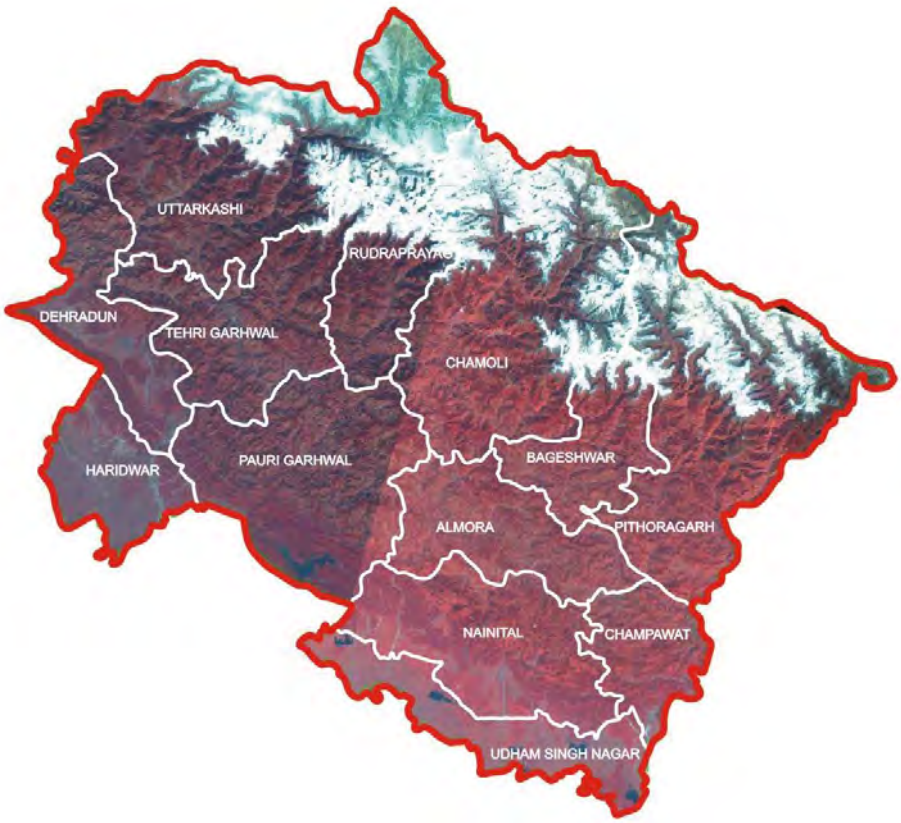
GROUND WATER YEAR BOOK 2014–2015

UTTARAKHAND

केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board



उत्तरांचल क्षेत्र
Uttaranchal Region

जनवरी 2016
January 2016

देहरादून
Dehra Dun

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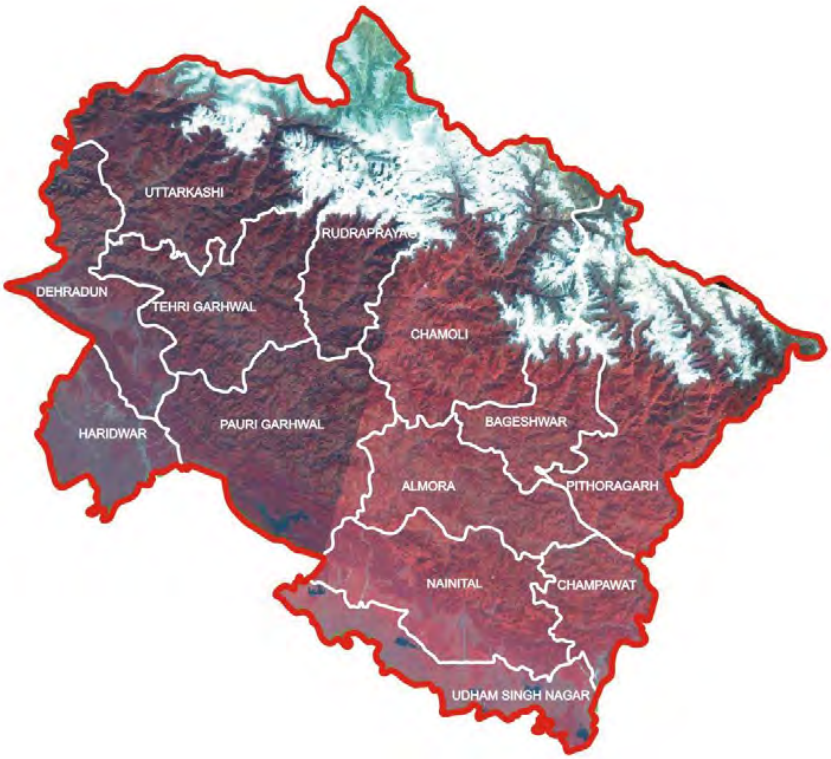
GROUND WATER YEAR BOOK, 2014–2015
UTTARAKHAND

Contributors

Ms. Amandeep Kaur, Scientist –'B' (Jr. Hydrogeologist)



CENTRAL GROUND WATER BOARD
UTTARANCHAL REGION
DEHRA DUN
January 2016

FOREWORD

*WATER is one of the essential natural resources for sustaining life on blue planet "**Earth**". The demand of fresh / usable water has increased manifold globally due to rapid growth in population, which in turn caused change in agricultural pattern and increase in industrial activities. To meet the demand of fresh water of various sectors, there is an enormous stress on ground water resources as the surface water pollution is increasing day by day. This has resulted in the water level decline in many parts of the country as the output has outstripped input of this resource.*

*Ground water being a limited resource requires proper management and judicious use of its storage for meeting out demand on long term basis without putting any adverse impact on its regime. To meet this objective, Central Ground Water Board monitors the behaviour of ground water regime through a network of Ground Water Monitoring Wells spread across the country. The data collected from such wells in each state are compiled, processed and the salient features brought out as a "**Ground Water Year Book**". The present report pertains to the State of Uttarakhand for the year 2014 – 2015.*

Central Ground Water Board, Uttaranchal Region is monitoring the groundwater regime under various hydrogeological setting through 210 ground water monitoring wells in plain and hilly areas of Uttarakhand State, viz. Dehradun, Haridwar, Nainital, Udham Singh Nagar, Champawat, Almora, Pauri Garhwal and Uttarkashi districts four times in a year (January, May, August and November). In the hilly areas of the State Thirty-eight springs are also being monitored.

The district wise details of ground water levels are presented along with thematic maps depicting the fluctuations for specific period of measurement as well as for the decade. The data has been stored in appropriate format in the data storage center of the Regional Office, Dehradun.

The present Ground Water Year Book, 2014 – 2015 is the outcome of the efforts made by Ms. Amandeep Kaur, Scientist- 'B' (Junior Hydrogeologist). The maps of the year book are prepared manually and then digitised in Coral Draw Software. The efforts in depicting the groundwater scenario of Uttarakhand State through maps and giving proper shape to this report, is highly appreciable. The information and data presented in this report will serve as a database to the user agencies, ground water planners and managers and will be of immense use to understand the regional picture on the quantitative and qualitative aspects of ground water development in the State of Uttarakhand.

(Anurag Khanna)

Place: Dehradun *Head of the Office*

GROUND WATER YEAR BOOK, UTTARAKHAND (2014 – 2015)

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Executive Summary

The predominantly hilly Uttarakhand State was carved out of Uttar Pradesh in November 2000. The State comprises thirteen districts - Almora, Bageshwar, Chamoli, Champawat, Dehradun, Haridwar, Nainital, Pauri Garhwal, Pithoragarh, Tehri Garhwal, Rudraprayag, Udham Singh Nagar and Uttarkashi. The state is situated between latitude 28°43'20"N to 31°28'00"N and longitude 77°34'06"E to 81°01'31"E with a total geographical area of 53,483 km^2.

Uttarakhand State is broadly subdivided into two hydrogeomorphic units namely

1) Gangetic Alluvial Plain
2) Himalayan Mountain Belt.

Majority of area in the state falls under hilly terrain, except for Udham Singh Nagar, Haridwar and parts of Dehradun districts. Northern parts of the state remain under snow cover throughout the year. The drainage of the state is controlled by major rivers like Ganga (Gangotri) and Yamuna (Yamnotri), originating from the glaciers in high Himalayan Mountain Range and their tributaries like Ramganga, Kali, Saryu, Pindar etc. A variety of rock units ranging in age from Archean to Quaternary are exposed over the state. The rock units in the Himalayan mountain regions have undergone repeated phases of deformation and metamorphism after their formation.

In the plain areas, ground water occurs in multi aquifer systems. Perched water bodies lying above the main water bearing formations are frequently encountered in Bhabar Zone and Doon Valley. Contrary to this, the occurrence of ground water in the hilly areas is limited to small, localized aquifers with limited ground water potential. Ground water in hilly terrains is found in the secondary porosity developed in crystalline igneous and metamorphic rocks in the form of fractures, joints and fissures. Low to moderate ground water potential exists in parts of the state where ground water is located in valley fill deposits of the alluvial plains and piedmont zones. The chemical quality of ground water is generally good and the water can be safely used for drinking, domestic and irrigation purpose.

During the period May 2014 to January 2015, ground water monitoring in the state was carried out in parts of Dehradun, Haridwar, Udham Singh Nagar, Nainital, Champawat, Pauri Garhwal, Almora and Uttarkashi districts. A number of dug wells, hand pumps and few piezometers, which are the part of Ground Water Monitoring Wells of Central Ground Water Board, were monitored in the plain areas of these districts during the months of May, August and November 2014 and January 2015.

The depth to water level maps and water level fluctuation maps viz. decadal, annual and seasonal water level fluctuations were generated manually and then digitised by using coral draw software. These maps were prepared section wise viz. Dehradun Section, Haridwar section and Udham Singh Nagar-Nainital-Champawat section. Instead of categorizing the

depth to water level into four categories for a better classification of depth to water level data.

To assess the behaviour of ground water storage in space and time, the fluctuation in storage for each measurement has been evaluated with respect to decadal average value. A summary of depth to water level data in the State during the period May 2014 to January 2015 and the overall fluctuation pattern of ground water level (rise or decline) during the same period as compared to the long-term data (decadal average) are shown in tabular forms below. Moreover, annual fluctuation of water level (for the corresponding periods of May, August, November and January) and the fluctuation pattern of ground water level during the periods August 2014, November 2014 (post monsoon) and January 2015 as compared to May 2014 (pre monsoon) are also given in separate tables.

The status of water level fluctuation during each season/period with respect to observed data of pre-monsoon water level (May) during the same year indicated that decline in water level in the categories 0-2 m, 2-4 m and >4 m were significantly higher than the corresponding rise in the range of water level. The same situation was also observed for the annual water level fluctuation data also.

Summary of Depth to Water Data in Uttarakhand during the Period 2014 – 2015

State	**Range of depth to water level (m bgl)**	**Percentage of Wells Analyzed**			
		May 2014	August 2014	November 2014	January 2015
Uttarakhand	0–5	29	35	35	37
	5-10	28	28	29	22
	10-15	13	10	10	15
	>15	31	27	26	26

Fluctuation of Water Level during the Period 2014 – 2015 (Compared to Decadal Average)

State	**Fluctuation (m)**	**Percentage of Wells Analyzed**							
		Avg. May		Avg. August		Avg. November		Avg. January	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	30	44	22	43	25	52	48	38
	2–4	11	9	2	19	2	10	0	10
	>4	0	7	0	14	0	12	2	2

Annual Fluctuation of Water Level during the Period 2014 – 2015

State	Fluctuation (m)	Percentage of wells analyzed							
		May 2013 vs. 2014		August 2013 vs. 2014		November 2013 vs. 2014		January 2014 vs. 2015	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	44	38	16	52	31	45	24	63
	2–4	12	3	5	15	5	12	0	6
	>4	2	0	2	8	1	6	2	5

Seasonal Fluctuation of Water Level (Compared to May 2014)

State	Fluctuation (m)	Percentage of wells analyzed					
		August 2014		November 2014		January 2015	
		Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	43	11	46	11	48	15
	2–4	23	4	28	4	23	6
	>4	18	2	11	1	6	2

A perusal of various maps viz. depth to water level maps and water level fluctuation maps reveals that in general, many areas of Doon Valley (Dehradun district), parts of Haridwar district and Tarai Zone in Udham Singh Nagar district have shown both rise and decline in water levels of various magnitudes in different temporal aspects. Fluctuation in water level is more conspicuous in the Bhabar Zone in Nainital and Champawat districts than in the relatively plain areas of Central Ganga Plains in Haridwar district and in the Tarai zone in Udham Singh Nagar district. This Bhabar zone shows high ground water level fluctuation due to steep hydraulic gradient.

Chemical analysis of one hundred and seventy two (172) ground water samples collected from Ground Water Monitoring Wells from parts of Dehradun, Haridwar, Pauri Garhwal, Udham Singh Nagar, Nainital, Champawat and Almora district were analysed at the Chemical Laboratory, Central Ground Water Board, North Region, Luckhnow. The water samples were analyzed for fourteen parameters viz. Electrical Conductivity (EC), pH, carbonate, bicarbonate, chloride, sulphate, nitrate, fluoride, calcium, magnesium, sodium, potassium, silica and Total Hardness (TH) as $CaCO_3$.

