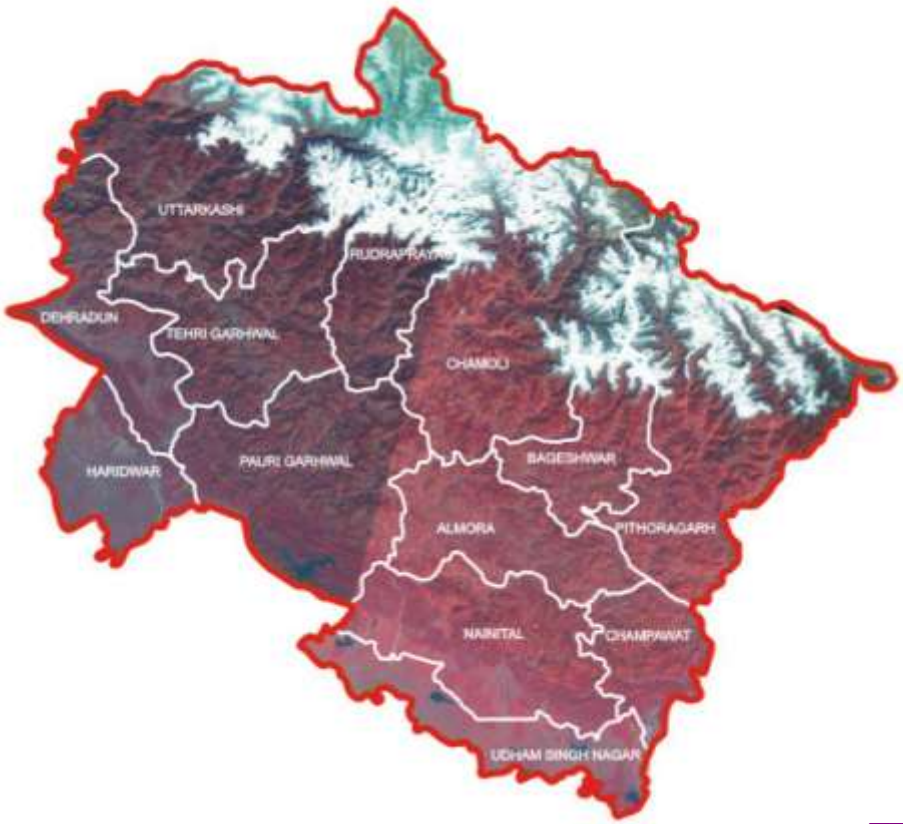
GROUND WATER YEAR BOOK 2018–2019

UTTARAKHAND

केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board



देहरादून
Dehra Dun

उत्तरांचल क्षेत्र
Uttaranchal Region

जनवरी2020
January 2020

केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board

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UTTARAKHAND

Contributor

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CENTRAL GROUND WATER BOARD

UTTARANCHAL REGION
DEHRADUN
January 2020

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 2018 – 2019.*

Central Ground Water Board, Uttaranchal Region is monitoring the groundwater regime under various hydrogeological setting through200ground 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-sixsprings 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, 2018 – 2019is the outcome of the effort made by Ms. Chandreyee De, Scientist- 'B' (Junior Hydrogeologist) and Sh. Debojyoti Mondal (Junior Hydrogeologist). The maps of the year book are prepared manually and then digitised. 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.

Place: Dehradun

Head of the Office

ACKNOWLEDGEMENT

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GROUND WATER YEAR BOOK, UTTARAKHAND (2018 – 2019)

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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 2018 to January 2019, 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 2018 and January 2019.

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.

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 2018 to January 2019 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 2018, November 2018 (post monsoon) and January 2019 as compared to May 2018 (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 lower 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 2018– 2019

State	Range of depth to water level (m bgl)	Percentage of Wells Analyzed			
		May 2018	August 2018	November 2018	January 2019
Uttarakhand	0–5	2.08	18.00	13.46	7.55
	5-10	22.92	30.00	28.85	26.42
	10-15	25.00	16.00	15.38	20.75
	>15	50.00	36.00	42.31	45.28

Fluctuation of Water Level during the Period 2018– 2019 (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	30.34	37.08	43.93	19.63	56.35	26.19	37.59	38.35
	2–4	2.25	8.99	6.54	11.21	7.14	3.97	0.75	11.28
	>4	4.49	16.84	6.54	12.15	2.38	3.97	3.01	9.02

Annual Fluctuation of Water Level during the Period 2018 – 2019

State	Fluctuation (m)	Percentage of wells analyzed							
		May 2017 vs. 2018		August 2017 vs. 2018		November 2017 vs. 2018		January 2018 vs. 2019	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	34.75	44.92	34.51	33.10	63.70	26.71	52.03	3.11
	2–4	2.54	4.24	9.86	2.82	4.79	2.05	5.41	4.73
	>4	6.78	6.78	11.97	7.75	1.37	1.37	2.03	2.70

Seasonal Fluctuation of Water Level (Compared to May 2018)

State	Fluctuation (m)	Percentage of wells analyzed					
		August 2018		November 2018		January 2019	
		Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	50.79	9.52	57.94	4.76	60.48	13.71
	2–4	24.6	0.79	23.02	0.79	12.10	1.61
	>4	10.32	3.97	10.32	3.17	8.87	3.23

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 186 ground water samples collected from Ground Water Monitoring Wells from parts of Dehradun, Haridwar, Pauri Garhwal, Udham Singh Nagar, Nainital, Champawat and Almora district is awaited at the Chemical Laboratory, Central Ground Water Board, North Region, Lucknow. The water samples are to be 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 $CaCO_3$.

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 km². 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.

