDWATER BROCHURE
CHAMPAWAT DISTRICT, UTTARAKHAND

1.0 INTRODUCTION

Champawat district is situated in the Kumaon Division, and lies in the eastern part of Uttarakhand. Earlier, it was a part of Pithoragarh district and was separated created when the Uttarakhand State was formed. Champawat district covering an area of about 1955.26 sq. km, lies between Latitude 28º 58' 00" and 29º 31' 00" North and Longitude 79° 46' 00" and 80º 16' 30" East, falling in Survey of India (SOI) Toposheet Nos.53O, 62C and D. The district is bounded by Pithoragarh district in the north, Nainital and Almora in the west, Udham Singh Nagar on the south and Nepal on the east; river Sarda forms the International boundary. District Champawat plays an important role from strategic point of view as it shares international boundary with Nepal. Trading and commerce between Nepal and Champawat takes place on daily basis.

Champawat district's head quarter situated at Champawat town. For the administrative convenience the district is divided into four developmental blocks viz. Champawat, Barakot, Pati and Lohaghat and three tehsils viz. Barakot, Champawat and Lohaghat. It is approachable from Dehradun via Hardwar and Udham Singh Nagar through motorable metalled road (NH-74). Rail links are available in the district up to Tanakpur. The total population of the district is 224542, out of which the male and female population is 111084 and 113458, respectively (Census, 2001). The population density is 171 persons/ km^2 and the male, female sex ratio is 1000:979. The overall literacy rate is 68.64%. The administrative map including drainage of District Champawat is given in **Fig 1** and the details of the blocks are given in **Table 1**.

Table1. Details of the developmental blocks, District Champawat, Uttarakhand

Sl. No	**Name Block**	**Reported Area (km^2)**	**Name of Tehsil**	**No. of Villages**	**No. of Towns**
1	Pati	244.0	Barakot	717	2
2	Barakot	181.0			
3	Lohaghat	216.0	Lohaghat		1
4	Champawat	471.16	Champawat		1
Forest		831.65			
Urban area		11.45			
Total		**1955.26**			