The analysis of physico chemical parameters like Electrical Conductivity, chloride, nitrate and fluoride was done on the basis of data for pre-monsoon 2014. The analysis result indicates that high Electrical Conductivity (>750–2250 µS/cm) is observed in 8% of samples

whereas majority of samples (74% of total) recorded EC value in the range of >250-750 µS/cm. The high EC may be either due to higher mineralization of ground water (geogenic) or due to industrial activity (anthropogenic). Data on chloride concentration in ground water samples indicates that relatively high chloride in the range of >100-150 mg/L is observed in only two samples, which was a bare minimum of 1% of the total number of samples.

High nitrate viz. higher than the acceptable Limit (>45 mg/L, BIS, 2009) is recorded in only one sample out of 142 samples. The 30 no of samples have shown nil concentration of nitrate in ground water during pre-monsoon, 2012. The high nitrate concentration recorded is 110 mg/L at Dharnauli in Almora district and 49 mg/L in a hand pump at Sultanpur in Haridwar district. High nitrate in ground water is attributed to anthropogenic source like unhygienic practices near the monitoring wells by the local populace. It is suggested the dug wells and hand pump in which high nitrate was observed should be avoided for drinking purpose and treated pipe line water should be used instead.

Chemical data on fluoride concentration in groundwater sample indicates that majority of samples (98% of total) has recorded fluoride less than the acceptable limit of 1.0 mg/L (BIS, 2009). High fluoride in the range of 1.0-1.5 mg/L and higher than the permissible limit (>1.5 mg/L) is also observed in single samples at Jaspur in Udham singh Nagar district and Dhalangaon in Almora district, respectively. High fluoride in ground water is attributed to geogenic source like leaching of fluoride from rocks and/or minerals into the groundwater system during rock-water interaction. It was found that fluoride concentration in groundwater is less in Dehradun-Haridwar section and relatively high in Udham Singh Nagar-Nainital section during pre-monsoon, 2014.

To conclude, the available hydrochemical data in parts of District Dehradun, Haridwar, Udham Singh Nagar, Pauri Garhwal, Nainital, Champawat and Almora (pre-monsoon 2014) in Uttarakhand State reveals that ground water is fresh and potable and therefore, suitable for drinking and domestic purpose.

CHAPTER – 1
INTRODUCTION

Ground water is a very important component of Earth's natural fresh water resource. Hence, ground water regime monitoring on periodic basis becomes essential for a safe and sustainable development and management of ground water resources of the hilly state of Uttarakhand. The directly measurable and often visible physical parameter of the otherwise invisible ground water system is the ground water level. Regular and systematic monitoring of ground water levels and evaluation of chemical parameters of ground water forms the base for scientific planning, development and management programmes. Scientific information about the behaviour of water level in time and in space becomes an essential exercise in this perspective. Indiscriminate withdrawal of ground water in rapidly developing urban and industrial areas poses a challenge to the scientific community. The challenge can be overcome by adopting sustainable ground water development and management practices.

Uttarakhand State lies between 28°43'20" – 31°28'00" N Latitude and 77°34'06" – 81°01'31" E Longitude and has a total geographical area of 53,483 km^2. The state has been divided into two Divisions and thirteen developmental blocks. Uttarakhand has a diverse hydrogeological set up. In order to assess the impact of continuously increasing stress on the ground water regime and to categorize various hydrogeological units in the State, systematic monitoring of ground water levels and spring discharge are being carried out four times in a year by the Central Ground Water Board, Uttaranchal Region, Dehradun through the Ground Water Monitoring Stations, which included periodic measurement of Springs discharge in the hilly terrain.

During the period May 2014-January 2015, efforts were made by the scientists of Central Ground Water Board to replace the monitoring wells with new ones depending on the field condition. Moreover, monitoring wells which are not representative of the local ground water regime were declared Abandoned for all future monitoring purposes. Nine springs were inventoried during the period May 2014-January 2015. Out of these, seven were located in Almora district, one in Nainital district and one in Champawat district. One dug well (at Kuanwala) and one hand pump (at Dudhli) were declared abandoned in Dehradun district. In Haridwar district, one dug well (at Teliwala) and three hand pumps (at Bugawala, Manglaur and Govardhanpur) were considered abandoned for reasons mentioned above. Similarly, one hand pump (at Sitapur) in Nainital district and one spring (at Dharanaula Zoo) were declared defunct and abandoned for future monitoring purpose. In Udham Singh Nagar district, two replacement hand pumps were established at Durgapur and Kichha while in Almora district, one spring (at Naula, Bhikiyasain block) was replaced by another spring locally known as "Manya Pani".

As on January 2015, a total of two hundred and seven ground water monitoring stations exist in Uttarakhand State, which are being monitored by the regional office four times in a year. The map showing locations of Ground Water Monitoring Wells and Springs in Dehradun, Haridwar, Nainital, Udham Singh Nagar, Champawat, Almora and Pauri Garhwal districts is shown as ***Fig. 1.***

Chemical analysis of water samples, collected from selected locations within the state once in a year during the month of May (pre-monsoon monitoring), is being carried out to check whether any significant change is taking place in groundwater quality in time and space.

The main objectives of ground water regime monitoring in Uttarakhand may be summarised as follows:

1. To study the fluctuation of water level, both spatially and temporally, in response to ground water recharge and/or discharge.
2. To evaluate changes in ground water level with respect to the preceding year for the same period.
3. To evaluate changes in ground water level with respect to a long term average water level such as the decadal mean.
4. To study the fluctuation of water level during different seasons of the period 2014 – 2015.
5. To study the hydrochemical behaviour of shallow aquifers.

The district wise break up of Ground Water Monitoring Stations (including the springs in hilly terrain), which were monitored during the period from May 2014 to January 2015 is given in ***Table 1.***

Table 1: District wise break up of active Ground Water Monitoring Stations (including Springs) monitored in Uttarakhand State

Sl. No.	*District*	*Number of Ground Water Monitoring Stations*			
		May 2014	*Aug 2014*	*Nov 2014*	*Jan 2015*
1.	Dehradun	61	61	60	59
2.	Haridwar	46	46	40	39
3.	Udham Singh Nagar	50	50	49	48
4.	Nainital	20	21	21	21
5.	Champawat	4	5	4	5
6.	Pauri Garhwal	1	1	1	1
7.	Almora	18	25	25	24
8.	Uttarkashi	10	0	10	10
TOTAL		**210**	**209**	**210**	**207**

Apart from the dug wells, hand pumps and piezometers, a total of thirty eight springs in hilly areas of Uttarakhand were also monitored (as on January 2015). The details of these springs during the period May 2014 to January 2015 are given in ***Table 2.***

Table 2: District wise break up of Springs in Uttarakhand State

Sl. No.	*District*	*Number of Springs*			
		May 2014	*Aug 2014*	*Nov 2014*	*Jan 2015*
1.	Dehradun	3	3	3	3
2.	Nainital	6	7	7	7
3.	Almora	19	25	24	24
4.	Uttarkashi	3	3	3	3
5.	Champawat	0	1	0	1
TOTAL		**31**	**39**	**37**	**38**

The Ground Water Monitoring Stations (including Springs) have been further categorized on the basis of geological set up and catchments of the river basins in Uttarakhand. The relevant information in this regard is given in ***Table 3.***

Table 3: Geology and Basin wise breakup of the existing Ground Water Monitoring Stations in Uttarakhand State (as on January 2015)

River Basin/ Sub Basin	*Geology*	*Well No. & Location*
DEHRADUN DISTRICT		
Yamuna Basin, Tons Sub-basin	Doon Gravels (bouldery formation)	DDN-04 (Rampura), DDN-05 (Kuanwala), DDN-06 (Herbertpur), DDN-07 (Jhajra), DDN-08 (Lal Tappar), DDN-09 (Motichur), DDN-10 (Nanda ki Chowki), DDN-11 (Selaqui), DDN-18 (Kanwali), DDN-19 (Chhorba), DDN-20 (Shankarpur), DDN-21 (Judli), DDN-22 (Dandi), DDN-PZ1 (Chhorba), DDN-PZ2 (CGWB Office), DDN-HP-1 (Jhajra), DDN-HP-2 (Redapur), DDN-HP-3 (Majra), DDN-HP-4 (Bhaniawala), DDN-HP-5 (Balliwala), DDN-HP-6 (Harbanswala), DDN-HP-7 (TarlaNagal), DDN-HP-8 (Nanurkhera), DDN-HP-9 (Nanda Ki Chowki), DDN-HP-10 (Selaqui), DDN-HP-11 (Badripur), DDN-HP-12 (Baronwala), DDN-HP-13 (Kuanwala), DDN-HP-17 (Gularghati), DDN-HP-18 (Vikas Nagar), DDN-HP-19 (Khandgaon), DDN-HP-20 (Lal Tappar), DDN-HP-21 (Kotimaichak), DDN-HP-23 (KhadiriKhadakmap), DDN-HP-24 (Dudhli), DDN-HP-25 (Dakpatthar), DDN-HP-26 (Barothiwala), DDN-HP-27 (Dhakrani), DDN-HP-28 (Timli), DDN-HP-35 (Mathrowala), DDN-HP-33 (Telpura), DDN-HP-31 (Baronwala), DDN-32 (Baluwala), DDN-DW-30 (Haripur), DDN-HP-36 (Chandmari), DDN-DW-23 (Duggiawala), DDN-HP-37 (Chhorba), DDN-DW-13 (Dharmawal)
	Doon Gravels (bouldery formation) and Upper Siwaliks (conglomerate, pebbly sands, clay)	DDN-12 (Redapur), DDN-14A (Sabhawala), DDN-15 (Singhniwala), DDN-16 (Ramgarh), DDN-SP2 (Khandoli), DDN-HP16 (Maldeota), DDN-HP22 (Soda Sarauli), DDN-SP3 (Soda Sarauli), DDN-DW-16A(Ramgarh)
	Blaini – Krol, boulder beds	DDN-03 (Rishikesh), DDN-SP1 (Bhatta), DDN-HP-14 (Rishikesh), DDN-HP-15 (Purukulgaon)
HARIDWAR DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Tarai (gravel, sand and clay)	HRW-07 (Bahadrabad), HRW-08 (Missarpur), HRW-09 (Dhanpura), HRW-10 (Hussainpur), HRW-11 (Budhwa Shahid), HRW-12 (Shahidwala Grant), HRW-14 (Rathaura), HRW-15 (Sarai), HRW-16 (Librahedi), HRW-PZ1 (Roorkee), HRW-PZ2

		(Chudiala), HRW-HP-1 (Bhagwanpur), HRW-HP-2 (Bahabalpur), HRW-HP-3 (Jhabrera), HRW-HP-4 (Iqbalpur), HRW-HP-5 (Bugawala), HRW-HP-6 (ShahpurShitlakhera), HRW-HP-7 (Khanpur), HRW-HP-8 (Lakhnauta), HRW-HP-9 (Gurukul Narsen), HRW-HP-10 (Manglaur), HRW-HP-11 (Dallawala), HRW-HP-12 (Govardhanpur), HRW-HP-13 (Dhanpura), HRW-HP-14 (Bhikkampur), HRW-HP-15 (Bahadrabad), HRW-HP-16 (Chudiala), HRW-HP-17 (Shahidwala Grant), HRW-HP-18 (Imlikhera), HRW-HP-19 (Landhaura), HRW-HP-20 (Bhopatwala), HRW-HP-22 (Mudlana), HRW-HP-23 (Bhogpur), HRW-HP-24 (Sultanpur), HRW-HP-25(Kotamuradnagar), HRW-HP-26 (Laksar, HRW-HP-24 (Dudhadyalwala), HRW-HP-25 (Syampur), HRW-DW-16 (Teliwala), HRW-DW-17 (Sikhar), HRW-DW-18 (Kherajat), HRW-DW-19 (Nijampur), HRW-DW-20 (Ambkhera), HRW-DW-21 (Mohamadpur), HRW-DW-23 (Jaswawala), HRW-DW-24 (Kota Muradnagar)
	Siwaliks (sandstone, siltstone, conglomerate)	HRW-13 (Bandarjud), HRW-HP-21 (Laldhang)
UDHAM SINGH NAGAR DISTRICT		
Ganga basin, Ramganga Sub- basin	Tarai (gravel, sand and clay)	USN-01A (Kashipur), USN-02 (Khatima), USN-03 (Bazpur), USN-06A (Sitarganj), USN-07 (Bara), USN-08 (Beria Daulat), USN-09 (Jaspur), USN-11 (Angadpur), USN-12 (Patrampur), USN-13 (Bharatpur), USN-15 (Barkhare Pande), USN-18 (Banna Khera), USN-19 (Shantipuri), USN-20 (Nanak Mata), USN-21 (Chakarpur), USN-HP-1 (Kamaria Pakki), USN-HP-2 (Gangapur), USN-HP-3 (Bhagwanpur), USN-HP-4 (Beria Daulat), USN-HP-6 (Jogipura), USN-HP-9 (Majhola), USN-HP-10 (Dhanauri Patti), USN-HP-11 (Kalyanpur), USN-HP-12 (Patthar Chatta), USN-HP-13 (Barkhare Pande), USN-HP-14 (Sultanpur Patti), USN-HP-15 (Bharatpur), USN-HP-16 (Patrampur), USN-HP-18 (Sitarganj), USN-HP-19A (Kichha), USN-HP-20A (Durgapur), USN-HP-21 (Kopa Signal), USN-HP-22 (Chakarpur), USN-HP-23 (Jharkhandi), USN-HP-24 (Mahabir Nagar), USN-HP-25 (Sarasariya), USN-HP-26 (Rudrapur), USN-HP-28 (Missarwala), USN-HP-29 (Shankhera), USN-HP-30 (Kanaura), USN-HP-31 (Pritpur), USN-HP-32 (Badripur), USN-HP-33 (Pattharpui), USN-HP-34 (Badakhera), USN-HP-35 (Lalpuri), USN-HP-36 (Kanakpur), USN-HP-37 (Rajpura), USN-HP-38 (Pipiliya), USN-HP-39 (Begur Mod), USN-HP-40 (Bidora), USN-HP-41 (Dhyanpur), USN-HP-42 (Barianjaniya)