As on March 2019, a total of two hundredground 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 2018 – 2019.
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 2018 to January 2019 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 2018	*Aug 2018*	*Nov 2018*	*Jan 2019*
1.	Dehradun	51	53	55	55
2.	Haridwar	37	40	40	40
3.	Udham Singh Nagar	44	44	45	45
4.	Nainital	20	20	20	20
5.	Champawat	4	4	4	4
6.	Pauri Garhwal	1	2	2	2
7.	Almora	22	22	22	22
8.	Uttarkashi	12	11	11	12
TOTAL		**191**	**196**	**199**	**200**

Apart from the dug wells, hand pumps and piezometers, a total of thirty six springs in hilly areas of Uttarakhand were also monitored (as on January 2019). The details of these springs during the period May 2018 to January 2019 are given in ***Table 2.***

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

Sl. No.	*District*	*Number of Springs*			
		May 2018	*Aug 2018*	*Nov 2018*	*Jan 2019*
1.	Dehradun	3	3	3	3
2.	Nainital	7	7	7	7
3.	Almora	22	22	22	22
4.	Uttarkashi	4	3	4	4
TOTAL		**36**	**35**	**36**	**36**

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 2019)

River Basin/ Sub Basin	*Geology*	*Well No. & Location*
DEHRADUN DISTRICT		
Yamuna Basin, Tons Sub-basin	Doon Gravels (bouldery formation)	DDN-04 (Rampura), DDN-06 (Herbertpur), DDN-07 (Jhajra), DDN-10 (Nanda ki Chowki), DDN-11 (Selaqui), UK-DDN-PZ-12 (Ladpur) 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-6 (TarlaNagal), DDN-Pz-7 (TarlaNagal), DDN-HP-8 (Nanurkhera), DDN-HP-9 (Nanda Ki Chowki), DDN-HP-10 (Selaqui), DDN-HP-11 (Badripur), DDN-HP-13 (Kuanwala), DDN HP14(Vikas Nagar), DDN-HP-19 (Khandgaon), DDN-HP-20 (Lal Tappar), DDN-HP-21 (Kotimaichak), DDN-HP-23 (Khadakmaf), 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-36 (Baronwala), DDN-32 (Baluwala), DDN-DW-30 (Haripur), DDN-HP-36 (Chandmari), DDN-DW-23 (Duggiawala), DDN-HP-37 (Chhorba), DDN-DW-13 (Dharmawala), UK-DDN-HP 54 (Barotiwala), UK-DDN-58 (Luxmipur)

	Doon Gravels (bouldery formation) and Upper Siwaliks (conglomerate, pebbly sands, clay)	DDN--33 (Redapur), UK-DDN-47 (Sabhawala), UK-DDN-48 (Singhniwala), UK-DDN-DW-49 (Ramgarh), DDN-SP2 (Khandoli), DDN HP16 (Maldevta),DDN-SP3 (Soda Sarauli)
	Blaini – Krol, boulder beds	DDN-SP1 (Bhatta), UK-DDN-15 (Rishikesh), UK-DDN-42 (Purukulgaon) ,
HARIDWAR DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Tarai (gravel, sand and clay)	HRW-10 (Hussainpur), HRW-11 (Budhwa Shahid), HRW-12 (Shahidwala Grant), HRW-14 (Rathaura), HRW-15 (Sarai), HRW-16 (Librahedi), HRW-PZ1 (Roorkee), HRW-HP-1 (Bhagwanpur), HRW-HP-2 (Bahabalpur), HRW-HP-3 (Jhabrera), HRW-HP-4 (Iqbalpur), HRW-HP-5 (Bugawala), HRW-HP-6 (Shahpur Shitlakhera), HRW-HP-7 (Khanpur), HRW-HP-8 (Lakhnauta), HRW-HP-9 (Gurukul Narsen), 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-22 (Mudlana), HRW-HP-23 (Bhogpur), HRW-HP-25(Kotamuradnagar), HRW-HP-26 (Laksar, HRW-HP-24 (Dudhadyalwala), HRW-HP-25 (Syampur), HRW-DW-17 (Sikhar), HRW-DW-18 (Kherajat), HRW-DW-19 (Nijampur), HRW-DW-23 (Jaswawala), UK-HRW-68 (Dalupuri), UK-HRW-64 (Panjanheri), UK-HRW-82 (Dandi Ibrahimpur)
	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-07 (Bara), USN-09 (Jaspur), USN-HP-11 (Angadpur), USN-18 (Banna Khera), USN-19 (Shantipuri), USN-20 (Nanak Mata), 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 (BarkharePande), USN-HP-14 (Sultanpur Patti), USN-HP-15 (Bharatpur), USN-HP-16 (Patrampur), USN-HP-18 (Sitarganj), USN-HP-20A (Durgapur), 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-31 (Pritpur), USN-HP-32 (Badripur), USN-HP-33 (Pattharpui), USN-HP-35

		(Lalpuri), USN-HP-36 (Kanakpur), USN-HP-37 (Rajpura), ¸ USN-HP-39 (Begur Mod), USN-HP-40 (Bidora), USN-HP-41 (Dhyanpur), USN-HP-42 (Barianjaniya), USN-HP-126 (Kichha), USN-HP-19 (Tukri), USN-HP-7A (Jhagarpuri), USN-HP-38 (Pipiliya)