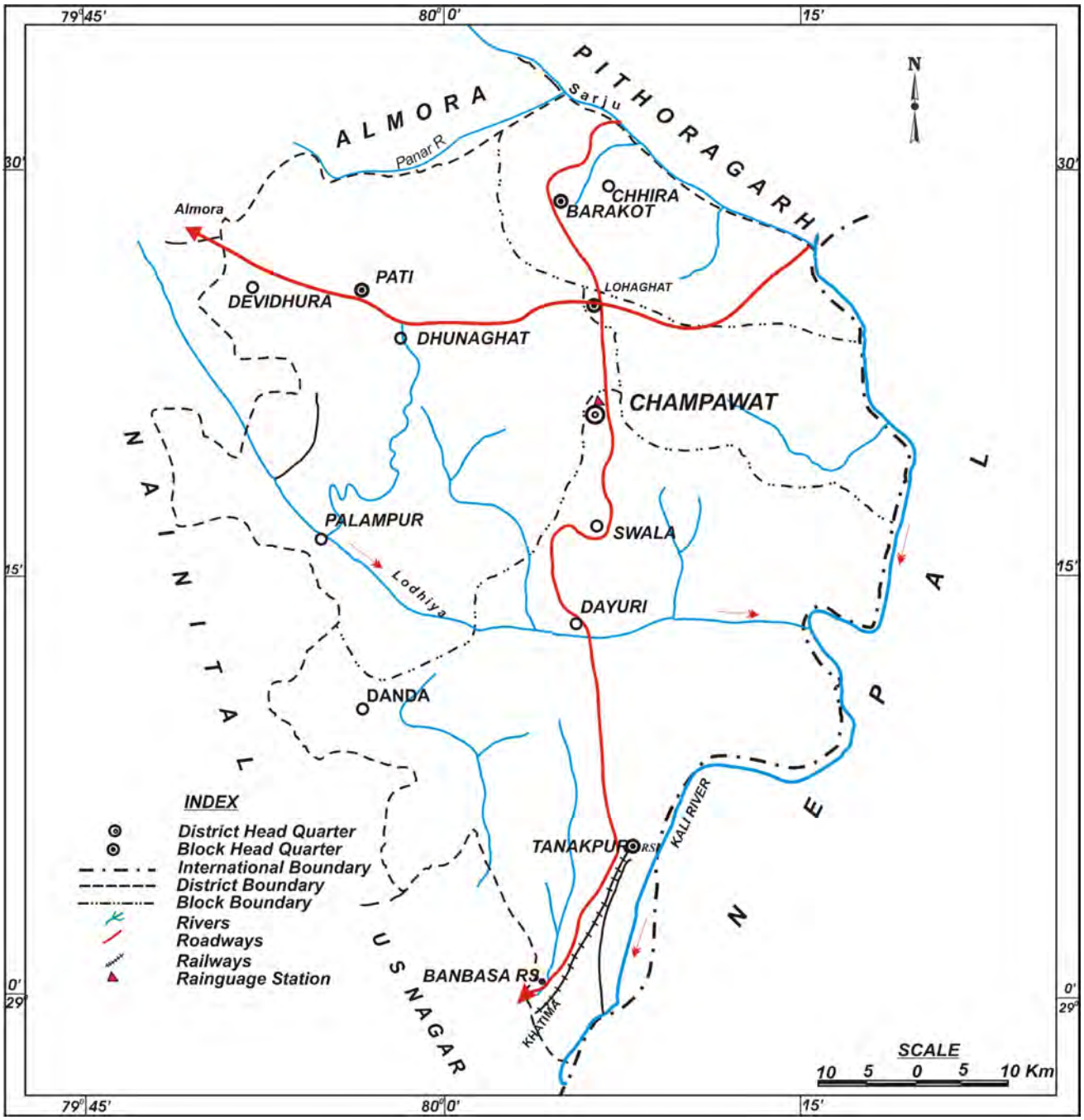


Fig. 1 Administrative map of District Champawat, Uttarakhand

The officers of Central Ground Water Board (CGWB), Northern Region, Lucknow carried out Reappraisal Hydrogeological Studies (RHS) during the early nineties, the then district Champawat was part of District Pithoragarh. District Groundwater Management Studies (DGWMS) were carried out during the AAP (2007 – 08). Central Ground Water Board has constructed six exploratory tubewells, out of them; Tanakpur and Chandni are the most productive in the Bhabars and two tubewells were abandoned due to some technical problems.

DRAINAGE: Ladhiya, Sarju, Kali/Sarda River and their tributaries like Lohawathi drain the district. Prominent of the tributaries are Panar, Ratiya, Gandhak and Lohawathi apart from major gad/gadheras like Nanathira, Lateshwar, Amkhadiaya, Goli, Quareli, Bardholi, and some local gadheras. The main drainage patterns are dendritic, sub-dendritic, trellis, sub-rectangular. The major rivers i.e. Ladhiya and Sarda are of antecedent type, whereas the drainage in the structurally disturbed area is of subsequent type.

CROPPING PATTERN: Agriculture is the main occupation of the people. The agricultural activities are restricted to river terraces, gentle hill slopes and intermontane valleys. The southern portion of the district comprises of Bhabar formation, which is bouldary formation. Probably because of this reason, the agricultural activities are intensive in this part. The major crops are rice, wheat, maize, mandua, potato, pulses, millets and seasonal vegetables etc. The net sown area, in the district, is 27362 ha, out of which 17206 ha is sown more than once in a year. The gross sown area is 44480 ha. Out of which 26936 and 17544 ha are covered under Khariff and Rabi, respectively.

IRRIGATION: The sources of irrigation are springs, gad, gadheras and rivers in the hilly terrain. Groundwater is the main source in the southern part of the district. The groundwater is developed through tube wells and hand pumps apart from dug wells. The spring water, which, flows through the gads and gadheras, is diverted to small canals and guls by the minor irrigation department, thus catering the needs of irrigation and agriculture in the district. In areas where sources, for minor irrigation, aren't available lift irrigation like hydrums are in practiced. There are 12 hydrum (surface lift-irrigation) units are catering irrigation needs in the study area. The total length of the canals (Minor Irrigation) in district is 229.7 km. Maximum length of the canals is in Champawat block, running 119.18 km. 759 ha area is irrigated through canals. The net irrigated and gross irrigated area, in the district, is 2171 and 3541 ha, respectively.

2.0 CLIMATE AND RAINFAL

The climate varies from Sub-tropical monsoon type (mild winter, hot summer) to tropical upland type (mild winter, dry winter, short warm summer). Severe winter and comparatively higher rainfall are the characteristic features of the northern part. The year may be divided into four seasons viz. the cold winter season, (December to February), the hot weather

season (March to May), southwest monsoon season (June to September) followed by post monsoon season (October to November). Larger part of the district is situated on the southern slopes of the outer Himalayas, monsoon currents can penetrate through trenched valleys, and the rainfall reaches its maximal in the monsoon season that occur between June to September. Rainfall, spatially, is highly variable depending upon the altitude. In the Lesser Himalayan Zone (1000-3000 m above mean sea level) maximum rainfall occurs about 70 to 80% in southern half. July and August are the rainiest months. Rainfall rapidly decreases after September and it is the least during November. The overall average annual rainfall in district Champawat is 1085.62 mm. The annual rainfall in the district for the year 2007 is 1747 mm.

3.0 GEOMORPHOLOGY AND SOIL TYPE

Champawat district is represented by highly rugged topography. It may be divided into three major Units the high Denudational Mountains, river valleys and the plains. The southern part of the district is comprised of Siwalik Group of rocks. It has a comparatively wide and mature topography with gentle slopes. Besides, morainous plains, river terraces, structural valleys, lineament, fault and thrusts are the other geomorphic units commonly observed in Champawat district. The geomorphology of an area plays a very significant role in the groundwater movement and occurrence. The hydrogeomorphological aspects, based on interpretation of IRS-IA & Land Sat TM imagery with field check, prepared by Remote Sensing Application Centre, Lucknow is shown in **Fig 2** and the detail of geomorphic units and lithostratigraphy are given in **Table 2**.