NAINITAL DISTRICT		
Ganga basin, Ramganga Sub- basin	Bhabar (boulders, gravel, sand and clay)	NTL-03 (Lalkuan), NTL-05 (Maldhan Colony), NTL-HP-1 (Ramnagar), NTL-HP-2 (Belparao), NTL-HP-3 (Dhela), NTL-HP-4 (PeeruMadara), NTL-HP-5 (Dhoniya), NTL-HP-6 (Lamachaur), NTL-HP-7 (Kaladhungi), NTL-HP-8 (Kathgodham), NTL-HP-9 (Sitapur), NTL-HP-10 (Khat Baas), NTL-HP-11 (Chilkiya), NTL-HP-12 (Chanda Devi Amratpur)
	Middle Siwaliks (sandstone with minor clay)	NTL04 (Garjiya), NTL-S1 (Dogaon), NTL-S3 (Garampani), NTL-S4 (Salari), NTL-S5 (Ranibagh), NTL-S6 (Jyolikote)
	Blaini-Krol, boulder beds	NTL-S2 (Sipahidhara), NTL-S7 (Kuda Ghat)
CHAMPAWAT DISTRICT		
Ganga basin, Ramganga Sub- basin	Bhabar (boulders, gravel, sand and clay)	CPT-01 (Tanakpur), CPT-HP-1 (Banbasa)
	Middle Siwaliks	CPT-HP-2 (Bastia), CPT-HP-3 (Bichayee)
	Lesser Himalaya	CPT-SP-1 (Lohaghat)
ALMORA DISTRICT		
Ganga basin, Ramganga Sub- basin	Almora – Ramgarh Formation	ALM-S-1 (Patali Talla), ALM-S-2 (Patali Malla), ALM-S-3 (Katarmal), ALM-S-4 (Dharanaula), ALM-S-5 (Palna), ALM-S-6 (Chinoda), ALM-S-7 (Guruda-I), ALM-S-8 (Guruda-II), ALM-S-9 (Dhansari), ALM-S-10 (Someshwar), ALM-S-11 (Dharanaula Zoo), ALM-S-12 (Bachuradi), ALM-S-13 (Deepakot), ALM-S-14 (Ramgath), ALM-S-15 (Bhagtola),ALM-S-16 (Itola), ALM-S-17 (Potasarain), ALM-S-18 Chhani Bartola), ALM-S-19 (Lodh), ALM-S-21 (Dhalnagaon), ALM-S-22 (Semalkhet), ALM-S-23 (Naula), ALM-S-24 (Bania Diggi)
PAURI GARHWAL DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Bhabar (boulders, gravel, sand and clay)	PG-HP-1 (Kaudiya)
UTTARKASHI DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Lesser Himalaya	UK-HP-1 (Chinyalisaur), UK-HP-2 (Devidhar), UK-HP-3 (Uttarkashi), UK-HP-4 (Barkot), UK-HP-5 (Sharukhet), UK-HP-6 (Ganeshpur), UK-HP-7 (Maneri), UK-SP-1 (Dharasu), UK-SP-2 (Nagal), UK-SP-3 (Ratodisar)

Location of Ground Water Monitoring Stations in Uttarakhand (As on January 2015)

DEHRADUN DISTRICT

1. Rishikesh 2. Rampura 3. Kuanwala 4. Herbertpur 5. Motichur
6. Sabhawala 7. Singhniwala 8. Ramgarh 9. Kanwali 10. Chhorba
11. Shankarpur 12. Judli 13. Jhajra 14. Redapur 15. Majra 16. Bhaniawala
17. Balliwala 18. Harbanswala 19. Tarla Nagal 20. Nanurkhera
21. Chhorba Pz 22. Nanda Ki Chowki 23. Selaqui 24. Baronwala
25. Kuanwala 26. Rishikesh 27. Purukulgaon 28. Maldeota 29. Gularghati
30. Vikas Nagar 31. Khandgaon 32. Lal Tappar 33. Kotimaichak
34. Soda Sarauli 35. CGWB Office 36. Dandi 37. Khadakmap
38. Dudhli 39. Bhatta Sp 40. Khandoli Sp 41. Soda Sarauli Sp
42. Dakpatthar 43. Barothiwala 44. Dhakrani 45. Badripur 46. Timli

HARIDWAR DISTRICT

47. Bahadrabad 48. Dhanpura 49. Hussainpur 50. Roorkee
51. Bhagwanpur 52. Chudiala 53. Bahabalpur 54. Jhabrera
55. Iqbalpur 56. Bugawala 57. Shahidwala Grant 58. Bandarjud
59. Rathaura 60. Sarai 61. Shahpur Shitlakhera 62. Khanpur
63. Lakhnauta 64. Chudiala 65. Gurukul Narsan 66. Manglaur
67. Dallawala 68. Govardhanpur 69. Bhikkampur 70. Imlikhera
71. Landhaura 72. Bhopatwala 73. Laldhang

PAURI GARHWAL DISTRICT

74. Kaudiya

UDHAM SINGH NAGAR DISTRICT

75. Kashipur	76. Khatima	77. Bazpur
78. Kichha	79. Sitarganj	80. Bara
81. Beria Daulat	82. Jaspur	83. Chakarpur
84. Dhanauri Patti	85. Kalyanpur	86. Patthar Chatta
87. Angadpur	88. Patrampur	89. Bharatpur
90. Barkhare Pande	91. Barhini	92. Sultanpur Patti
93. Banna Khera	94. Shantipuri	95. Nanak Mata
96. Kamaria Pakki	97. Gangapur	98. Bhagwanpur
99. Mahabir Nagar	100. Jogipura	101. Jhagarpuri
102. Majhola	103. Jharkhandi	104. Tukri
105. Sarasariya	106. Durgapur	107. Kopa Signal
108. Rudrapur		

NAINITAL DISTRICT

110. Lalkuan 111. Garjia 112. Maldhan Colony 113. Ramnagar
114. Belparao 115. Dhela 116. Peeru Madara 117. Dohniya
118. Lamachaur 119. Kaladhungi 120. Kathgodham 121. Sitapur
122. Khat Baas 123. Dogaon 124. Sipahidhara 125. Garampani
126. Salari 127. Ranibagh 128. Jyolikote

CHAMPAWAT DISTRICT

129. Banbasa 130. Tanakpur 131. Bastia

ALMORA DISTRICT

132. Patli Talla 133. Patli Malla 134. Katarmal 135. Dharanaula
136. Dharanaula Zoo 137. Palna 138. Chinoda 139. Guruda-I
140. Guruda-II 141. Bachuradi 142. Someshwar 143. Dhansari
144. Deepakot 145. Ramgath 146. Bhagtola

UTTARKASHI DISTRICT

147. Chinyalisaur 148. Devidhar 149. Uttarkashi 150. Dharasu 151. Barkot
152. Sherukhet 153. Ganeshpur 154. Maneri 155. Nagal 156. Ratodi Sar

CHAPTER – 2

CLIMATE

The hilly parts of Uttarakhand experience cold climate and high rainfall. Significantly large part of the state remains under snow cover throughout the year. The intermontane valleys and the plain area in the southern part of the state experience a sub tropical climate with three seasons – summer, monsoon and winter. The normal annual rainfall varies from 1256 mm in Haridwar district to 2426 mm in Pithoragarh district. The average annual rainfall varies from 927.7 mm at Joshimath (Chamoli district) to 2599.4 mm at Munsyari (Pithoragarh district). Most of the rainfall occurs as monsoon rainfall during the months of July and August. The Isohyetal Map of Uttarakhand prepared using mean normal rainfall is given in **Fig. 2**. The map reveals that intensity of rainfall increases from SW to NW in a broadly linear pattern with high rainfall prevailing in both the eastern and the western parts of the state. The district wise normal monthly and annual rainfall data, available for seventy years (1901 to 1970) is given in **Table 4.**

Table 4: District wise normal monthly and annual rainfall (mm) in Uttarakhand State (1901-1970)

District	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*
Dehradun	57.4	55.8	37.6	17.1	34.0	178.9	686.9	751.5	314.5	47.1	7.8	37.4	2212.0
Chamoli	103.0	107.8	114.5	57.2	47.9	117.1	314.4	322.0	169.0	51.4	23.5	47.0	1474.8
Nainital	37.7	33.4	18.7	8.6	27.2	173.6	466.2	454.7	239.7	52.2	3.9	11.9	1527.8
Pithoragarh	257.8	193.4	190.9	78.2	70.9	239.4	496.7	441.8	290.9	57.2	32.4	76.3	2425.9
Haridwar	48.1	45.8	24.5	9.8	19.9	108.9	360.1	393.8	190.2	34.3	5.4	15.4	1256.2
Tehri Garhwal	64.1	50.5	57.5	25.9	47.0	120.7	374.3	339.8	207.2	62.5	10.6	34.5	1394.6
Uttarkashi	102.4	59.2	90.4	46.6	72.7	128.8	400.3	426.5	301.4	46.9	20.4	36.5	1732.1
Almora	54.8	56.5	49.8	32.4	56.8	162.4	345.5	321.5	165.5	56.0	7.5	21.6	1330.3
Pauri Garhwal	58.9	59.8	41.9	23.5	45.0	151.4	412.9	402.5	188.9	43.7	6.8	23.0	1458.4

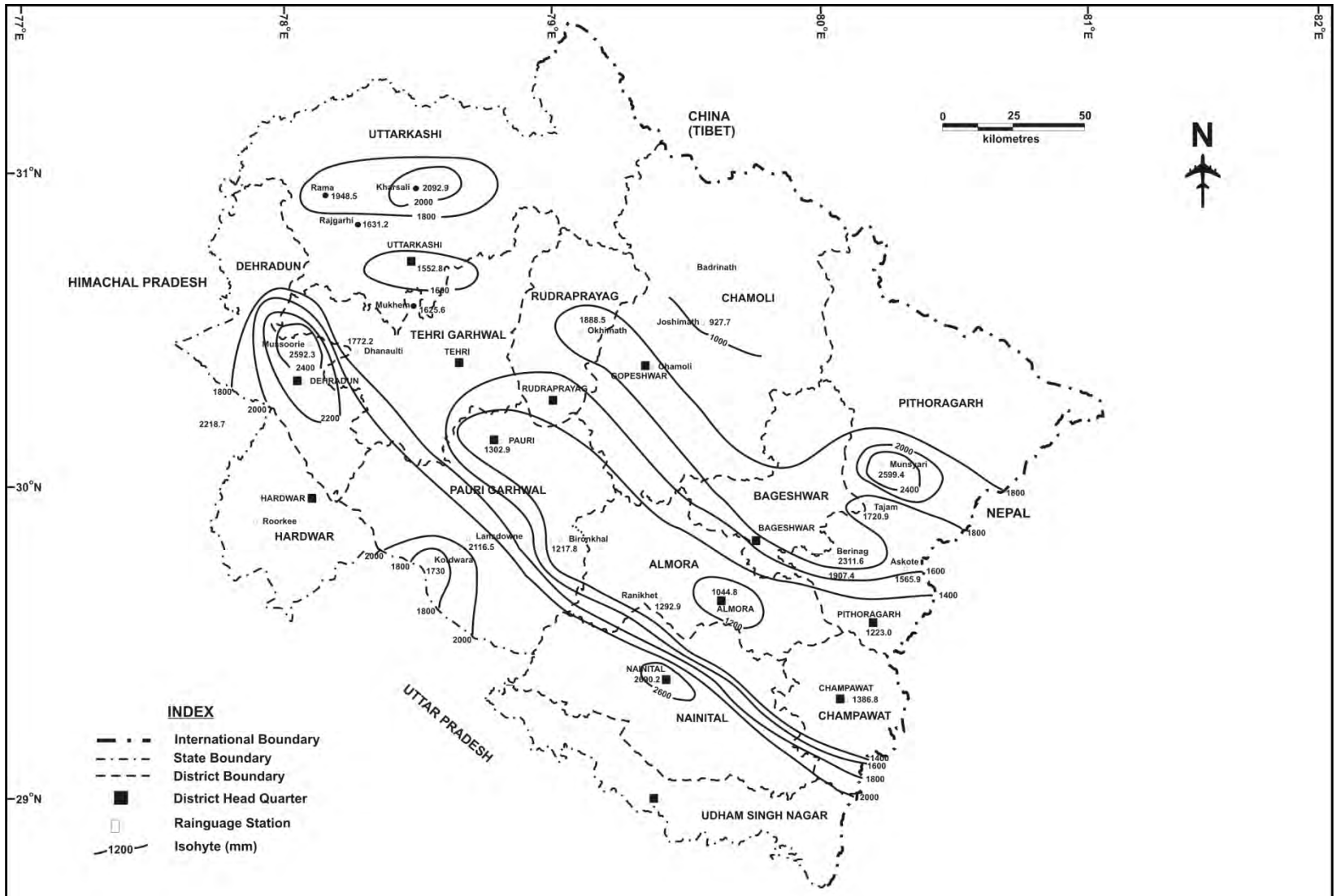

Fig. 2. Mean Annual Isohyetal Map, Uttarakhand State

CHAPTER – 3

GEOLOGY

The state of Uttarakhand has distinct geological attributes with a wide spectrum of rock types ranging in age from Achaean to Quaternary. Based on the diversity of geological processes in time and space, the state can be subdivided into two major physiographic-cum-tectonic units, viz.