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-10 (Khat Baas), NTL-HP-11 (Chilkiya),
	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)
ALMORA DISTRICT		
Ganga basin, Ramganga Sub- basin	Almora – Ramgarh Formation	ALM-S-1 (PataliTalla), ALM-S-2 (PataliMalla), ALM-S-3 (Katarmal), ALM-S-4 (Dharanaula), ALM-S-5 (Palna), ALM-S-6 (Chinoda), ALM-S-7 (Guruda-I), ALM-S-8 (Dhansari), ALM-S-20 (Someshwar), ALM-S-11 (Bhoolgaon), ALM-S-12 (Deepakot), ALM-S-13 (Ramgath), ALM-S-14 (Bhagtola),ALM-S-15 (Itola),ALM-S-17 ChhaniBartola), ALM-S-18 (Lodh), ALM-S-21 (Dhalnagaon), ALM-S-22 (Semalkhet), ALM-S-23 (Naula), ALM-S-24 (Bania Diggi), ALM-S-19 (Peepal Dhar), ALM-S-25 (Jholi),
PAURI GARHWAL DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Bhabar (boulders, gravel, sand and clay)	PG-HP-1 (Kaudiya), PG-HP-2 (Ramdayalpur)
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), UK-HP8 (Charethi), UK-SP-4 (Gangnani),

DEHRADUN DISTRICT

1. Rishikesh 2. Rampura 3. Kuanwala 4. Herbertpur 5. Motichur
6. Sahhawala 7. Singhniwala 8. Ramgarh 9. Kanwali 10. Chhorba
11. Shankarpur 12. Judli 13. Jhajra 14. Rednpur 15. Majra 16. Bhaniawala
17. Balliwala 18. Harbanswala 19. Tarla Nagal 20. Nanurkhera
21. Chhorba Px 22. Nanda Ki Chowki 23. Selaqui 24. Baronwala
25. Kuanwala 26. Rishikesh 27. Purukulgaon 28. Maldevta 29. Gularghati
30. Vikas Nagar 31. Khandgaon 32. Lal Tappar 33. Kettmaichak
34. Soda Sarauli 35. CGWB Office 36. Dandi 37. Khadakmaji
38. Dudhli 39. Bhatta Sp 40. Khandoli Sp 41. Soda Sarauli Sp
42. Dakpatthar 43. Barothiwala 44. Dhakrani 45. Badripur 46. Timli 150. Chandmari
159. Sahanpur 160. Telpura 161. Laxmipur 162. Haripur 163. Baluwala 164. Ladpur

HARDWAR 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 Shillakhera 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. Saraswariya	106. Durgapur	107. Kopa Signal
108. Rudrapur		

NAINITAL DISTRICT

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

CHAMPAWAT DISTRICT

129. Banbasa 130. Tanakpur 131. Bastia 157. Bichayee

ALMORA DISTRICT

132. Patti Talla 133. Patti Malla 134. Katarmal 135. Dharanaula
136. Dharanaula Znc 137. Palna 138. Chinoda 139. Guruda-I
140. Guruda-II 141. Bachuradi 142. Someshwar 143. Dhanaari
144. Deepakot 145. Ramgarh 146. Bhagtola

UTTARKASHI DISTRICT

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

Figure 1 Location of Ground Water Monitoring Stations in Uttarakhand (As on March 2019)

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

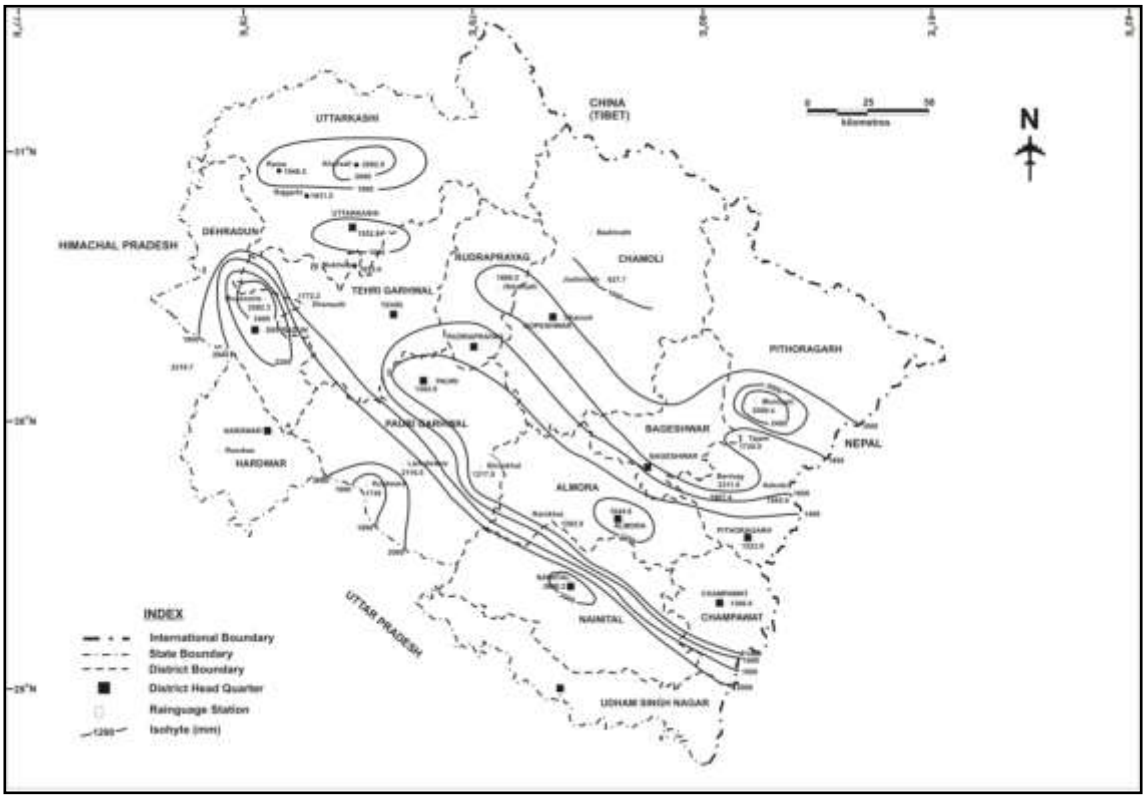


Figure 2 Mean Annual Isohyetal Map, Uttarakhand State

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 withcalcareous 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