The soil types are controlled by the topography and rock types. The soils, on the fluvial valleys, moderately deep, well drained fine loamy soils with loamy surface with slight erosion. The soils occurring on the cliffs side are very shallow, excessively drained, whereas the soils on the Summits and Ridges moderately shallow, excessively drained, coarse loamy soils with loamy surface and moderate association. Soils occurring in the Lesser Himalayan range are moderately shallow, somewhat excessively drained, thermic, loamy skeletal soils on moderately steep slopes with loamy surface, moderate erosion. The Lesser Himalayan range is mainly composed of highly compressed and altered rocks like granite, phyllites, quartzite etc. and a major part of it is under forest. Intermittent sparse patchy terraced cultivation is also practiced on fairly steep hill slopes whereas dry and wet cultivation are prevalent on the uplands and low-lying valleys respectively. The broader valley slopes dominantly deep, well drained, fine-loamy, moderately acidic and slightly stony

Fig 2. Geomorphological Map of Champawat District, Uttarakhand

4.0 *GROUNDWATER SCENARIO*

4.1 GEOLOGY

Geologically, district Champawat comprises of diverse rock types. The geological set up is very complex due to the repeated tectonic disturbances caused by different orogenic cycles. Valdiya (1980) carried out extensive geological and structural mapping in the area. The salient features of geology are depicted in the geological map of the Champawat district (**Fig 3**). The rock succession exposed in the district mainly falls in two groups namely, Ramgarh and Almora Group of rocks apart from the Siwalik Group of Tertiary rocks at the

southern side of the district, which is Late Tertiary to Quarternary, exposed all along the foothill belt of the Sub-Himalaya.

The Ramgarh Group is separated by the Main Boundary Fault (MBF) from Siwaliks, which consists of Bhimtal, Bhamdoli, Maula and Swala Formations. The rock types of Ramgarh Group are purple to pale green quartzite with interbeds of greenish grey phyllite, Metavolcanic rocks, streaky gneiss, chlorite schist with sericitic quartzite and metabasites, schistose quartzite and limestone with calc-phyllites. The Almora Group consists of Salla, Gorakhnath, Gumalikheth formations along with the Champawat granodiorite. The major rock types are pale green to cream coloured quartzite with chlorite schist, phyllite, metabasitic rocks, garnetiferous biotite mica schist with interbeds of quartzite, augen gneiss with paragneisses and few orthogniessic interbands, black carbonaceous phyllite alternating with black fine grained, biotite-rich greywacke, garnetiferous mica schist and micaeous flaggy quartzites. The grade of metamorphism increases from south to north. The Garhwal Group of rocks exposed extreme northern part of district (Pithoragarh district).

4.2 HYDROGEOLOGY

Groundwater is the primary source of water supply in the district for drinking as well as agriculture purpose. Groundwater in the major part of the district occurs as localized, disconnected aquifer bodies under favourable geohydrological conditions such as in channel and alluvial terraces of river valleys, joints, fractures and fissures of crystallines and metasedimentary rocks. The occurrence and movement of groundwater depend not only on the nature of the litho units and the nature of the interspaces, but also on the degree of interconnection between them, the vertical and aerial extension of joints, faults and shear zones and the local and regional geomorphology. Groundwater emergences as springs and seepages under favourable physiographic conditions such as in gently sloping areas, broad valleys of river sand along the lithological contacts.

4.2.1 HARD ROCK: Rainfall is the principal source of the groundwater replenishment. Champawat district receives very good amount of rainfall, which in filtrates into ground through soil and plants, some considerable part of the precipitation flows as surface runoff, some apart from in the form of evapotranspiration. The aquifers occur within Ramgarh, Almora and parts of Siwalik Group as localised and disconnected water bodies. Groundwater in these areas occurs generally under unconfined to semi-confined conditions in the sedimentary and low-grade metamorphic rocks. Aquifer characteristics are not available in this area, as no pumping tests have been carried out so far. However, a study of

the springs indicates that in general, the yield is low and varies from 1 to 15 lpm. The occurrence of springs is a natural phenomenon in the district Champawat. The moving groundwater surfaces out as springs at the contacts of different rock types through joints/fractures etc. the topographical breaks also are the favourable location for spring formations. Various aspects of the springs, geological formation, are summarised in **Table 3.** The springs are located on roadside slopes and their discharge during pre-monsoon and post monsoon period ranges from 2 to 12 lpm and from 3 to 15 lpm respectively. The temperature of spring water varies in pre-monsoon and post monsoon from 13 to 16°C and from 10 to 15°C respectively. The seasonal fluctuation, in the springs ranges from 1.0 to 3.0 lpm respectively. The locations of the springs and hand pumps are shown in the Hydrogeological map of Champawat district in **Fig 4**. The discharge and temperature of the springs fluctuate throughout the year depending upon its recharge and discharge factor. During the rains the favourable hydrogeological structures get recharged and resulting in higher discharge of spring and gadheras after monsoons. During the post-monsoon period their discharge reduces gradually with time and space, thus, gets minimum in pre-monsoon period. In general, the cold-water springs are of gravitational type, and are not deep seated as in the case of hot/thermal springs. The springs have been developed for drinking and irrigation water supplies. The groundwater budgeting (water resources) in the hilly terrain is not possible due to slope more than 20%, rugged topography and hydrogeological discontinuity.