1) Gangetic Alluvial Plain
2) Himalayan Mountain Belt.

A brief description of the geology of Uttarakhand is given below.

1. Gangetic Alluvial Plain

Gangetic Alluvial Plain, a part of the Indo-Gangetic Foreland Basin, occupies the southernmost part of the state. This zone consists of Quaternary fluvial sediments also known as Ganga Alluvium. Subsurface investigations in this belt have revealed a thick pile of alluvium resting conformably over the Siwalik succession of Neogene to early Pleistocene Period. The thickness of alluvium increases towards north and attains its maximum adjacent to the *Foot Hill Fault* (FHF), which marks the northern limit of the youngest foreland basin in India i.e. the Ganga Fore deep Basin. The Ganga Fore deep sediments extend up to the south of depositional boundary of the Siwalik succession and rests over Precambrian cratonic rocks of Peninsular Indian Shield.

2. Himalayan Mountain Belt (Extra Peninsular Belt)

The Himalayan Mountain Belt is a part of the global mobile belt of Mesozoic to Cenozoic age that is believed to have evolved through the convergence of active Indian Plate and passive Eurasian Plate during the continent-continent lithospheric collision. Late Proterozoic (Neoproterozoic) to early Cenozoic crustal sequences form a small part of Himalaya, whereas the main mountain chain consisting predominantly of Proterozoic rocks represents a part of the Indian Shield. The Proterozoic crystalline rocks have been affected by various orogenic episodes of Mesozoic to Cenozoic Period and show signs of multiple phases of deformation and metamorphism. The Extra-Peninsular region has a wide spectrum of rocks of sedimentary, metamorphic and igneous origin.

Uttarakhand State is a part of Western Himalaya. Four distinct tectonic zones, each characterized by specific geological attributes and bounded by prominent dislocation zones can be recognized in Uttarakhand Himalaya from south to north. A brief description of the zones is given below:

2.1. Outer Himalaya or Sub Himalaya

This zone constitutes of a thick Cenozoic sedimentary pile ranging in age from Paleocene to Upper Pleistocene. Its northern and southern boundaries are delimited by the *Main Boundary Thrust* (MBT) and the *Foot Hill Fault* (FHF) also known as the *Main Frontal Thrust* (MFT), respectively. This zone consists predominantly of continental molasses sediments of Siwalik Group ranging in age from Middle Miocene to Upper Pleistocene. The Siwalik Group has been subdivided into the Lower Siwalik, Middle Siwalik and Upper Siwalik. The Lower Siwalik consists of fine to medium grained

sandstone with clay, the Middle Siwalik is formed of medium grained sandstone with calcareous concretions and sandy clay and the Upper Siwalik consists predominantly of conglomerate with lenticular outcrops of sandstone and minor clay. The elevation of this zone ranges from 250 to 800 m above mean sea level and width varies from 25 to 100 km. This zone is also characterized by a number of flat-floored structural valleys such as the *Doon Valley.*

2.2. Lesser Himalaya

The litho units lying between the Main Boundary Thrust (MBT) in the south and the *Main Central Thrust* (MCT) in the north are included under the Lesser Himalayan Zone, which has the greatest exposed width of about 80 km in the Garhwal and Kumaun regions of Uttarakhand. The rocks of this zone are overlain by crystalline thrust sheets in the form of large klippen masses occupying mostly the higher topographical levels of the mountain ranges. Regionally metamorphosed Proterozoic rocks emplaced by granites of variable ages along with weakly metamorphosed to unmetamorphosed sedimentary rocks (quartzites with interbedded volcanics, carbonates associated with slate, quartzite and shale) occur extensively in this zone. The granitoids are associated with volcano sedimentary sequence (Bhimtal Formation) and are emplaced along with the predominantly metamorphic and metasedimentary rocks of this zone, forming large-scale nappes like the Almora-Ramgarh nappe, Baijnath-Askot nappe and Garhwal nappe.

2.3. Central or Higher Himalaya

This zone consists of thick slabs of Proterozoic crystalline rocks, which thrust southward along the *Main Central Thrust* (MCT), over-riding the Lesser Himalayan Zone. This zone is a 10-15 km wide sequence of metamorphic rocks and granites. This zone represents the Proterozoic basement that has been reactivated due to crustal shortening during the continent-continent collision of the Himalayan Orogeny. The metamorphic rocks exposed in this zone show progressive regional metamorphism ranging from green schist facies to upper amphibolite facies. Both foliated and non-foliated granitoids are emplaced in different structural and tectonic levels within the regionally metamorphosed crystallines.

2.4. Tethys Himalaya

This zone is occupied by the thick sedimentary sequence ranging in age from Late Precambrian (Neoproterozoic) to Lower Eocene. Sediments of marine facies, characteristic of continental shelf to continental slope environments of the Tethys Sea regime, are the predominant litho types of this zone. In Uttarakhand, this zone is well exposed in the Zanskar Mountains and mountain ranges of Kumaun region. This zone is separated from the Central Crystallines by Dar-Martoli Fault, with the Lower Martoli Formation representing the base of Phanerozoic, which is broadly folded and faulted with several local thrusts. The rock sequence comprises phyllite, mica schist and quartzite with lenticular outcrops of limestone.

CHAPTER – 4

HYDROGEOLOGY

Uttarakhand State has a very diverse hydrogeological set-up. However, thishilly state can broadly be classified into two hydrogeological regimes namely Gangetic Alluvial Plain and Himalayan Mountain Belt. The description of these two types of hydrogeological-cum-physiographic units with further subdivisions is given below.

1. Gangetic Alluvial Plain

The Gangetic Alluvial Plain is a vast expanse of alluvium of Tertiary and Quaternary age. Alluvium is a generalized term for detrital unconsolidated sediments comprising predominantly of clay, silt, sand and gravels formed on river beds, flood plains, alluvial fans etc. This zone is very promising from the hydrogeological point of view having substantial water resource. This unit can be subdivided into three distinct hydrogeological regimes from south to north, viz. Axial Belt, Tarai and Bhabar.

1.1. Axial Belt

This unit, also called as the Alluvial Plains, is demarcated by the termination of alluvial fans that grade further down slope into vast alluvial plains. This zone is composed of a mixture of gravel, sand, silt and clay deposited in alternating layers. The aquifers present in this zone are of unconfined to confined nature. The area, in general, has good ground water resource potential but overexploitation of ground water reserve at places has resulted in the decline of water levels and needs implementation of artificial recharge methods. Drilling in this zone can be best accomplished by Rotary Drilling method having high drilling rate and hence, requiring less time for drilling.

1.2. Tarai

This is a generalised term for a sedimentary unit consisting of a mixture of gravel, sand and clay (sometimes also referred to as Tarai Formation). The boundary between Tarai and Bhabar is demarcated by the presence of springs forming a linear pattern, thus delineating a "spring line". Due to the highly porous and permeable nature of the constituting material of sedimentary origin, many potential aquifers having groundwater of good chemical quality exist in this area. Two types of aquifers can be found in this zone –

a) Unconfined Aquifers down to depths of 30 meters below ground level (m bgl) and

b) Confined Aquifers that occur at depths greater than 30 m bgl under very high hydrostatic pressure.

The tubewells are tapping these aquifers generally exhibit free flowing conditions with hydraulic head sometimes as high as 10 m agl and discharge of 5000 lpm.

1.3. Bhabar

A mixture of clastic material having different size fractions (e.g. boulder, pebble, gravel, sand, silt and clay) constitutes this unit, which is also referred to as Bhabar Formation. Bhabar zone is also a promising hydrogeological entity though the occurrence of ground water at deeper levels (generally greater than 100 m bgl) poses a

five tectonic units from south to north. These units are Outer Himalaya, Lesser Himalaya, Central Himalaya, Tethyan Himalaya and Indus Suture Zone. However, the Indus Suture Zone does not fall within the geographical area of Uttarakhand State. A brief description of the remaining four units that falls in the state is as follows:

1.4. Outer Himalaya (Siwalik Mountain Range)

This unit is composed dominantly of sandstone, ferruginous shale and clay and is younger in age as compared to the other units of the belt. The general elevation of the zone is less than 1000 m above mean sea level. Due to the semi-consolidated nature of rocks, potential ground water bearing formations are present in areas, which have a good weathered mantle and highly fractured/jointed rocks. In the Siwaliks, a number of valleys have also been developed as a result of tectonic activities (e. g. Doon Valley), which are very important from the hydrogeological point of view. The Doon Valley was formed as an *Intermontane Valley* within the Siwalik Group of rocks in a foreland propagating thrust system. The Lower, Middle and Upper Siwaliks are exposed in the area, and the Doon Gravels, a post-Siwalik Formation, were deposited with the evolution of the valley. The Doon Gravels are thickly bedded coarse clastic fan deposit of late Pleistocene and Holocene age. The Central Ground Water Board has successfully constructed 11 deep tubewells, with discharge ranging from 252 to 3197 lpm in the Doon Valley of Dehradun district. The water levels in these aquifers range from 20 m bgl in the southern part of the valley to about 100 m bgl in the northern part.

1.5. Lesser Himalaya

This zone is represented by mountains bounded by Main Boundary Thrust (MBT) in the south and Main Central Thrust (MCT) in the north having an elevation ranging between 1000 and 3000 m above mean sea level. This unit is dominantly composed of metasedimentary rocks and minor plutonic intrusives (granitoids). Springs form the most important source of ground water in this zone. In these formations ground water occurrence is restricted to the weathered residuum and the highly fractured/jointed zones of the area. Several hand pumps have been installed successfully in this zone. At a few places, especially in the river valleys, tubewells having low to moderate discharges have also been successfully constructed.

1.6. Central Himalaya

The Central Himalayan zone lies to the north of *Main Central Thrust* (MCT) with an elevation ranging from 5000 to 8000 m above mean sea level. Both cold water and hot water (thermal) springs are present in this zone. So far a total of 25 thermal springs have been investigated with temperatures ranging from 32°C to 70°C and discharge varying between 60 to 600 lpm, corresponding to 5^{th} order and 4^{th} order as per Meinzer's Classification of spring discharge. Due to highly inaccessible, snow-covered areas in this zone and a very steep hydraulic gradient, the possibility of ground water development is almost negligible.

1.7. Tethys Himalaya

Situated to the north of Central Himalayan zone, this zone is predominantly occupied by the highly fossiliferous sedimentary rocks ranging in age from Precambrian to Jurassic. Due to the porous and permeable nature of the litho units, this zone is generally suitable for ground water development.

CHAPTER – 5

BEHAVIOUR OF WATER LEVEL

The water levels of Ground Water Monitoring Wells of Uttarakhand were measured four times during the period 201-201 (May, August, November 2014 and January 2015). The water levels observed are shown in Table 5. The ground water levels in different seasons were analyzed to evaluate the temporal behaviour of water level. The behaviour of water levels in each season during the period May 2014 – January 2015 has been compared with the water levels of previous year as well as with average water level for the last decade to ascertain the changes in ground water regime.

Apart from this, the fluctuation of water levels during the current year and previous year has also been evaluated in order to assess the adverse impact on hydrogeological regime, if any.