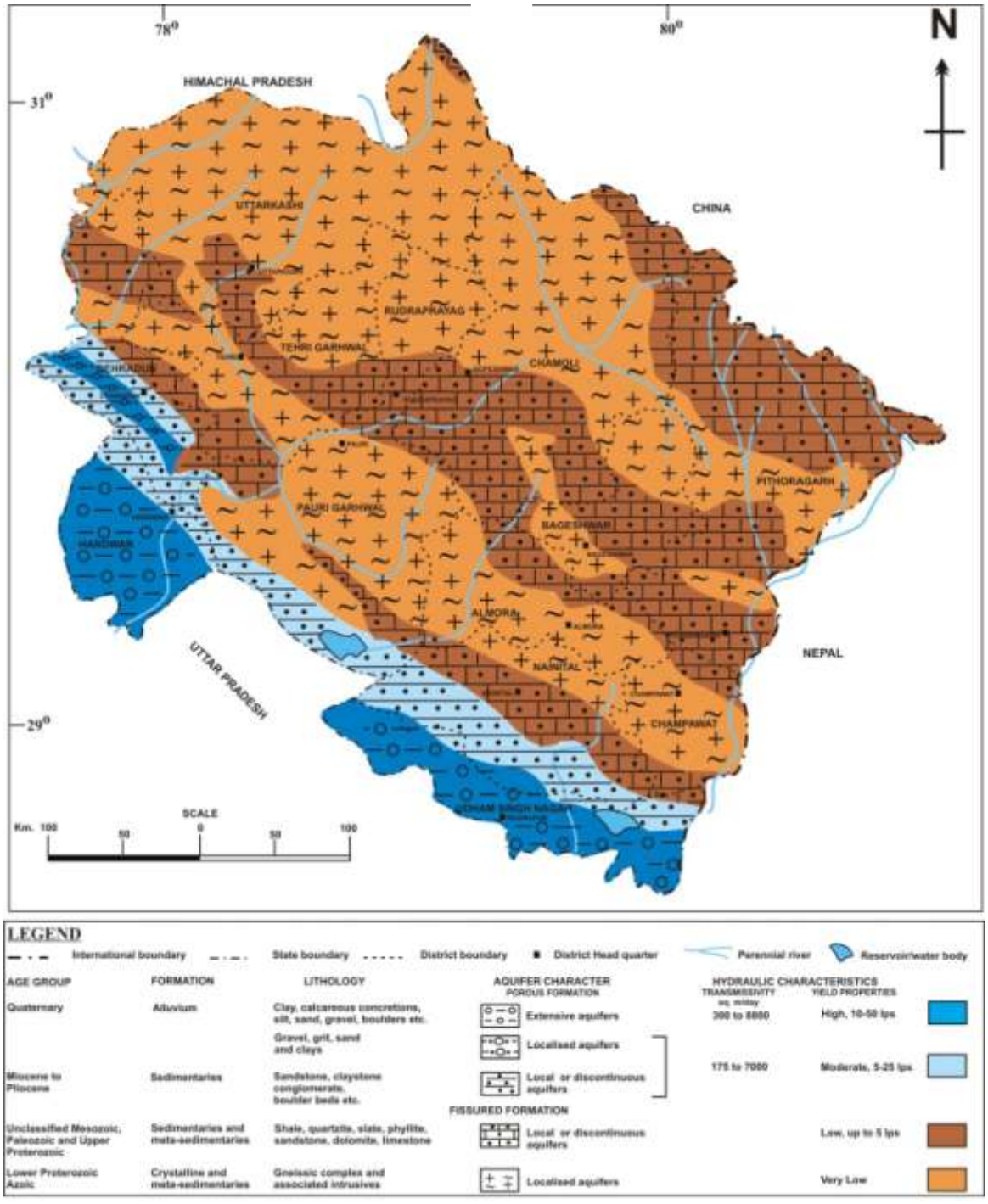
b) Confined Aquifers that occur at depths greater than 30 m bgl under very high hydrostatic pressure.

The tubewells 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 problem for ground water exploitation. Perched water bodies having smaller water resource potential are frequently encountered in this zone.

Figure 3 Hydrogeological Map of Uttarakhand



2. Himalayan Mountain Belt

This is a part of the Alpine-Himalayan Mountain Chain and constitutes a major part of the total geographical area of Uttarakhand. This zone is also known as Extra-Peninsular Region. The belt trends northwest – southeast with roughly parallel mountain ranges spanning across the state. This region can be further subdivided into 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:

2.1. 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.

2.2. 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.

2.3. **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.

2.4. **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 AND SPRING DISCHARGE

The water levels and spring discharge of Ground Water Monitoring Wells of Uttarakhand were measured four times during the period 2018-2019 (May 2018, August 2018, November 2018 and January 2019) as 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 2018 – January 2019has 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: Monitoring data of Ground Water Monitoring Wells, Uttarakhand State

Sl No.	*District*	*Block*	*Location Details*	Type of Well	Jan-19	May-18	Aug-18	Nov-18
1	Dehradun	*Doiwala*	Khandgaon	HP	7.58	10.55	5.92	6.04
2			Khadiri (Khadak Maf)	HP	15.06	14.6	10.93	16.03
3			Rishikesh	HP	4.47	9.12	4.03	4.83
4			Lal Tappar	HP	12.3	18.6	13	11.45
5			Dandi	HP	5.98	6.6	NA	0.43
6			Bhaniawala	HP	24.88	42.72	16.85	20.67
7			Dudhli	HP	NA	NA	NA	21.88
8			Kotimachak	HP	19.54	21.62	9.22	16.00
9			Chandmari	HP	26.78	35.34	26.97	24.68
10			Duggiawala	DW	1.37	2.88	3.24	6.28
11			Mathrowala	HP	9.12	12.22	5.92	8.29
12		*Raipur*	Kuanwala	HP	8.90	14.9	NA	NA
13			Gularghagti	HP	NA	14.96	8.06	10.04
14			Balliwala	HP	56.42	64.53	72.79	72.63
15			Maldeota	HP	12.68	16.97	4.33	7.86
16			Nanurkhera	HP	65.91	81.48	48.12	47.9
17			Tarla Nagal	PZ	71.55	76.23	59.76	65.40
18			Tarla Nagal	HP	85.47	45.38	44.12	50.82
19			Purukulgaon	HP	26.42	26.53	17.16	22.94
20			Majra	HP	9.93	27.96	26.04	21.03
21			CGWB Office	PZ	47.53	61.36	58.04	54.78
22			Harbanswala	HP	46.90	53.65	75.38	43.12