Table 3. Spring discharge and Seasonal fluctuation, district Champawat (Period, 2007)

S. No	**Geological Formation**	**No of Springs**	**Discharge (lpm)**				**Range of seasonal Fluctuation (2007) in lpm**
			Pre-monsoon (2007)		**Post-monsoon (2007)**		
			Min	**Max**	**Min**	**Max**	
1	Siwalik Group	1	4.5	6.0	6.0	8.0	1.5 – 2.0
2	Ramgarh Group	2	6.0	12.0	8.0	13.0	2.0 – 1.0
3	Almora Group	10	2.0	12.0	3.0	15.0	1.0 – 3.0

Barring the alluvial deposits along the river courses and flood plains, entire area of district Champawat is covered by hard rocks. The main rock types are quartzites, phyllites, gneisses of varying degree of metamorphism along with granite intrusive and metabasics. The topography is highly undulating and geological formations are moderately to steeply dipping. Due to frequent undulations of high magnitude a continuous water table doesn't exist. Whenever, permeable formation overlies an impermeable one, the water table exists,

and its extension depends upon the aquifer and topography relation. Hand pumps have been installed by Uttarakhand Jal Nigam, Pey Jal Nigam and Jal Sansthan all along the road sides wherever is feasible. Pre monsoon and post monsoon water levels and other aspects of the hand pumps are summarised, geological formations wise, in **Table 4**. A perusal of **Fig. 3** reveals that the Maximum number of hand pumps is constructed in the Almora Group of formations. Overall, in the hard rock terrain, the depth of the hand pumps ranges from 39.63 to 88.40 m bgl. The pre-monsoon and post-monsoon depth to water level range from 4.04 to 91.43 m bgl and from 3.64 to 88.43 m bgl respectively, the seasonal fluctuations ranges from 0.40 to 3.00 m, and are tabulated in **Table 5**.

Table 4. Total depth and discharge of hand pumps, district Champawat (Period, 2007)

S. No	Geological Formation	No of Hand Pumps	Total Depth (m)		Discharge (lpm)	
			Min	Max	Min	Max
1	Siwalik Group	9	39.63	81.20	24.00	42.00
2	Ramgarh Group	3	73.00	88.40	18.00	28.00
3	Almora Group	41	25.50	98.20	20.00	38.00

Table 5. Depth to water and Seasonal fluctuation, district Champawat (Period, 2007)

S. No	Geological Formation	No of Hand Pumps	Depth to water (m bgl)				Range of seasonal Fluctuation (2007) in mts
			Pre-monsoon (2007)		Post-monsoon (2007)		
			Min	Max	Min	Max	
1	Siwalik Group	9	5.48	32.28	4.63	31.06	0.85 – 1.22
2	Ramgarh Group	3	6.53	73.78	5.12	71.26	1.41 – 2.52
3	Almora Group	41	4.04	91.43	3.64	88.43	0.40 – 3.00