Table 5: Water level data of Ground Water Monitoring Wells, Uttarakhand State

SL. No.	Location	May-14	Aug-14	Nov-14	Jan-15
DEHRADUN DISTRICT					
Raipur block					
1	Kuanwala (old)	9.48	--	--	--
2	Kanwali	15.30	8.73	12.46	13.60
3	CGWB Office	53.30	55.51	53.30	53.86
4	Tarla Nagal	72.30	71.63	68.25	74.30
5	Majra	21.24	24.55	17.33	27.55
6	Balliwala	52.40	50.52	51.43	53.90
7	Harbanswala	42.04	41.20	47.33	55.02
8	Tarla Nagal	53.72	48.65	51.20	55.51
9	Nanurkhera	72.60	71.28	59.47	61.98
10	Kuanwala	13.80	8.20	4.95	10.66
11	Purukulgaon	26.53	19.48	29.84	8.17
12	Maldeota	10.80	4.07	8.81	12.63
13	Gularghati	14.20	8.18	12.03	12.28
14	Soda Sarauli	8.56	7.89	7.87	7.82
Doiwala block					
15	Rishikesh DW	14.52	9.97	12.16	13.19
16	Rishikesh HP	6.57	2.56	4.09	5.26
17	Lal Tappar	17.23	14.36	13.33	14.08
18	Motichur	11.67	5.38	9.16	10.08
19	Dandi	7.15	4.65	5.23	6.04
20	Khandgaon	11.90	4.70	6.27	9.00
21	Kotimaichak	22.38	17.87	17.71	19.89
22	Khadak Maaf	15.66	10.38	13.78	2.88
23	Dudhli	28.40	34.79	--	--
24	Bhaniawala	32.13	21.39	23.02	27.86

Sahaspur block					
25	Rampura	12.48	8.32	10.88	11.78
26	Jhajra DW	8.82	10.85	8.23	13.37
27	Jhajra HP	7.60	5.60	8.47	10.90
28	Selakui DW	10.05	7.23	8.83	9.84
29	Selakui HP	16.30	10.89	12.97	15.44
30	Nanda Ki Chowki DW	9.35	7.20	8.30	9.17
31	Nanda Ki Chowki HP	12.35	9.40	8.20	12.16
32	Redapur DW	2.82	4.57	5.80	12.36
33	Redapur HP	4.08	6.66	3.97	7.92
34	Shankarpur	22.46	19.80	20.23	19.10
35	Chhorba DW	--	21.30	15.99	17.30
36	Chhorba PZ	--	78.40	58.50	70.10
Vikas Nagar block					
37	Herbertpur	8.07	7.93	8.62	10.25
38	Dharmawala	5.10	4.65	5.69	4.90
39	Sabhawala	9.40	6.78	8.22	8.83
40	Singhniwala	9.79	7.34	8.05	9.44
41	Ramgarh	6.30	4.60	5.73	6.30
42	Judli	12.56	11.60	12.69	12.84
43	Badripur	8.01	7.83	9.24	8.33
44	Vikas Nagar	25.28	20.96	25.41	27.34
45	Dak Patthar	25.73	21.87	24.66	25.89
46	Barotiwala	28.02	23.14	31.66	28.32
47	Dhakrani	19.87	16.20	18.42	18.50
48	Timli	62.10	60.66	56.49	58.93
HARIDWAR DISTRICT					
Bahadrabad block					
1	Bahadrabad	3.44	10.84	10.64	12.81
2	Dhanpura	9.04	6.97	5.12	6.19
3	Bandarjud	10.45	8.35	6.63	9.45
4	Rathaura	5.05	4.05	5.43	4.85
5	Sarai	11.86	10.66	11.21	12.56
6	Shahpur Shitlakhera	5.05	3.16	3.83	3.56
7	Laldhang	61.44	59.63	59.92	59.80
8	Panjanheri	7.45	7.40	6.11	6.69
9	Dudhya Dayalwala	3.25	2.50	3.21	2.67
10	Shyampur	10.25	4.06	7.11	10.71
11	Jaswawala	--	4.40	4.09	4.43
Bhagwanpur block					
12	Budhwa Shahid	3.92	2.73	2.57	3.07
13	Shahidwala Grant DW	10.60	9.40	8.06	8.95
14	Shahidwala Grant HP	11.66	9.36	8.98	8.81
15	Bhagwanpur	22.03	18.34	18.15	15.44
16	Bahabalpur	1.30	2.98	2.54	2.50

17	Iqbalpur	17.00	17.67	15.68	13.14
18	Bugawala	6.08	3.62	--	--
19	Chudiala	22.06	22.56	19.04	18.54
20	Kota Muradnagar DW	10.68	7.75	11.65	10.11
21	Kota Muradnagar HP	8.57	9.32	5.97	6.47
Roorkee block					
22	Roorkee	7.30	6.70	6.88	6.28
23	Imlikhera	16.34	12.49	12.96	13.39
24	Nijampur	10.50	10.06	10.60	11.00
25	Ambkheri	2.80	2.34	2.47	2.10
26	Landhaura	19.75	13.40	17.63	18.48
27	Teliwala	6.25	5.25	--	--
Laksar block					
28	Hussainpur	4.73	2.63	2.47	1.98
29	Bhikkampur	4.42	2.74	3.29	10.26
30	Laksar	4.52	2.69	3.16	2.82
Narsan block					
31	Jhabrera	10.77	9.14	9.40	9.15
32	Lakhnauta	4.36	4.46	8.06	7.10
33	Gurukul Narsen	5.76	3.65	6.10	6.15
34	Libberhedi	7.25	6.19	6.35	6.43
35	Manglaur	5.88	5.53	--	--
36	Mundlana	18.48	17.49	18.00	17.78
37	Bhogpur	4.16	1.86	3.00	3.48
38	Sikhar	17.10	16.40	16.92	17.02
39	Khera Jat	6.25	5.85	6.45	6.60
Khanpur block					
40	Khanpur	3.40	1.57	2.57	2.32
41	Dallawala	2.20	1.17	1.62	1.53
42	Govardhanpur	4.45	3.03	--	--
43	Mohammadpur	1.75	1.35	1.38	0.85
PAURI GARHWAL DISTRICT					
1	Kaudiya (Kotdwar)	54.70	55.50	56.75	55.04
UDHAM SINGH NAGAR DISTRICT					
Jaspur block					
1	Jaspur	15.18	13.68	9.17	12.04
2	Patrampur	10.43	10.82	7.08	8.26
3	Angadpur	6.25	5.25	5.14	4.19
4	Durgapur	4.82	3.37	2.7	3.96
5	Missarwala	14.6	13.23	8.08	5.26
Kashipur Block					
6	Barkhare Pande	8.57	6.8	5.77	5.82
7	Sultanpur Patti	3.89	1.2	0.83	1.8
8	Kashipur	7.33	6.5	5.97	4.29
9	Bharatpur	10.05	8.18	8.29	6.25

10	Dhannauri Patti	5.76	2.35	2.74	3.01
11	Shankhera	6.5	4.1	5.18	4.52
Bazpur Block					
12	Bazpur	2.68	0.8	1.65	1.15
13	Barhini	2.65	1.3	-	-
14	Jharkhandi	2.6	2.1	1.46	0.95
15	Jogipura	8.3	2.8	2.73	3.41
16	Banna Khera	6.25	3.7	3.89	3.87
17	Kanaura	8.8	7.28	3.69	4.33
18	Pritpur	6.75	8.17	3.18	3.2
19	Badripur	6.4	6.13	3.79	5.32
Gadarpur Block					
20	Jhagarpuri	3.01	1.71	2.18	2.59
21	Mahabir Nagar	3.83	2.3	2.37	2.66
22	Kopa Signal	0.98	0.28	0.7	0.57
23	Beria Daulat	5.29	3.08	2.74	3.24
24	Bhagwanpur	6.15	6.95	4.14	3.3
25	Pattharpui	3.2	3.22	2.88	4.15
26	Badakhera	3.72	3.1	2.44	3.14
27	Lalpuri	2.92	2.62	1.68	2.05
Rudrapur Block					
28	Bara	2.15	1.95	1.88	1.95
29	Kichha	5.49	-	5.77	-
30	Kichha	6.6	5.4	5.98	7.83
31	Kamaria Pakki	6.82	7.5	4.79	4.47
32	Gangapur	4.2	1.95	2.6	2.85
33	Shantipur	2.25	3	1.9	1.65
34	Pattar Chatta	3.46	3.13	2.39	2.18
35	Rudrapur	5.2	5.1	3.15	3.52
36	Kanakpur	3.94	4.64	2.27	2.79
37	Rajpura	3.45	5.3	2.32	2.06
38	Pipiliya	6.57	6.7	2.94	3.34
Sitarganj Block					
39	Sitarganj	2.54	1.1	1.43	1.27
40	Nanak Mata	4.99	1.92	3.26	3.29
41	Kalyanpur	2.5	2.3	2.28	2.4
42	Tukri	4.64	6.66	2.09	1.93
43	Begur Mod	4.16	8.9	3.12	3.12
44	Bidora	4.66	14.65	2.48	2.67
45	Dhyanpur	3.3	6.74	1.22	1.44
Khatima Block					
46	Majhola	4.9	2.8	3.4	4.6
47	Khatima	2.9	0.1	1.76	2.12
48	Sara Sariya	1.95	4.38	2.35	2.66
49	Chakarpur	6.97	3.1	5.39	6.24

50	Barianjariya	5.9	4.8	3.26	4.14
NAINITAL DISTRICT					
Haldwani Block					
1	Khat Baas	37.50	26.75	27.1	17.5
2	Lalkuan	11.45	10.11	10.03	9.17
3	Lamachaur	46.05	46.8	42.44	39.26
4	Kaladungi	29.85	29.2	28.62	28.49
5	Kathgodham	20.15	16.15	19.05	18.86
6	Sitapur	61.75	58.19	54.96	-
Ramnagar Block					
7	Belparao	58.12	57	58.44	59.18
8	Peeru Madara	26.95	22.45	20.33	21.98
9	Maldhan Colony	5.55	2.44	2.68	3.23
10	Dhela	65.66	66	67.25	53.39
11	Ramnagar	8.19	8.13	11.13	8.7
12	Garjia	5.1	2.73	4.47	4.43
13	Dhoniya	72.35	-	60.91	47.61
14	Chilkiya	60.10	51.2	53.83	51.13
CHAMPAWAT DISTRICT					
1	Tanakpur	12.2	9.15	9.82	9.58
2	Banbasa HP	6.1	14.7	17.43	9.58
3	Bastia HP	31.25	28.53	31.24	38.46
4	Bichayee HP	18.5	17.65	15.04	10.98
UTTARKASHI DISTRICT					
1	Chiniyalisaur HP	53.57	-	26.83	47.55
2	Devidhar HP	10.6	-	12.10	9.32
3	Uttarkashi HP	19.7	-	15.20	18.15
4	Barkot HP	22.85	-	17.42	16.25
5	Serukhet HP	43.03	-	43.59	51.28
6	Ganeshpur HP	18.75	-	16.84	17.2
7	Maneri HP	17.4	-	15.11	14.1

5.2 DISCHARGE OF SPRINGS

The discharge data of thirty-four cold-water springs in Dehradun, Nainital, Uttarkashi and Almora districts for the months of May, August, November 2014 and January 2015 is given in ***Table 10.*** A study of the table shows that spring discharge is lowest in pre-monsoon (May) whereas during post-monsoon (August), the discharge increased significantly. This indicates that rainfall is the principal contributing factor for variation in spring discharge.

A perusal of ***Table 10*** indicates that discharge of the cold-water springs during the period May 2014-January 2015 varies from a minimum measurable discharge of 0.52 LPM at Someshwar in January 2015 to a maximum of 420 LPM at Sipahidhara (August 2014). Discharge of springs varies within wide limits during the intervening period.

In Dehradun district, spring discharge varies between 2.92 LPM at Bhatta in May 2014 and 42.85 LPM at Khandoli in August 2014. In Nainital district, spring discharge varies from a minimum of 2.87 LPM at Kudaghat (May 2014) to a maximum of 420 LPM at Sipahidhara (August 2014). In Almora district, the spring discharge was found to be varying from a minimum of 0.52 LPM at Someshwar in January 2015 to a maximum of 150.0 LPM at Dhansari in January 2015. In Uttarkashi district, spring discharge was varying from 2.74 LPM at Dharasau in November 2014 to a maximum of 17.57 LPM in Dharasau in January 2015.

Table 10: Discharge of Springs in May, August, November 2014 and January 2015

SL. No.	Location	May-14	Aug-14	Nov-14	Jan-15
DEHRADUN DISTRICT					
1	Bhatta SP	2.92 lpm	15.70 lpm	8.40 lpm	4.80 lpm
2	Khandoli SP	41.66 lpm	42.85 lpm	6.64 lpn	10 lpm
3	Soda Sarauli SP	5 lpm	375 lpm	17.23 lpm	5.71 lpm
UTTARKASHI DISTRICT					
4	Dharasu Spring	7.4 lpm	NA	2.74 lpm	17.57 lpm
5	Nagal Spring	7.84 lpm	NA	11.45 lpm	20 lpm
6	Ratodi Sar Spring	14.1 lpm	NA	7.02 lpm	30 lpm
NAINITAL DISTRICT					
7	Dogaon SP	15.33 lpm	13 lpm	40 lpm	20.91 lpm
8	Sipahidhara SP	194 lpm	420 lpm	198 lpm	50.0 lpm
9	Garampani SP	32.91 lpm	27.40 lpm	48 lpm	34.64 lpm
10	Salari SP	20 lpm	32 lpm	18.80 lpm	5.60 lpm
11	Ranibagh SP	3.33 lpm	33.10 lpm	58.60 lpm	NA
12	Jeolykot SP	30 lpm	98.50 lpm	38 lpm	33.08 lpm
13	Chilkiya HP	60.10	51.20	53.83	NA
14	Kudagath SP *	2.87 lpm	8.50 lpm	12 lpm	3.10 lpm
15	Amritpur SP	NA	NA	NA	10.17 lpm
CHAMPAWAT DISTRICT					