23			Kanwali	DW	12.50	29.18	7.2	10.75
24			Badawali *	HP	NA	NA	0.48	1.5
25	Dehradun	*Sahaspur*	Singhniwala	DW	9.01	5.12	6.34	8.57
26			Baronwala	HP	10.41	NA	10.9	9.59
27			Ramgarh	DW	6.05	6.6	5.7	5.86
28			Jhajra	HP	9.00	16	6.3	6.07
29			Jhajra	DW	10.54	13.1	NA	NA
30			Nanda ki Chowki	DW	13.86	15.63	7.86	7.05
31			Nanda ki Chowki	HP	9.72	14	15.15	11.08
32			Selakui	DW	9.44	9.56	7.24	7.90
33			Selakui	HP	14.93	17.38	12.03	13.66
34			Sabhawala	DW	7.25	8.24	4.64	6.13
35			Rampura	DW	10.26	9.88	5.31	9.37
36			Shankarpur	DW	19.90	24.7	12.03	17.97
37			Redapur	HP	5.41	7.6	5.68	4.80
38			Redapur	DW	3.14	6.5	1.73	2.58
39			Chhorba	DW	16.62	NA	NA	NA
40			Chhorba	PZ	56.95	NA	NA	NA
41			Sahaspur	HP	2.23	NA	2.86	1.73
42			Chhorba	HP	26.98	32.59	32.55	26.00
43			Telpura	HP	30.52	NA	NA	30.60
44	Dehradun	*Vikas Nagar*	Badripur	HP	8.90	8.71	5.98	8.54
45			Judli	DW	13.35	13.62	11.02	12.67
46			Herbertpur	DW	9.45	10.32	4.03	7.82
47			Vikas Nagar	HP	24.54	25.6	19.27	23.61
48			Dharmawala	DW	8.25	5.59	2.45	3.45
49			Dakpatthar	HP	24.05	26.45	21.36	23.60
50			Barwala	HP	10.41	NA	11.7	10.3
51			Barothiwala	HP	NA	26.85	16.08	16.94
52			Dhakrani	HP	17.01	12.1	7.32	11.31
53			Timli	HP	68.7	NA	13.56	Dry
54			Baluwala	HP	32.6	21.88	35.27	31.21
55			Luxmipur	HP	24.58	14.74	24.44	24.00
56			Haripur	HP	10.71	11	7.13	9.74
57			Ladpur Pz *	PZ	81.47	90.75	74.6	76.47
	District	***Block***	***Location Details***	**Type of Well**	**Jan-19**	**May-18**	**Aug-18**	**Nov-18**
1	*Haridwar*	*Bhagwanpur*	Shahidwala Grant	DW	9.50	11.95	10.6	8.91
2			Sahidwala Grant	HP	10.59	11.26	10.01	8.47
3			Budhwa Shahid	DW	3.07	4.62	2.67	2.73
4			Bugawala	HP	6.51	11.75	5.84	5.72

5			Bahabalpur	HP	2.31	3.51	0.93	1.96
6			Bhagwanpur	HP	22.18	27.5	22	17.17
7			Chudiala	HP	21.36	27.5	21.35	20.05
8			Iqbalpur	HP	18.23	20.9	10.44	13.53
9			Jaswawala	DW	3.40	NA	3.75	3.09
10			Kota Muradnagar	HP	13.45	10.1	10.84	8.82
11			Bandarjud	DW	8.66	11.78	5.48	8.53
12			Rathora	DW	6.05	4.92	4.89	3.51
13			Bahadrabad	HP	11.81	8.44	13.56	11.37
14			Sarai	DW	12.74	14.04	11.93	12.00
15			Dhanpura	HP	7.06	7.64	5.36	7.40
16		*Bahadrabad*	Shahpur Shitlakhera	HP	5.47	7.53	1.79	3.09
17			Laldhang	HP	59.90	76.3	68.09	54.83
18			Bhogpur	HP	3.74	5.45	1.51	3.05
19			Dalupuri	DW	23.77	29.05	27.25	22.66
20			Panjaheri	HP	6.96	8.02	4.3	6.30
21			Dudhya Dayalwala	HP	2.79	4	2.55	2.51
22			Shyampur	HP	11.31	10.65	9.15	9.29
23	*Haridwar*		Imlikhera	HP	16.43	3.44	17.55	16.09
24			Roorkee	PZ	5.69	7.7	5.6	5.38
25		*Roorkee*	Sikhar	DW	16.16	17.9	15.93	15.59
26			Khera Jat	DW	5.32	6.7	5.32	4.99
27			Nizampur	DW	10.15	NA	10.46	10.44
28			Jhabreda	HP	9.95	7.9	6.13	10.51
29			Landhaura	HP	18.67	21.2	18.51	17.53
30			Lakhnauta	HP	6.62	5.81	2.45	6.32
31		*Narsan*	Gurukul Narsen	HP	5.51	5.95	4.08	5.12
32			Libhrahedi	DW	5.15	7.15	4.75	5.93
33			Mudlana	HP	16.84	19.19	16.44	17.09
34			Hussainpur	DW	0.71	3.63	0.49	1.44
35		*Laksar*	Laksar	HP	2.84	4.49	1.38	2.74
36			Bhikkampur	HP	4.57	3.78	2.06	2.16
37			Govardhanpur	HP	2.27	5.53	1.05	1.79
38		*Khanpur*	Dallawala	HP	4.86	2.5	0.55	1.32
39			Khanpur	HP	2.57	4.26	1.18	2.2
40			Dandi Ibrahimpur *	HP	8.78	NA	8.54	8.54
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**Jan-19**	**May-18**	**Aug-18**	**Nov-18**
1			Khaat Baans	HP	30.27	17.5	28.11	25.79
2	Nainital	*Haldwani*	Lalkuan	DW	8.60	11.27	10.58	8.75
3			Lamachaur	HP	45.71	50.62	52.36	46.36