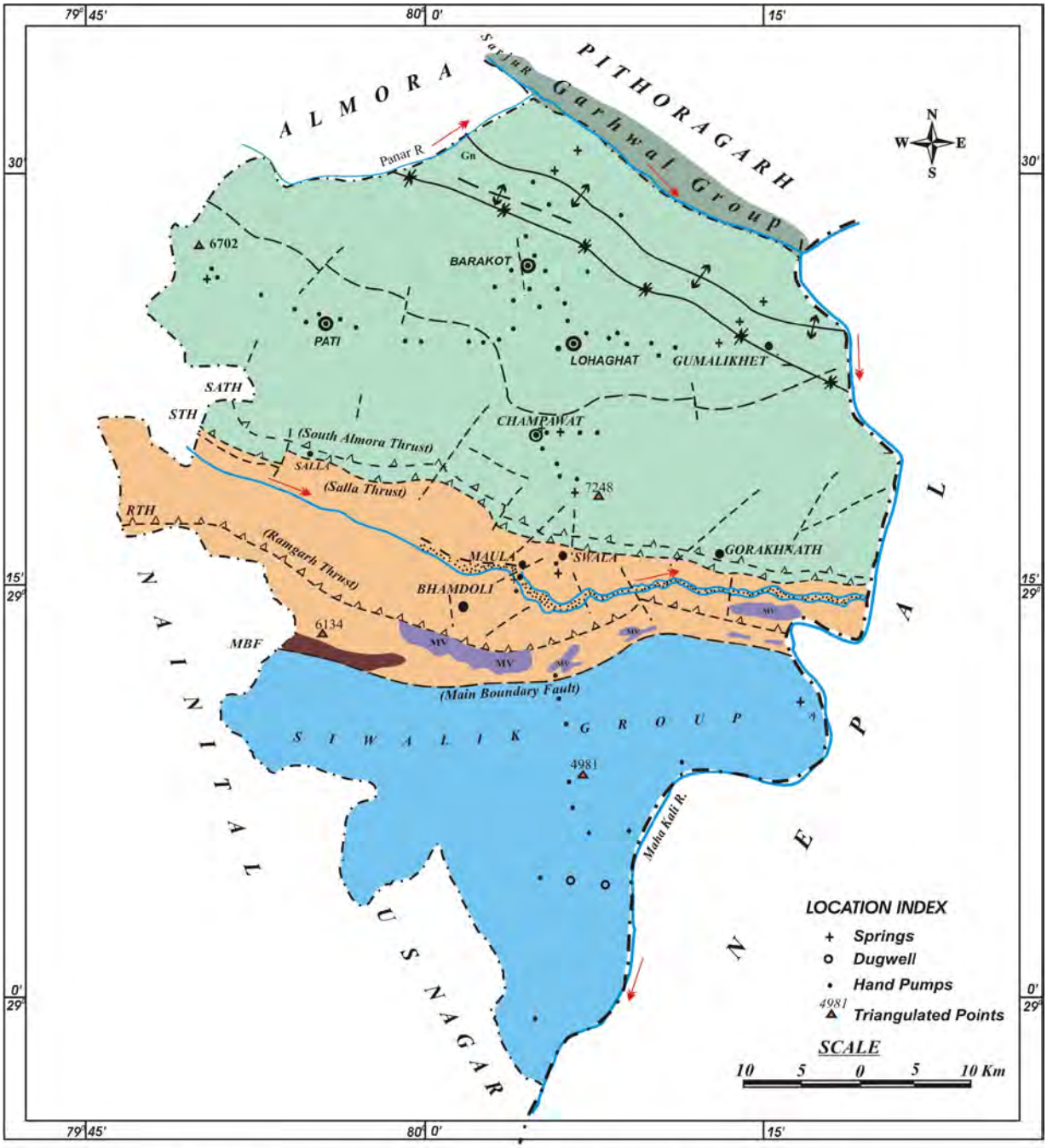
4.2.2 ALLUVIUM: Alluvium occurs along the river courses and in their flood plains. The alluvial deposits are generally thinner than the hard rocks. These are unconsolidated deposits. Alluvium mainly consists of sand, gravel, silt and clay. At places, big boulders are buried within the alluvium. The alluvial thickness is more where the valleys are broad and ground slope is gentle such as Champawat Khethikhan and Karankaryat valleys. The alluvium is both porous and permeable and hence suitable for groundwater development. In alluvial formation, groundwater occurs in the valley fill deposits, terraces, river terraces and weathered rock cover and in moraines and glacial deposits. On the hill slope groundwater

mostly occurs in the form of seepages, springs and gadheras under gravity and favourable geological structures intercepting the topography.

The Bhahbar Formation is exposed in the southern part of the district. It is essentially constituted of alluvial deposits lying on the sloping plains in the Himalayan foothills, exposed immediately south of the Siwaliks. Primarily it consists of unconsolidated sediments like sand, gravel, boulder and clays. Groundwater in these areas occurs generally under unconfined to confined conditions. The aquifer is continuous and homogenous compared to hilly terrain. In general, the water levels are deeper in Bhabars, compared to the Tarai formations, further south of the district; however, it is out of the study area. Thus, overall in the district, there is no homogenous aquifer system having wide aerial extent. In the hilly part groundwater occurs along the thrust plains, strike slip fault/normal fault plains, tensile joints, synclinal folds, tensile fractures and at the contact of two different rock formations etc. The pre monsoon and post monsoon water levels in hand pumps, ranges from 5.48 to 32.28 m bgl and 4.63 to 31.06 m bgl respectively. The seasonal fluctuation range from 0.85 to 1.22 m, and is mentioned in **Table 5**. The depth to water levels of two dug well for pre monsoon and post monsoon ranges from 7.13 to 11.43 m bgl and from 6.83 to 10.96 m bgl respectively. The seasonal fluctuation ranges from 0.30 to 0.47 m. The discharge of two exploratory well at Tanakpur and Chandni are 2683 and 3100 lpm respectively with drawdown 9.68 and 3.94 m. The aquifer characteristics i.e. Transmissivity ranges from 7484 to 14140 m^2/day, hydraulic conductivity ranges from 32.94 to 171.8 m/day and field permeability is 119. 8 to 175.2 m/ m^2/day. The groundwater is developed through tube wells, hand pumps and dug wells. The groundwater resource estimation could not be carried out as the area is hilly (with slope >20%) and in major part aquifers are small, isolated bodies).