16	Lohaghat SP *	1.5 lpm	5.57 lpm	NA	NA
ALMORA DISTRICT					
17	Patali Talla SP	Dry	21 lpm	8 lpm	11.11 lpm
18	Patali Malla SP	10 lpm	23 lpm	4 lpm	5.26 pm
19	Katarmal SP	20.47 lpm	60 lpm	12 lpm	11.11 lpm
20	Dhara Naula SP	5.71 lpm	8 lpm	48 lpm	4.0 lpm
21	Palna SP	2 lpm	3 lpm	21 lpm	3.16 lpm
22	Chinoda SP	0.99 lpm	1.20 lpm	65 lpm	0.74 lpm
23	Guruda - SP	15.99 lpm	18.18 lpm	20 lpm	11.54 lpm
24	Dhansari SP	60 lpm	150 lpm	3 lpm	3.16 lpm
25	Someshwar SP	2.88 lpm	10 lpm	16 lpm	0.52 lpm
26	Dharanaulla Zoo SP	1.42 lpm	2.75 lpm	16 lpm	NA
27	Bachuradi SP	35.29 lpm	120 lpm	6 lpm	12.24 lpm
28	Deepakot SP	7.5 lpm	5 lpm	12 lpm	7.79 lpm
29	Ramgath SP	15.79 lpm	46 lpm	4 lpm	12.77 lpm
30	Bhagtola SP	1 lpm	3.87 lpm	32 lpm	1.67 lpm
31	Itola SP	1.73 lpm	3.35 lpm	16 lpm	2.75 lpm
32	Potarsain	1.13 lpm	15 lpm	22 lpm	1.32 lpm
33	Chhani Bartola SP	57.97 lpm	19.35 lpm	20 lpm	7.50 lpm

NA: Not Available

5.3 LONG TERM (DECADAL) DEPTH TO WATER LEVEL

The available long-term data of ground water levels in some of the Ground Water Monitoring Wells of the state was analyzed to have an idea of the decadal (long-term) water level data and decadal versus current depth to water level fluctuations. The average value of depth to water level for selected Ground Water Monitoring Wells (based on availability of long-term water level data) was calculated for the past ten years (May, August and November for the period from 2004 to 2013 and January for the period from 2005 to 2014). The average depth to water level data available for maximum 68 Ground Water Monitoring Wells is given in ***Table 11.***

Table 11: Long-term (Decadal) Depth to Water Level Data, Uttarakhand State

Sr. No.	Location	Depth to Water Level (m bgl)			
		Avg. May	Avg. August	Avg. November	Avg. January
		2004-2013			2005-2014
Dehradun District					
1	Rishikesh	16.15	10.23	11.80	13.03
2	Rampura	14.39	7.08	11.05	12.58
3	Kuanwala	NA	3.85	4.92	9.45
4	Herbertpur	10.21	5.17	7.99	9.51
5	Jhajra	NA	4.20	NA	10.26
6	Lal Tappar	NA	14.76	13.60	14.21
7	Motichur	10.86	4.36	7.85	9.75
8	Nanda ki chowki	14.86	7.31	8.17	9.70
9	Selakui	10.53	6.92	7.92	8.90
10	Redapur	6.51	3.85	4.88	3.37
11	Sabhawala	9.28	5.65	7.27	8.07
12	Singhniwala	9.57	6.59	8.64	9.46
13	Ramgarh	8.27	4.27	6.31	5.85
14	Kanwali	15.44	8.80	12.58	15.00
15	Chhorba	18.34	10.69	14.54	17.71
16	Majra	22.28	19.48	NA	NA
District Haridwar					
17	Bahadrabad	NA	4.02	NA	NA
18	Dhanpura	NA	3.47	NA	NA
19	Hussainpur	3.76	1.69	2.40	2.40
20	Roorkee-Pz	7.34	5.41	5.85	5.91
21	Bhagwanpur	20.43	16.26	17.32	16.62
22	Bahabalpur	3.33	2.53	2.87	3.32
23	Jhabrera	10.38	7.53	8.83	8.24
24	Iqbalpur	17.30	12.35	14.32	14.96

25	Bugawala	7.73	4.86	NA	5.98
26	Shahidwala Grant	13.24	11.29	NA	NA
27	Chudiala	NA	18.02	NA	NA
District Udham Singh Nagar					
28	Kashipur	5.77	3.11	3.77	4.03
29	Jaspur	8.48	7.83	6.65	8.13
30	Patrampur	10.10	7.43	6.48	7.32
31	Khatima	3.45	0.81	1.58	2.47
32	Bazpur	2.57	0.57	1.42	1.77
33	Kichha	NA	5.10	5.06	5.63
34	Sitarganj	4.29	1.62	2.30	2.02
35	Bara	2.70	0.94	1.89	2.21
36	Banna Khera	4.95	3.35	3.57	3.78
37	Shantipuri	2.39	0.68	1.57	1.72
38	Nanak Mata	5.41	2.56	3.22	3.88
39	Gangapur	3.43	2.63	2.29	2.88
40	Bhagwanpur	5.57	3.20	3.47	3.63
41	Beria Daulat	3.69	1.04	2.54	2.92
42	Mahabir Nagar	2.70	1.23	1.89	2.64
43	Jogipura	6.71	4.42	4.63	5.11
44	Majhola	4.57	2.66	3.62	3.88
45	Dhanauri Patti	4.49	2.46	2.61	3.24
46	Patthar Chatta	2.78	1.77	2.64	2.45
47	Chakarpur	NA	4.69	4.52	NA
48	Angadpur	NA	3.98	3.87	NA
49	Barkhare Pande	NA	4.17	NA	NA
50	Barhini	1.74	0.49	NA	NA
51	Kamaria Pakki	6.81	3.44	NA	NA
52	Jhagarpuri	2.73	1.17	NA	NA
53	Kalyanpur	NA	1.33	NA	NA
District Nainital					
54	Lalkuan	9.10	8.28	7.29	6.98
55	Garjia	4.37	2.78	4.30	4.26
56	Maldhan Colony	4.44	2.01	2.63	3.30
57	Ramnagar	7.39	6.38	6.54	6.89
58	Peeru Madara	23.24	21.96	16.15	18.90
59	Lamachaur	46.26	45.33	38.55	44.04
60	Khaat Baas	34.02	24.79	27.42	29.85
61	Sitapur	57.10	53.74	50.51	NA

62	Dohniya	66.13	66.93	56.41	NA
63	Belparao	55.93	51.75	52.11	NA
64	Dhela	60.49	66.36	64.86	NA
65	Kaladhungi	26.17	NA	NA	NA
66	Kathgodam	20.71	NA	NA	NA
District Champawat					
67	Tanakpur	11.31	6.65	8.88	10.40
68	Banbasa	8.65	7.47	9.26	7.03
69	Bastia	31.53	23.59	26.30	28.07

NA: Not Available

A perusal of the long-term (decadal) depth to water level data given in ***Table 11*** indicates that the depth to water level varies widely. The minimum long-term water level is 0.49 m bgl at Barhini hand pump in Udham Singh Nagar district in August whereas the maximum was 66.13 m bgl at Dhoniya hand pump in Nainital district in May.

The table also shows that for Dehradun district, the minimum long-term water level is 3.37 m bgl at Redarpur in January whereas the maximum is 18.34 m bgl at Chorba in May. In Haridwar district, decadal water level is varying from 1.69 m bgl at Hussainpur dug well in August to the maximum of 20.43 m bgl at Bhagwanpur hand pump in May. In Udham Singh Nagar district, the long-term depth to water level is varying from 0.49 m bgl at Barhini in August to 10.10 m bgl at Patrampur hand pump in May viz. in the pre-monsoon period. The decadal water level in Nainital district was varying from 2.01 m bgl at Maldhan Colony dug well in August to a maximum of 66.13 m bgl at Dhoniya hand pump in May viz. in the pre-monsoon period. Long-term depth to water level in Champawat district was ranging from 7.03 m bgl at Banbasa Handpump in January to 31.53 m bgl at Bastia hand pump in May viz. during pre-monsoon period.

major areas in Udham Singh Nagar-Nainital-Champawat section. Decadal decline in the range of 2-4 m is observed in western part of Udham Singh Nagar District around Jaspur; around Kaladhungi, Belparao, and Peeru Madara in Nainital district. Highest decadal decline of >4 m is observed around Angadpur (Udham Singh Nagar); Dhela, Dhoniya and Sitapur in Nanital districts).

Table 12. Decadal Water Level Fluctuation (May 2004 –May 2013 Versus May 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	12	0.14	2.51	0.12	0.81	6	50	3	25	0	0	3	25	0	0	0	0
Haridwar	8	0.04	2.64	0.39	1.60	3	38	2	25	0	0	3	38	0	0	0	0
Udham Singh Nagar	21	0.14	1.75	0.01	6.70	5	24	0	0	0	0	15	71	0	0	1	5
Nainital	13	0.21	0.56	0.73	6.22	2	15	0	0	0	0	3	23	5	38	3	23
Champawat	3	0.28	2.55	0.89	--	1	33	1	33	0	0	1	33	0	0	0	0
Total	**57**	**0.04**	**2.64**	**0.01**	**6.7**	**17**	30	**6**	11	**0**	0	**25**	44	**5**	9	**4**	7

Table 13. Decadal Water Level Fluctuation (August 2004 –August 2013 versus August 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	15	0.07	0.4	0.31	5.08	4	27	0	0	0	0	7	47	2	13	2	13
Haridwar	11	1.24	1.89	0.45	6.82	2	18	0	0	0	0	4	36	2	18	3	27
Udham Singh Nagar	25	0.11	1.62	0.14	5.85	7	28	0	0	0	0	11	44	6	24	1	4
Nainital	10	1.63	2.89	0.67	6.69	1	10	1	10	0	0	5	50	1	10	2	20
Champawat	2	--	--	2.5	4.94	0	0	0	0	0	0	0	0	1	50	1	50
Total	**63**	**0.07**	**2.89**	**0.14**	**6.69**	**14**	22	**1**	2	**0**	0	**27**	43	**12**	19	**9**	14

Table 14. Decadal Water Level Fluctuation (November 2004-November 2013 Versus November 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	13	0.17	0.91	0.03	1.31	6	46	0	0	0	0	7	54	0	0	0	0
Haridwar	6	0.33	--	0.07	1.37	1	17	0	0	0	0	5	83	0	0	0	0
Udham Singh Nagar	20	0.01	2.29	0.04	2.52	5	25	1	5	0	0	12	60	2	10	0	0
Nainital	11	0.32	--	2.39	6.33	1	9	0	0	0	0	2	18	3	27	5	45
Champawat	2	--	--	0.94	4.94	0	0	0	0	0	0	1	50	0	0	1	50
Total	**52**	**0.01**	**2.29**	**0.03**	**6.33**	**13**	25	**1**	2	**0**	0	**27**	52	**5**	10	**6**	12

Table 15. Decadal Water Level Fluctuation (January 2005-January 2014 Versus January 2015)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	15	0.02	1.4	0.16	4.55	6	40	0	0	0	0	8	53	0	0	1	7
Haridwar	6	0.42	1.82	0.37	1.16	4	67	0	0	0	0	2	33	0	0	0	0
Udham Singh Nagar	19	0.07	1.7	0.02	2.20	11	58	0	0	0	0	6	32	2	11	0	0
Nainital	6	0.07	4.78	0.17	3.08	1	17	0	0	1	17	2	33	2	33	0	0
Champawat	2	0.45	--	2.55	--	1	50	0	0	0	0	0	0	1	50	0	0
Total	**48**	**0.02**	**4.78**	**0.02**	**4.55**	**23**	48	**0**	0	**1**	2	**18**	38	**5**	10	**1**	2

Table 16. Annual Water Level Fluctuation (May 2013 Versus May 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	38	0.07	4.65	0.5	2.73	13	34	8	21	2	5	13	34	2	5	0	0
Haridwar	39	0.02	3.02	0.14	3.83	23	59	5	13	0	0	9	23	2	5	0	0
Udham Singh Nagar	31	0.01	2.96	0.11	1.74	18	58	2	6	0	0	11	35	0	0	0	0
Nainital	13	0.54	--	0.06	1.89	1	8	0	0	0	0	12	92	0	0	0	0
Champawat	3	--	5.73	0.26	0.5	0	0	0	0	1	33	2	67	0	0	0	0
Total	**124**	**0.01**	**5.73**	**0.06**	**3.83**	**55**	44	**15**	12	**3**	2	**47**	38	**4**	3	**0**	0

Zone. Higher annual decline of 2-4 m is observed along the Bhagwanpur- Kamaria Pakki in Udham Singh Nagar; Dhela-Ramnagar in Nanital District and also at Tanakpur in Champawat district. The highest annual decline of >4 m is inferred only around the Rudrapur in Udham Singh Nagar District.