4	Nainital		Kaladungi	HP	30.55	29.42	27.79	27.37
5			Kathgodam	HP	19.11	19.12	17.91	14.49
6		*Ramnagar*	Belparao	HP	55.24	63.66	59.36	53.37
7			Peeru Madara	HP	28.05	25.35	25.51	21.22
8			Maldhan Colony	DW	2.31	6.23	2.53	2.2
9			Dhela	HP	68.40	69.97	71.2	70.68
10			Ram Nagar	HP	8.23	9.07	4.89	5.5
11			Garjiya	DW	3.75	4.1	3	4.19
12			Dohniya	HP	71.17	72.58	70.98	58.43
13			Chilkiya	HP	51.41	47.38	47.69	44.6
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-19**	**May-18**	**Aug-18**	**Nov-18**
1	Udham Singh Nagar	*Khatima*	Kanchanpur (Majhola) HP	HP	4.16	5.59	6.1	7.63
2			Khatima	DW	2.55	3.85	0.96	0.94
3			Sarasariya	HP	4.81	7.38	5.4	2.35
4			Chakarpur	HP	6.95	NA	3.95	3.2
5			Barianjaniya	HP	4.18	5.66	1.39	3.23
6		*Sitarganj*	Sitarganj	HP	1.60	3.42	0.92	5.18
7			Nanak Mata	DW	2.63	4.1	NA	1.94
8			Kalyanpur	HP	2.43	3.5	1.18	3.6
9			Tukri	HP	5.26	6.37	2.76	2.14
10			Begur Mod	HP	3.55	4.26	2.11	4.96
11			Bidora	HP	2.96	3	2.52	8.63
12			Dhyanpur	HP	1.96	4.09	1.3	16.01
13		*Rudrapur*	Bara	DW	2.05	2.33	0.43	1.96
14			Kichha	HP	8.21	11.32	8.58	7.63
15			Kamaria Pakki	HP	4.48	6.86	3.16	2.41
16			Gangapur	HP	3.08	4.48	1.88	4.77
17			Shantipuri	DW	2.85	2.22	0.08	3.02
18			Patthar Chatta	HP	2.58	3.48	2.06	0.77
19			Rudrapur	HP	3.32	3.33	0.87	3.18
20			Kanakpur	HP	3.31	6.06	1.78	2.14
21			Rajpura	HP	2.36	4.79	2.01	2.35
22			Pipaliya	HP	3.70	8.36	2.56	2.66
23		*Gadarpur*	Jhagarpuri	HP	2.20	3.35	1.36	1.14
24			Mahabir Nagar	HP	3.17	3.05	0.08	7.06
25			Beria Daulat	HP	3.29	2.86	1.84	7.28
26			Bhagwanpur	HP	3.89	12.07	4.63	12.04
27			Pattharpui	HP	2.13	4.1	2.24	3.2
28			Lalpuri	HP	2.09	2.93	2.04	1.81
29		*Bazpur*	Bazpur	DW	1.78	3.01	-0.02	3.0

30			Jharkhandi	HP	1.38	2.35	0.78	1.81
31			Jogipura	HP	3.51	5.61	3.74	1.13
32			Banna Khera	DW	3.66	5.13	3.18	0.82
33			Pritpur	HP	3.72	7.59	3.32	3.23
34			Badaripur	HP	3.98	5.16	3.54	3.27
35		*Kashipur*	Barkhare Pande	HP	6.26	11.98	8.72	2.31
36			Sultanpur Patti	HP	3.74	2.75	2.8	7.21
37			Kashipur	DW	5.71	7.55	5.81	2.76
38			Bharatpur	HP	7.39	12.13	12.58	12.27
39			Dhanauri Patti	HP	3.31	5.18	2.61	2.33
40			Durgapur	HP	2.94	5.42	3.81	3.27
41			Shand Khera	HP	5.91	10.63	5.5	0.94
42		*Jaspur*	Jaspur	HP	13.68	17.38	19.62	4.05
43			Patrampur	HP	10.88	11.53	12.68	1.85
44			Angadpur	HP	7.05	18.85	14.17	2.66
45			Missarwala	HP	9.26	16.19	12.03	1.09
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-19**	**May-18**	**Aug-18**	**Nov-18**
1	Champawat	Champawat	Tanakpur	DW	10.35	Dry	7.19	8.97
2			Banbasa	HP	4.43	8.31	1.39	3.24
3			Bastia	HP	36.74	43.41	21.94	22.74
4			Bichai	HP	9.48	10.21	6.98	7.75
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-19**	**May-18**	**Aug-18**	**Nov-18**
1	*Pauri Garhwal*	*Dugadda*	Kaudia (Kotdwar)	HP	60.25	60.4	69.6	51.18
			Ramdayalpur HP*	HP	66.74	NA	68.39	Dry
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-19**	**May-18**	**Aug-18**	**Nov-18**
1	*Uttarkashi*	*Chinyalisaur*	Chinyalisaur	HP	19.50	29.55	27.01	4.96
2		*Dunda*	Devidhar	HP	10.46	10.51	8.05	8.63
3			Uttarkashi	HP	17.16	17.73	15.05	16.01
4		*Naugaon*	Barkot	HP	16.90	15.07	15.34	15.97
5			Sharukhet	HP	45.28	45.4	41.18	41.23
6			Ganeshpur	HP	17.63	17.61	14.35	16.66
7		*Bhatwari*	Maneri	HP	16.12	27.93	13.22	29.24
8			Charethi HP *	HP	39.98	24.78	23.35	NA