4.3.3 GROUNDWATER MONITORING WELLS (GWMW):

Central Ground Water Board (CGWB), Uttaranchal Region, Dehradun has established three groundwater monitoring wells (Tanakpur -DW, Banbasa – HP and Bastia – HP) in the entire district tapping the shallow aquifers and restricted to Bhabhars only. The depth to water level in the pre monsoon and post monsoon ranges from 5.43 to 29.90 m bgl and from 3.16 to 20.61 m bgl, respectively in hand pumps. The fluctuation in hand pumps ranges from 2.27 to 9.29 m. The Depth to water (DTW) in dug well pre and post monsoon ranges from 11.43 to 8.71 m bgl.



Symbol	Group/Formation	Groundwater Potential (Hand Pumps Discharge) (Pre-monsoon, 2007) Min	Max	(Post-monsoon, 2007) Min	Max	(Springs Discharge) (Pre-monsoon, 2007) Min	Max	(Post-monsoon, 2007) Min	Max
	Siwalik Group	5.48	32.28	4.63	31.06	4.5	6.0	4.5	6.0
	Ramgarh Group	6.53	73.78	5.12	71.26	6.0	12.0	8.0	13.0
	Almora Group	4.04	91.43	3.64	88.43	2.0	12.0	3.0	15.0

Main Boundary Fault (MBF)
South Almora Thrust (NAT)
Ramgarh Thrust (RTH)/ Salla Thrust
Trace of axial plane of syncline
Trac e of axial plane of anticline

Fig 4. Hydrogeological Map of Champawat District, Uttarakhand

4.3 GROUNDWATER RESOURCES

The groundwater resource estimation could not be carried out as the area is hilly (with slope >20%) and in major part aquifers are small, isolated bodies, and groundwater abstraction is done mainly through hand pumps and springs with almost negligible discharges. Hence large-scale Groundwater development could not be possible in the Champawat district.

4.4 GROUNDWATER QUALITY

The variations of different chemical parameter, in District Champawat, are as given in **Table 6**. Overall, the water quality in the district is fresh and potable.

Table 6. Range of different chemical parameters, District Champawat

Parameter	Hand Pumps	Springs
Electrical Conductivity	96-745 µmohos	127-222
pH	7.38 - 8.25	7.69-8.24
Calcium	6-76 mg/l	16-36
Magnesium	3.6-28.0 mg/l	4.9-7.3
Bicarbonate	49-250 mg/l	61-134
Chloride	3.5-67 mg/l	5.3-8.9
Total Hardness as $CaCO_3$	30-260 mg/l	70-110

5.0 GROUNDWATER MANAGEMENT STRATEGY

5.1 GROUNDWATER DEVELOPMENT

Taking into consideration the extremely rugged topography in major parts of the district, it is not feasible to go for a large-scale groundwater development in Champawat district. However, at lower reaches (southern side of the district), there is scope of groundwater development through tube wells and hand pumps. For this, hydrogeological investigation is required at micro-level so as to decipher the water bearing rock formations, which has sufficient secondary porosity like joints, fractures, lineaments etc. These discontinuous aquifers along with favorable physiographical set-up can help to develop groundwater by hand pumps. The promising areas for the development of groundwater resources are the

relatively broad river valleys such as Champawat, Khethikhan, Karankarayt and Lohaghat besides the plain area of Tanakpur vicinity.

Besides, hand pumps, there are number of natural springs, which can be utilized to cater the need for drinking and irrigation. There are numerous springs with sufficient discharge; the water of these springs can be channelized for irrigation. During non-monsoon period, the discharge of springs gets reduced. To augment the discharge and sustainability of these springs, small surface water reservoir can be developed at suitable locations on higher level. The reservoir can be developed by constructing gully plugs, check dams, gabion structures etc. at suitable places. These reservoirs will not only provide surface water availability but will also help in recharging the aquifers. Groundwater may be developed in valley areas like Champawat, Khethikhan, Karankaryat and Lohaghat by constructing large diameter dug wells and shallow tube wells. The large diameter dug wells and shallow tube wells will be able to sustain the discharges between 200 to 700 lpm.

5.2 WATER CONSERVATION AND ARTIFICIAL RECHARGE

Groundwater, in the area, is mainly developed through hand pumps. The area replenishing the hand pumps should be identified precisely all along the valleys portion. Suitable groundwater recharge structures like gully plugs, check dams, gabion structures etc. can be constructed so that the yield of the hand pump is sustained throughout the year.

Further, groundwater is also developed naturally through springs. It oozes out in the under gravity and favourable geological structures/formations intercepting the topography. Basically *spring* is a localized natural discharge of groundwater issuing on the land surface through outlets. The discharge of spring may vary from a trickle to as big as a stream. Rain water harvesting structures like gully plugs, check dams, gabion structures etc. may be constructed in the nearby vicinity of the springs and *naolas* having negligible to low discharges.