Table 17. Annual Water Level Fluctuation (August 2013 Versus August 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	33	0.23	2.15	0.18	5.18	9	27	1	3	0	0	12	36	7	21	4	12
Haridwar	36	0.22	4.20	0.20	8.80	9	25	1	3	2	6	17	47	3	8	4	11
Udham Singh Nagar	30	1.20	--	0.03	4.39	1	3	0	0	0	0	24	80	4	13	1	3
Nainital	10	1.52	2.64	0.50	3.85	1	10	3	30	0	0	4	40	2	20	0	0
Champawat	1	--	--	--	2.65	0	0	0	0	0	0	0	0	1	100	0	0
Total	**110**	**0.22**	**4.20**	**0.03**	**8.80**	**20**	18	**5**	5	**2**	2	**57**	52	**17**	15	**9**	8

Table 18. Annual Water Level Fluctuation (November 2013 Versus November 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	34	0.04	3.07	0.35	5.82	6	18	3	9	0	0	14	41	7	21	4	12
Haridwar	38	0.11	4.21	0.01	4.72	10	26	3	8	1	3	19	50	2	5	3	8
Udham Singh Nagar	47	0.01	1.01	0.04	3.98	23	49	0	0	0	0	22	47	2	4	0	0
Nainital	14	0.26	5.71	0.15	3.97	2	14	1	7	1	7	5	36	5	36	0	0
Champawat	3	0.48	--	0.11	5.84	1	33	0	0	0	0	1	33	0	0	1	33
Total	**136**	**0.01**	**5.71**	**0.01**	**5.84**	**42**	31	**7**	5	**2**	1	**61**	45	**16**	12	**8**	6

Table 19. Annual Water Level Fluctuation (Annual January 2014Versus January 2015)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	37	0.05	1.64	0.45	5.14	9	24	0	0	0	0	20	54	3	8	5	14
Haridwar	35	0.15	0.52	0.05	5.42	6	17	0	0	0	0	25	71	3	9	1	3
Udham Singh Nagar	47	0.05	0.7	0.02	3.56	11	23	0	0	0	0	34	72	2	4	0	0
Nainital	9	0.03	4.95	0.25	0.86	4	44	0	0	1	11	4	44	0	0	0	0
Champawat	3	1.32	4.12	--	4.93	1	33	0	0	1	33	0	0	0	0	1	33
Total	**131**	**0.03**	**4.95**	**0.02**	**5.42**	**31**	24	**0**	0	**2**	2	**83**	63	**8**	6	**7**	5

Udham Singh Nagar district. The lowest seasonal decline of 0-2 m is observed along the Northwestern part of the Bhabar zone and as isolated patches around Tukri, Bhagwanpur and Rajpur in Udham Singh Nagar district. Seasonal decline of 2-4mis observed as isolated patch at Ramnagar in Nanital district only. Whereas the seasonal decline of >4m is not recorded in this section.

Table 20. Seasonal Water Level Fluctuation (May 2014 Versus August 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	48	0.14	11.12	1.00	6.39	13	27	11	23	18	38	1	2	3	6	2	4
Haridwar	36	0.05	6.35	0.10	7.40	21	58	8	22	2	6	4	11	0	0	1	3
Udham Singh Nagar	42	0.10	5.50	0.02	2.02	22	52	10	24	1	2	8	19	1	2	0	0
Nainital	13	0.63	6.79	0.32	2.94	4	31	2	15	4	31	2	15	1	8	0	0
Champawat	3	0.85	3.05	--	--	1	33	2	67	0	0	0	0	0	0	0	0
Total	**142**	**0.05**	**11.12**	**0.02**	**7.40**	**61**	43	**33**	23	**25**	18	**15**	11	**5**	4	**3**	2

isolated patches at Sara sariya (Udham singh nagar); Belparao and Dhela in Nanital district. The seasonal decline in the range of 2-4 m is observed only at Ramnagar in Nanital District. Whereas, the highest seasonal decline (>4 m) is not recorded by any monitoring for which the data is available.

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Table 21. Seasonal Water Level Fluctuation (May 2014 Versus November 2014)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	43	0.11	13.13	0.11	3.64	16	37	9	20.9302	8	19	7	16	3	7	0	0
Haridwar	36	0.04	3.92	0.10	7.20	19	53	9	25	0	0	6	17	1	3	1	3
Udham Singh Nagar	47	0.22	6.52	0.40	--	25	53	17	36.1702	4	9	1	2	0	0	0	0
Nainital	12	0.63	6.79	0.32	2.94	4	33	2	16.6667	3	25	2	17	1	8	0	0
Champawat	3	0.01	3.46	--	--	1	33	2	67	0	0	0	0	0	0	0	0
Total	**141**	**0.01**	**13.13**	**0.1**	**7.2**	**65**	46	**39**	28	**15**	11	**16**	11	**5**	4	**1**	1

Table 22. Seasonal Water Level Fluctuation (May 2014 Versus January 2015)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2-4*		*>4*		*0-2*		*2-4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	41	0.18	18.36	0.28	3.84	14	34	7	17	5	12	10	24	5	12	0	0
Haridwar	35	0.20	6.59	0.35	5.84	21	60	5	14	1	3	6	17	1	3	1	3
Udham Singh Nagar	43	0.10	3.80	0.71	0.95	26	60	15	35	0	0	2	5	0	0	0	0
Nainital	10	0.67	8.97	0.51	2.03	3	30	2	20	2	20	2	20	1	10	0	0
Champawat	4	--	2.62	3.48	7.52	0	0	1	25	0	0	0	0	1	25	2	50
Total	**133**	**0.1**	**18.36**	**0.28**	**7.52**	**64**	48	**30**	23	**8**	6	**20**	15	**8**	6	**3**	2

CHAPTER – 6

HYDROCHEMISTRY

Monitoring of groundwater quality is very important as this determines the suitability of groundwater for various purposes like domestic, agricultural and industrial use and also for deciphering the water quality trends in space and time. Analysis of hydrochemical data also helps in evaluating the nature and extent of groundwater pollution and to ascertain the effectiveness of pollution control measures already in existence.

The chemical quality of groundwater in Uttarakhand State has been ascertained from complete chemical analysis of one hundred and seventy-two (172) water samples collected during pre-monsoon period (May 2014). The analysis was carried out in Chemical Laboratory, North Region, Luckhnow. The result of chemical analysis for four parameters viz. Electrical Conductivity (EC), chloride (Cl), nitrate (NO_3) and fluoride (F) has been used to prepare thematic maps. The water samples were collected from ground water monitoring stations like dug wells, hand pumps and springs in Dehradun, Haridwar, Pauri Garhwal, Udham Singh Nagar, Nainital, Almora, Champawat and Uttarkashi districts. The result of chemical analysis is given in ***Table 23***.

6.1 Analytical Results and Discussions

The chemical quality of groundwater of shallow and deep aquifers in Uttarakhand State varies widely depending on physiography, soil texture and geology of the area. The aquifers are mostly dominated by Ca-Mg-HCO_3 and Ca-HCO_3 types of groundwater. The general chemical quality reveals that most of the wells contain low dissolved mineral contents and hence, groundwater in Uttarakhand state is fresh and potable. The chemical quality of groundwater with respect to Electrical Conductivity (EC), chloride (Cl), nitrate (NO_3) and fluoride (F) are given separately.

Table 23. Chemical Analysis of Water Samples Collected from Ground Water Monitoring Stations, Pre-monsoon (May 2014)

Sl.No.	Location	pH	E.C. (m/cm) at 25°C	Concentration (mg/l)											
				CO_3	HCO_3	Cl	F	NO_3	SO_4	TH as $CaCO_3$	Ca	Mg	Na	K	SiO_2
District: Dehradun															
1	Jhajra	7.92	370	nil	183	14	0.08	3.1	4.3	150	48	7.3	8.5	0.8	30
2	Majra	7.86	900	nil	317	14	0.09	16	146	400	92	41	14	0.8	28
3	Tarla Nagal	8.16	500	nil	256	14	0.08	nd	8.6	230	36	34	3.4	1.2	17
4	Nanda Ki Chowki	8.03	410	nil	159	36	0.08	1.8	6.7	160	44	12	16	0.8	17
5	Selaqui	7.42	280	nil	85	21	0.01	19	17	100	16	15	13	0.8	39
6	Badripur	7.67	360	nil	183	7.1	0.09	0.6	9.6	140	48	4.9	11	0.8	35
7	Badonwala	7.86	670	nil	293	21	0.03	16	38	300	72	29	8.5	0.8	29
8	Kuanwala	8.03	270	nil	134	7.1	0.08	nd	5	110	24	12	6.9	1.5	19
9	Rishikesh	7.98	400	nil	159	14	0.13	5	37	170	40	17	6.9	1.2	23
10	Purkulgaon	7.81	450	nil	110	14	0.12	3.1	103	200	56	15	7.4	0.8	23
11	Maldevta	8.57	2350	12	159	92	0.53	0.2	816	170	12	34	448	9.7	8
12	Gularghati	8.04	860	nil	207	14	0.2	0.37	221	400	92	41	3.2	1.2	16
13	Khandgaon	7.89	530	nil	220	28	0.16	nd	29	180	36	22	35	1.5	14
14	Lal Tappar	7.81	220	nil	85	21	0.06	0.24	5.8	90	16	12	5.5	1.2	8
15	Kotimaichak	7.50	235	nil	110	7.1	0.19	1.9	6.7	90	20	9.7	9.9	0.8	17
16	Soda Sarauli	7.89	350	nil	122	14	0.11	3.1	46	140	40	9.7	12	1.2	24
17	Bhaniawala	8.06	600	nil	171	14	0.11	1.2	125	270	56	32	4.6	1.2	15
18	Sahaspur	7.69	240	nil	85	28	0.1	0.3	2.4	80	16	9.7	15	0.8	14

19	Dakpathar	7.77	350	nil	146	14	0.16	9.3	20	140	40	9.7	14	1.2	22
20	Barotiwala	7.26	190	nil	73	14	0.07	5	5.7	70	12	9.7	9.2	0.4	32
21	Dhakrani	7.53	180	nil	61	14	0.06	0.6	14	70	20	4.9	5	0.8	21
22	Timli	7.56	250	nil	128	7.1	0.1	0.6	1.9	100	28	7.3	7.4	0.8	33
23	Barawala	7.61	185	nil	49	7.1	0.09	27	14	70	16	7.3	7.1	0.8	31
24	Baluwala	7.26	165	nil	79	7.1	0.09	2.5	2.4	50	12	4.9	13	0.4	39
25	Telpura	7.76	880	nil	354	28	0.03	28	77	400	92	41	7.8	0.8	26
26	Haripur	7.85	350	nil	146	14	0.08	13	18	140	44	7.3	9.7	1.9	24
27	Mothrowala	7.91	680	nil	281	14	nd	nd	72	310	64	36	9.4	0.8	17
28	Chandmari	7.99	720	nil	232	14	nd	3.1	134	340	72	39	3.7	1.2	17
29	Chhorba	8.18	170	nil	73	14	nd	nd	2.4	50	12	4.9	13	0.4	25
30	Khandari College	8.12	400	nil	171	21	0.12	1	19	150	24	22	19	1.5	22
31	Bhatta	8.28	630	nil	232	21	0.15	2.3	84	300	56	39	3	0.7	17
32	Khandoli	8.04	135	nil	61	7.1	nd	nd	2	50	4	9.7	5.5	0.3	37
33	Soda Sarauli	9.51	225	24	24	2.1	0.07	2	16	80	16	10	11	0.5	29
District: Haridwar															
34	Budhwa Shahid	8.00	505	nil	305	7.1	nd	18	7.1	260	72	19.5	8.5	1.4	22
35	Shahidwala Grant	7.90	581	nil	329	7.1	nd	34	6	300	76	26.8	8.3	1.3	20
36	Buggawala	8.10	564	nil	342	7.1	nd	23	5.4	290	76	24.3	9.2	1.4	22
37	Bandarjud	8.00	592	nil	366	14	nd	5.5	2.5	295	64	32.8	14	1.6	24
38	Rathaura	7.80	570	nil	354	7.1	nd	0.25	2.8	230	32	36.5	35	2.7	25
39	Kota Muradpur	8.00	628	nil	403	7.1	nd	0.18	3.2	260	56	29.2	39	2.4	26
40	Teliwala	7.90	902	nil	317	92	nd	33	71	360	108	21.9	63	2.9	15
41	Imlikhera	8.10	564	nil	354	7.1	0.12	1.4	6.3	135	28	15.8	80	1.9	18
42	Bahabalpur	8.00	559	nil	354	11	0.08	1.8	2.7	245	48	30.4	29	1.8	20
43	Bhagwanpur	8.10	812	nil	329	96	0.12	0.81	37	350	72	41.3	44	3.6	21

44	Chudiyala	7.69	620	nil	378	14	0.36	nd	10	275	56	32.832	29	3.2	25
45	Iqbalpur	7.97	455	nil	262	18	0.52	nd	9.1	200	44	22	20	4.6	26
46	Jhabrera	7.75	950	nil	354	78	0.33	26	80	360	68	46	70	8.4	25
47	Chudiyala	8.03	420	nil	250	3.5	0.22	0.09	13	180	44	17	14	3.8	26
48	Khera Jat	8.15	455	nil	244	11	0.14	5.1	25	230	52	24	8.1	3.8	30
49	Gurkul Narsan	8.15	545	nil	281	25	0.2	nd	36	280	60	32	7.5	4.3	26
50	Libraheri	7.75	1535	nil	494	128	0.13	86	177	490	64	80	80	119	28
51	Manglore	7.86	544	nil	299	11	0.21	1.3	37	270	68	24	6.9	5.9	22
52	Landhaura	7.75	550	nil	329	7.1	0.11	7.7	13	250	64	22	23	3.2	32
53	Sikhar	8.10	655	nil	378	14	0.04	23	11	315	76	30	19	2.5	32
54	Amkheri	8.15	397	nil	220	11	0.3	11	7.8	180	48	15	11	2.8	28
55	Mundlana	7.88	665	nil	329	35	0.13	29	23	290	76	24	31	4	31
56	Hussainpur	8.20	465	nil	287	11	0.03	0.08	4.3	185	36	23	30	5	24
57	Laksar	7.70	1500	nil	390	128	nd	3.8	310	610	88	95	92	11	14
58	Goverdhanpur	7.90	725	nil	427	21	0.01	0.31	17	200	44	22	87	5.1	20
59	Khanpur	8.20	630	nil	366	21	0.19	nd	18	180	40	19	74	7	19
60	Dallawala	8.05	800	nil	403	43	0.1	0.94	45	230	60	19	88	8.1	20
61	Roorkee	8.16	332	nil	171	7.1	0.44	nd	22	155	40	13	8.2	2.9	19
62	Bahadrabad	8.00	262	nil	128	7.1	0.21	nd	20	120	36	7.3	5.3	0.49	20
63	Sarai	7.66	756	nil	342	35	0.17	31	43	230	60	19	35	72	17
64	Panjaheri	8.18	505	nil	256	21	0.14	9.5	23	235	68	16	17	4.8	12
65	Dhanpura	8.04	588	nil	256	28	0.13	36	44	270	52	34	22	4.8	20
66	Shpur Sitlakhera	7.98	730	nil	342	28	0.21	41	42	310	68	34	19	36	20
67	Bikkhampur	7.76	585	nil	317	14	0.23	0.18	30	280	60	32	17	4.3	23
68	Bhogpur	8.19	940	nil	427	43	0.23	25	67	315	84	26	39	91	22
69	Sultanpur	7.70	1095	nil	415	85	nd	49	82	435	92	50	62	20	23
70	Dudha	7.84	537	nil	281	14	0.05	0.1	34	225	56	21	22	2.2	24