NOTE: HA: Hand Pump, DW: Dug Well, Pz: Peizometer. NA: Not Available

DEPTH TO WATER LEVEL

5.1.1May 2018

The depth to water level data was analyzed for 154 Ground Water Monitoring Wells in Uttarakhand during May 2018 and is given in ***Table 6.*** Analysis of depth to water level data given in the table indicates that the deepest water level was 90.75 m bgl at Ladpur in Dehradun district whereas the shallowest water level was 2.22 m bgl at Shantipuri in Udham Singh Nagar, district. The depth to water level in the range of 0–5 m bgl was recorded in 33 ground water monitoring wells, which is 21.43% of the total number of wells. Water level in the range of 5–10 m bgl was shown by 40 monitoring wells (25.97% of total number), whereas deeper water level of 10–15 m bgl was recorded in 28 monitoring wells, which was 18.18% of the total number. The deepest water level of >15 m bgl was shown by 53 monitoring wells, which is 34.42% of the total monitoring wells in Uttarakhand during May 2018.

Table 6: District wise categorization of depth to water level data, May 2018

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	48	2.88	90.75	1	2.08	11	22.92	12	25.00	24	50.00
Haridwar	37	2.5	76.3	10	27.03	12	32.43	7	18.92	8	21.62
U. S. Nagar	44	2.22	18.58	21	47.73	14	31.82	6	13.64	3	6.82
Nainital	13	4.1	72.58	1	7.69	2	15.38	1	7.69	9	69.23
Champawat	3	8.31	43.41	0	0.00	1	33.33	1	33.33	1	33.33
Uttarkashi	8	10.51	45.4	0	0.00	0	0.00	1	12.50	7	87.50
Pauri Garhwal	1	60.4		0	0.00	0	0.00	0	0.00	1	100.00
Total	**154**	**2.22**	**90.75**	**33**	21.43	**40**	25.97	**28**	18.18	**53**	34.42

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for ***May 2018*** is shown in ***Fig. 4*** *(Dehradun, Section),* ***Fig.5*** *(Haridwar section)* and ***Fig. 6*** *(Nainital-Udham Singh Nagar-Champawat Section).*

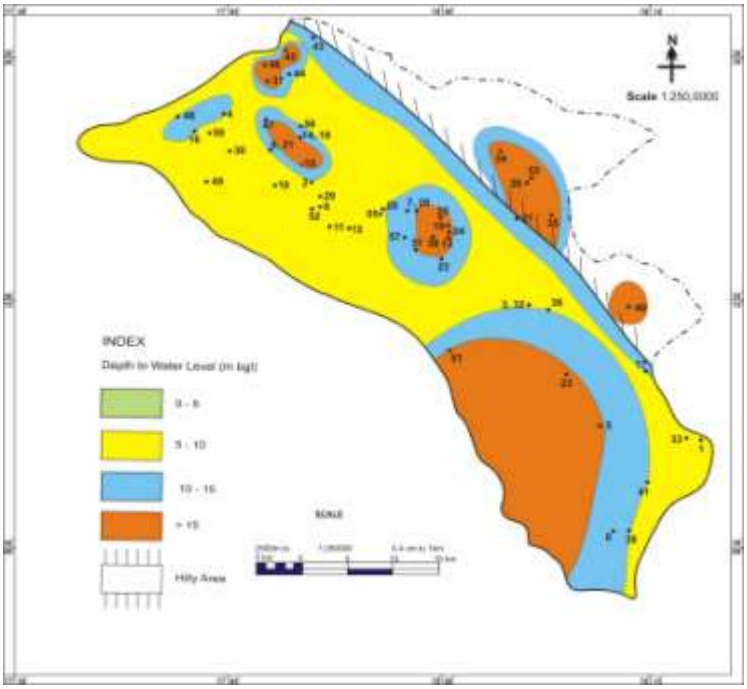


Figure 4 Depth To water Level Map (May 2018), Dehradun District

A study of Fig. 4 indicates that the major part of the Dehradun district shows shallow water levels (in the range of 5-10 m bgl). The water level in the range of 10-15 m is observed in the form of a patchesmainly covering south eastern part of Doon valley andalso as isolated patches in the north western part of the Doon valley. The deeper water level (> 15 m) occurs in the south eastern and central part of Doon valley.

The visual interpretation of the **Fig. 5** indicates that the shallowest water level in the range of 0-5m occurs mostly in the southern part of the Haridwar district and also as lenticular patch around Budhwa Sahid. The major part of the Haridwar district shows shallow water levels in the range of 5-10 m. The water level in the range of 10-15m zone occurs as patches in the western and easternparts of Haridwar district. The deepest water level in the range of more than 15m occurs as patchesin western part of the district and Laldhang (which demarcates the Bhabar zone).