Social Welfare Research Centre (SWRC), a Non Governmental Organization, Champawat has constructed 14 numbers of Rooftop rainwater harvesting water storage tanks under the technical guidance of Central Ground Water Board, Dehradun sanctioned by the Ministry of Water Resources, New Delhi. The water storage capacity of these structures ranges from 37000 to 42000 litre. The same are constructed in the remote areas of Chalthi village vicinity, executed them in the premises of primary schools, which are very useful in the lean period when there is acute shortage of water.

6.0 GROUNDWATER RELATED ISSUES AND PROBLEMS

There are some local problems in the study area

1. There is scarcity of safe drinking water in some of the villages in the study area. It is mainly unavailability of the hand pumps and springs nearby. This problem can be solved either by installing hand pumps in feasible areas or storing the rainwater in storage tanks and harnessing the surplus monsoon runoff through small check dams and/or gully plugs in suitable areas. Adopting the Low Density Poly Ethylene (LDPE) technological water storage tanks are more attractive as the system of rainwater harvesting in the hilly areas has proved cost-effective and eco-friendly.

2. Poor quality of water coming out of some of the hand pumps (India Mark –II), installed recently by Uttarakhand Jal Sansthan. The quality problem is mainly because of the color (yellowish brown) and bitter taste, indicating that the water has very high iron content. Putting an iron filter unit with the outlet of the hand pump can solve the problem. The filter unit consists of a filter plant and valve for flushing out the residue/precipitate. The iron content is groundwater is in ferrous form, which in contact with air gets converted into ferric state and subsequently precipitated.

3. Poor quality of groundwater in some of the naolas. This may be due to misuse and/or disuse of the structures. This problem may be tackled by development and renovation of the structures, cleaning of dirt and other garbage (frequently dumped in and around naolas) and periodic maintenance, by involving the local populace and authorities. The local people need to be properly educated and trained by the district authorities so that they can understand the value of fresh drinking water they are supposed to get from the naolas.

7.0 RECOMMENDATIONS

The following recommendations are made to augment and develop the groundwater resources of Champawat district:

(1) The northern part of Champawat district is occupied by Himalayan ranges, where large-scale groundwater development is not possible, whereas the southern side of the district is consists of the Bhabar area, where large-scale development of groundwater is possible.

(2) Groundwater can be developed through hand pumps and springs in the area occupied by Lesser Himalayas, whereas in the Bhabar formation groundwater can be developed through tube wells and hand pumps as well.

(3) Installation of hand pumps should be in appropriate locations and in scientific manner, so that sustainability of the same will be long lasting.

(4) Springs and naolas should be properly maintained with the participation of local authorities' Panchayat, village level volunteer organizations and State government departments.

(5) Unhygienic activities near by hand pumps and springs should be avoided by the local populace as these structures act as point source of pollution. Especially dumping of garbage in springs and naolas in the upper reaches is to be avoided. For which the village communities are to be educated through *Mass Awareness Programme* and various campaigns in improving the water quality, augmentation and its judicious use.

(6) Small-scale groundwater development can be made in the valley area having considerable valley fill deposits like Karankaryat, Khetikhan, Lohaghat and Champawat by constructing shallow tube wells and large diameter dug wells.

(7) Small surface water reservoir/artificial lakes may be developed at suitable locations so as to increase the recharge of the aquifer and surface water availability.

(8) The water of the high discharge springs may be channelized for irrigation at lower altitude.

(9) The village communities are to be encouraged to tap Roof Top Rainwater to practice the Rainwater Harvesting system in the hilly areas, as it eco-friendly and cost-effective. Due to sufficient rainfall and more number of rainy days, roof top rainwater harvesting in urban as well as rural areas may be promoted to cater the domestic requirement.

(10) Finally, Wastage of groundwater should be arrested by putting valves or water taps in storage cum supply tanks constructed at the outlets of the springs.

For Technical Guidance Contact:

Regional Director

Central Ground Water Board

Uttaranchal Region

419 – A, Kanwali Road, Balliwala

Dehradun – 248 001

Telefax: 0135 – 2769525

Tel: 0135 – 2769533

E-mail: 1. rodcur-cgwb@nic.in

2. rdur-cgwb@nic.in

Website: www. cgwb.gov.in

CONTRIBUTORS

Prepared by

Ravikalyan Bussa, Scientist – 'B'

Under the able guidance of

Mrs. Anita Gupta, Regional Director

Under the Supervision of

Dr. R. P. Singh, Scientist – 'D'

Table 2. Hydrogeomorphological aspects and details of geomorphic units, District Champawat, Uttarakhand