	Dayalwala														
71	Laldhang	7.85	572	nil	305	7.1	nd	8.3	35	280	88	15	15	1.5	17
72	Shyampur	7.86	598	nil	336	14	0.01	15	21	295	72	28	8.7	3.4	19
72	Bhupatwala	8.10	555	nil	329	14	0.08	1.7	12	260	72	19	21	2.1	22
District: Pauri Garhwal															
73	Kotdwar	8.20	560	nil	305	14	0.22	2.47	13	230	48	27	25	2.39	29
District: Uttarkashi															
74	Chiniyalisaur	8.01	835	nil	305	64	0.14	41	29	280	72	24	57	7	27
75	Devidhar	8.21	320	nil	159	14	0.13	0.6	2.6	125	24	16	11	0.7	18
76	Uttarakashi	7.96	425	nil	159	36	0.07	13	14	160	40	15	17	5.5	27
77	Barkot	7.94	180	nil	73	14	nd	nd	2	70	16	7.3	6	0.6	18
78	Sharukhet	8.12	290	nil	122	21	0.01	nd	4.6	100	20	12	15	1.3	16
79	Ganeshpur	7.92	120	nil	37	11	nd	nd	7.6	50	16	2.4	0.4	3.1	16
80	Maneri	7.86	350	nil	98	50	0.14	nd	17	70	8	12	41	3.4	19
81	Dharasu	8.26	500	nil	268	7.1	0.09	0.8	6.36	180	64	4.9	20	15	27
82	Nagal	8.08	225	nil	85	21	nd	nd	6	100	20	12	3	0.3	22
83	Rotori Sar	8.03	230	nil	92	14	0.01	7.2	8.5	100	28	7.3	3	2	27
District: Udham Singh Nagar															
84	Angadpur	8.03	400	nil	244	7.1	0.35	0.26	4.7	180	56	9.7	12	0.92	35
85	Patrampur	7.96	520	nil	317	14	0.68	0.09	1.8	180	32	24	41	0.89	29
86	Jaspur	8.30	650	nil	403	7.1	1.4	0.38	3.9	90	20	9.7	113	1.06	23
87	Durgapur	8.25	500	nil	293	7.1	0.43	0.06	5.8	200	52	17	27	1.34	29
88	Bharatpur	8.27	570	nil	342	7.1	0.93	0.28	4.2	120	24	15	77	1.53	23
89	Missarwala	8.19	500	nil	293	7.1	0.27	1.46	8.9	200	64	9.7	27	1.7	31
90	Barkhera Pandey	8.06	450	nil	256	7.1	0.36	nd	11	170	28	24	31	1.87	30
91	Kashipur	7.80	750	nil	342	43	0.25	0.68	43	230	44	29	63	2.57	29
92	Sultanpur Patti	8.15	369	nil	207	7.1	0.14	nd	nd	160	36	17	9.5	1.38	26

93	Kanaura	8.18	597	nil	342	14	0.32	2.31	nd	260	56	29	15	1.56	31
94	Jhagarpuri	8.24	620	nil	317	7.1	0.32	0.02	54	260	36	41	27	1.95	30
95	Patharpur	8.07	699	nil	354	21	0.25	0.28	9	310	44	49	11	8.72	21
96	Badakheda	7.90	684	nil	366	7.1	0.21	1.54	20	310	56	41	15	2.05	30
97	Mahabir Nagar	8.20	490	nil	195	7.1	0.13	3.92	65	230	20	44	7.2	1.71	30
98	Lalpuri	8.20	510	nil	293	7.1	0.1	3.68	8	230	48	27	8.5	1.71	32
99	Kopa Signal	8.20	510	nil	293	14	0.21	0.47	2	240	36	36	5.9	2.19	27
100	Beria Daulat	7.80	661	nil	293	50	0.21	0.26	22	290	36	49	25	2.27	31
101	Badripur	8.14	740	nil	390	14	0.21	0.12	26	320	40	54	29	3.26	24
102	Pritampur Fauji Colony	7.90	627	nil	354	7.1	0.21	0.12	20	270	52	34	17	1.6	31
103	Jogipur	7.80	6.2	nil	366	14	0.27	nd	1	270	40	41	16	1.53	30
104	Bannakhera	7.90	650	nil	390	7.1	0.18	0.02	5	290	48	41	16	1.5	30
105	Bazpur	7.80	725	nil	366	21	0.25	0.11	50	280	52	36	40	1.54	33
106	Jharkhandi	7.70	680	nil	390	7.1	0.16	9.8	14	320	48	49	8.9	1.24	30
107	Barhani	7.80	650	nil	305	14	0.19	0.21	69	280	28	51	24	1.18	28
108	Sankhera	8.14	399	nil	207	7.1	0.17	2.3	2	170	32	22	9.6	1.23	30
109	Bhagwanpur	8.00	350	nil	207	7.1	0.26	nd	5	150	32	17	12	2.38	31
110	Patthar Chatta	7.90	413	nil	232	7.1	0.20	5.2	17	190	40	22	8.9	2.89	34
111	Santipur	8.10	343	nil	183	7.1	0.24	0.13	15	150	48	7.3	7.4	2.33	26
112	Rajpura	8.10	370	nil	195	7.1	0.49	0.73	20	150	44	9.7	15	1.41	31
113	Sitarganj	7.90	450	nil	268	7.1	0.28	nd	8	170	48	12	26	1.84	31
114	Kalyanpur	8.00	360	nil	207	7.1	0.20	nd	7.7	130	32	12	27	1.89	31
115	Begur Mod	8.00	450	nil	268	7.1	0.48	nd	15	160	40	15	34	1.16	28
116	Bara	8.20	450	nil	256	7.1	0.38	0.07	20	170	40	17	31	1.65	29
117	Pipiliya Chauraha	8.10	501	nil	220	7.1	0.42	0.71	55	230	52	24	12	1.66	32
118	Kiccha	8.15	343	nil	183	7.1	0.46	0.34	23	140	40	9.7	16	1.63	30

119	Bidora	7.97	371	nil	220	7.1	0.20	nd	8	150	44	9.7	19	1.58	30
120	Nanak Mata	7.84	700	nil	366	21	0.64	1.8	28	240	44	32	41	13.82	25
121	Tukri	7.90	414	nil	220	7.1	0.29	0.57	nd	160	44	12	17	1.17	27
122	Dhayanpur	7.90	398	nil	244	7.1	0.20	nd	0.5	170	44	15	14	1.44	29
123	Khatima	8.10	510	nil	317	7.1	0.39	1.27	nd	200	44	22	29	2.8	32
124	Chakarpur	7.70	399	nil	220	7.1	0.22	0.39	nd	160	56	4.9	9.3	2.22	25
125	Majhola	7.60	430	nil	256	7.1	0.19	0.29	nd	190	60	9.7	9.6	2.3	21
126	Barinjariya	8.10	350	nil	207	7.1	0.35	nd	nd	160	44	12	8.3	2.61	27
127	Sara Sariya	8.10	750	nil	403	7.1	0.64	0.13	30	220	40	29	77	1.13	25
128	Gangapur	8.20	400	nil	232	7.1	0.21	6.56	2	180	48	15	9.2	2.64	34
129	Kanakpur	8.20	410	nil	232	7.1	0.2	8.36	2.2	180	56	9.7	8.4	2.71	35
130	Kamariaya Pakki	8.20	354	nil	183	7.1	0.3	3.2	23	150	40	12	15	2.24	32
131	Rudrapur	8.10	360	nil	183	7.1	0.3	4.54	24	150	36	15	16	2.27	33
132	Dhanauri Patti	8.10	685	nil	256	85	0.4	0.68	23	260	52	32	39	1.96	28
District Nainital															
133	Bhelparao	8.00	632	nd	354	14	0.04	2.4	35	330	64	41.3	8.2	1.5	22
134	Dhela	7.80	523	nd	305	11	nd	14	11	265	84	13.4	11	1.5	15
135	Peeru Madara	7.90	458	nd	268	14	nd	7.6	6.6	230	60	19.5	9.5	1.6	22
136	Dhoniya	7.90	543	nd	232	7.1	nd	6.8	86	285	60	32.8	5.5	1.1	17
137	Lamchaur	8.00	302	nd	171	7.1	nd	0.21	16	150	32	17	6.9	1	14
138	Kaladungi	8.10	661	nd	329	14	nd	4.2	65	350	64	46.2	5.8	1.3	18
139	Kathgodam	8.10	553	nd	293	21	nd	19	19	255	68	20.7	21	4.7	18
140	Khat Baas (Pachuakhera)	8.00	473	nd	281	7.1	nd	9	9.2	240	76	12.2	8	1.2	18
141	Dogaon	7.90	412	nd	256	7.1	nd	1.1	5.8	200	56	14.6	11	1.6	15
142	Garam Pani	8.00	175	nd	92	11	nd	1.22	3.3	90	20	9.7	1.8	0.69	12
143	Salari	7.90	356	nd	183	14	0.02	10	12	180	44	17	6.5	1.5	28

144	Kudagath	7.80	498	nd	256	14	nd	5.6	38	270	36	43.8	1.4	0.84	6.7
145	Jeyolikote	8.00	279	nd	146	7.1	nd	6.2	12	130	32	12.2	8.2	2.8	13
146	Sitapur	7.90	324	nd	171	14	0.13	0.26	15	160	36	17	8.1	1	19
147	Ranibagh	8.00	573	nd	262	32	nd	44	18	270	80	17	20	3.3	19
District Almora															
148	Patli Malla	8.00	291	nd	153	14	nd	4.3	13	140	44	7.3	8.9	1.8	19
149	Katarmal	7.90	252	nd	67	32	nd	22	17	100	32	7.9	14	5	35
150	Dharanaula	7.90	570	nd	98	64	nd	110	43	160	52	7.3	62	12	29
151	Palna	8.00	154	nd	73	7.1	0.09	0.88	6.9	60	12	7.3	8.1	2.1	31
152	Chinoda	7.90	192	nd	98	14	nd	0.26	3.7	100	24	9.7	2.7	0.53	16
153	Guruda-II	8.00	63	nd	24	7.1	0.05	0.31	3.3	30	8	2.4	0.09	2	10
154	Someshwar	8.00	92	nd	49	5.3	nd	0.16	3	50	16	2.4	0.34	0.1	12
155	Bachuradi	7.80	691	nd	366	28	nd	38	12.1	340	56	48.6	9.5	17	15
156	Bhagtola	7.90	159	nd	85	7.1	nd	0.94	4.5	65	24	1.2	8.9	0.6	23
157	Itola	7.90	162	nd	73	14	nd	3.5	4.1	70	16	7.3	8.1	1.1	26
158	Channi Bartola	7.90	99	nd	43	11	nd	0.49	3.1	50	12	4.9	1.5	1.1	12
159	Dhalangaon	7.90	476	nd	256	21	1.64	2.1	14	180	36	21.9	32	10	13
160	Semalkhet	8.00	335	nd	201	7.1	nd	7.6	5.5	180	40	19.5	1.3	1.7	9.2
161	Naula	7.90	209	nd	122	7.1	nd	0.43	5.6	105	24	10.9	4.2	1.3	13
166	Baniya Diggi	7.80	215	nd	104	14	nd	6.9	8	85	28	3.6	14	2.5	25
167	Jholi	7.90	115	nd	37	12	nd	4.9	8.1	40	12	2.4	8.2	1.9	26
168	Dhansari	7.80	367	nd	232	7.1	0.03	0.71	4.6	200	40	24.3	0.43	0.8	10
169	Dhansari-II	7.95	365	nd	220	11	nd	1.18	4.5	200	40	24.3	0.4	0.68	9.7
170	Gurna	7.90	460	nd	281	11	nd	0.74	6	250	44	34	0.5	1	11
171	Dharanaulla Zoo	8.00	124	nd	55	7.1	nd	3.3	5.8	40	8	4.9	11	1.9	39
172	Peepla Dhar	7.90	368	nd	220	11	nd	0.63	3.7	200	36	26.8	0.31	0.53	11