Map Symbol	Geomorphic Unit	Lithostratigraphy	Structure	Description	Groundwater Prospectus
SV	Structural Valley	Quartzite (Q), Granite (Gr), Gneisses (Gn) Garhwal Group	Linear structural features	Structural valleys occur between the hills controlled by structural features such as fractures and faults	Good
SH	Structural Hill	Stromatolitic Dolomite with magnesite and talc schist	Folded and faulted	Linear hills showing definite trend lines.	Moderate to good
T	Terrace	Mainly gravel terraces quartzite (Q), Dolomitic Limestone (Dol Lst) Limestone as basement	--	Terraces, which are formed as a result of river cutting and deposition of material by itself creating step like features are demarcated at several places along Kali river and others. These terraces are with thick growth of vegetation. Terraces disposed as flat small area on hill cut slopes are also demarcated at few places.	Moderate to good
Structural Features:					
----------	Lineament	--	Inferred joint, fault and fractures	Lineaments show the linear topographic features of regional extent reflecting tectonic features such as faults, joints, contact zones and stream courses. They cut across quartzite, slate, granite, schist and limestone.	Good Excellent at intersections of lineaments
^^^	Thrust	--	Inferred thrust, at places conformed	North Almora Thrust (NAT) separates quartzites of Garhwal Group and granite-gneiss and schists of Almora Group.	Moderate to good

Source: Regional Remote Sensing Centre, Lucknow. IRS-1A, LISS-II, Satellite data of P27 R47, dated 20-10-1988, LandSat TM date of P147 R039 dated 15-04-1988. 2. 530 and 62C. 3. Proceedings of Himalayan Geology Vol.10, 1979.

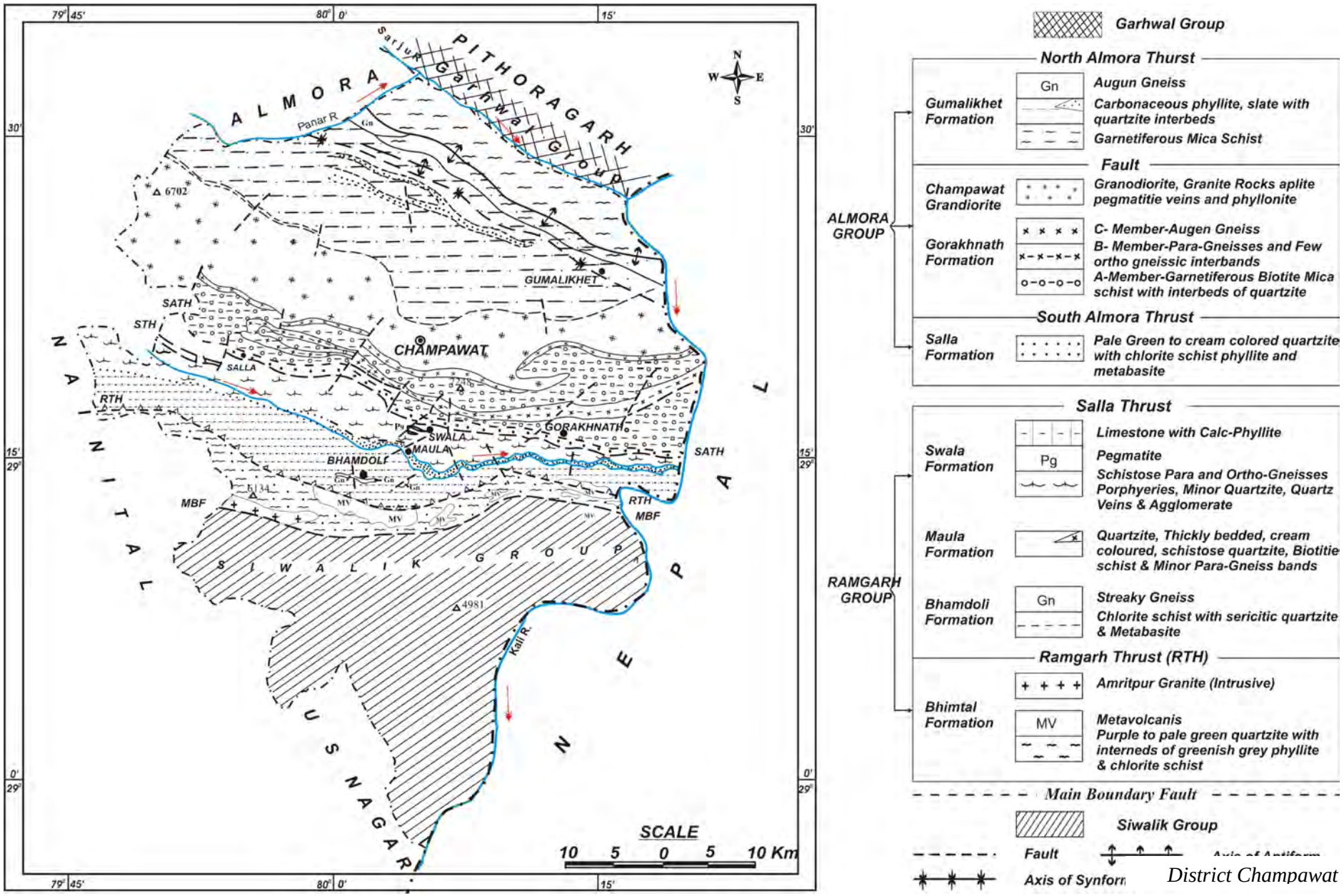


Fig 3. Geological cum structural Map of Champawat District, Uttarakhand