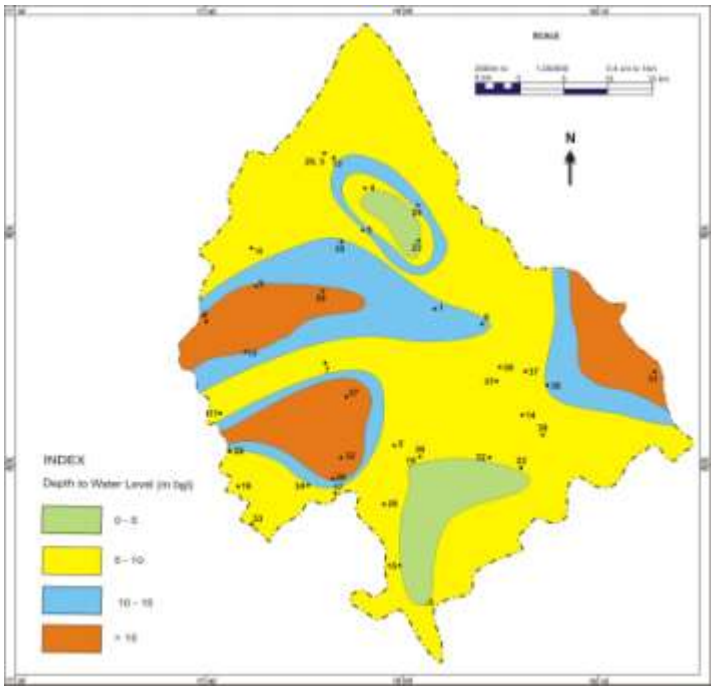


Figure 5 Depth To water Level Map (May 2018), Haridwar District

The visual interpretation of the **Fig. 6** indicates that the major part of the Udham Singh Nagar district shows shallow water levels in the range of 0-5 m along with isolated patches with water level in the range of 5-10 m and 10-15 m in the western part of the district. The water level goes on deepening in the form of narrow continuous bands as one moves from south to north of the section.

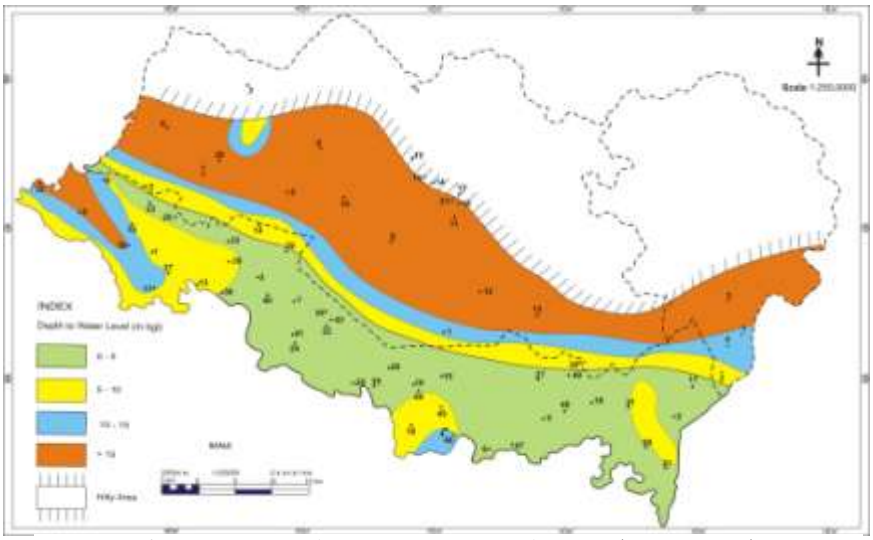


Figure 6 Depth To water Level Map (May 2018), Udham Singh Nagar-Nainital-Champawat District

5.1.2 August 2018

During the month of August 2018, total of 161 Groundwater monitoring wells (including dug wells, hand pumps and piezometers) were monitoried in Uttarakhand State in District Dehradun, Haridwar, Udham Singh Nagar, Pauri Garhwal, Nainital and Champawat. The depth to water level data has been classified and is given in **Table 7.** A perusal of the table indicates that deepest water level was 75.38 m bgl at Harbanswala in District Dehradun district while the shallowest water level was 0.02 m bgl at Bazpur in Udham Singh Nagardistrict. The analysis of depth to water level data has also shown that shallowest water level of 0-5 m was recorded by 63 monitoring wells, which was 39.13% of the total number. Depth to water level in the range of 5-10 m was shown by 32 wells (19.88% of total number), the deeper water levels of 10-15 m was shown by 22 wells (13.66% of total) and the deepest water levels (>15 m) was recorded by 44 monitoring wells, which was 27.33% of the total number of wells in Uttarakhand monitored during August 2018.

Table 7: District wise categorization of depth to water level data, August 2018

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5	5 to 10			10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	50	0.48	75.38	9	18.00	15	30.00	8	16.00	18	36.00
Haridwar	40	0.49	68.09	17	42.50	8	20.00	7	17.50	8	20.00
U. S. Nagar	44	0.02	19.62	33	75.00	6	13.64	4	9.09	1	2.27
Nainital	13	2.53	71.2	3	23.08	0	0.00	1	7.69	9	69.23
Champawat	4	1.39	21.94	1	25.00	2	50.00	0	0.00	1	25.00
Uttarkashi	8	8.05	41.18	0	0.00	1	12.50	2	25.00	5	62.50
Pauri Garhwal	2	68.39	69.6	0	0.00	0	0.00	0	0.00	2	100.00
Total	**161**	**0.02**	**75.38**	**63**	39.13	**32**	19.88	**22**	13.66	**44**	27.33

The depth to water level maps (August 2018) for Dehradun section in fig 7, Haridwar section is given in Fig. 8 and for Udham Singh Nagar-Nainital-Champawat section is given in Fig. 9.

A perusal of **Fig.7** indicates that the major part of the Dehradun district shows shallow water levels (in the range of 5-10 m bgl).The shallowest water level of 0-5 m is observed as small lenses in the north western part of Doon valley. The water levels in the range of 10-15 m are observed as elliptical patches rimming the deepest water level of greater than 15 m bgl in the central part of Doon valley and also as isolated patches in the south eastern part of the district.

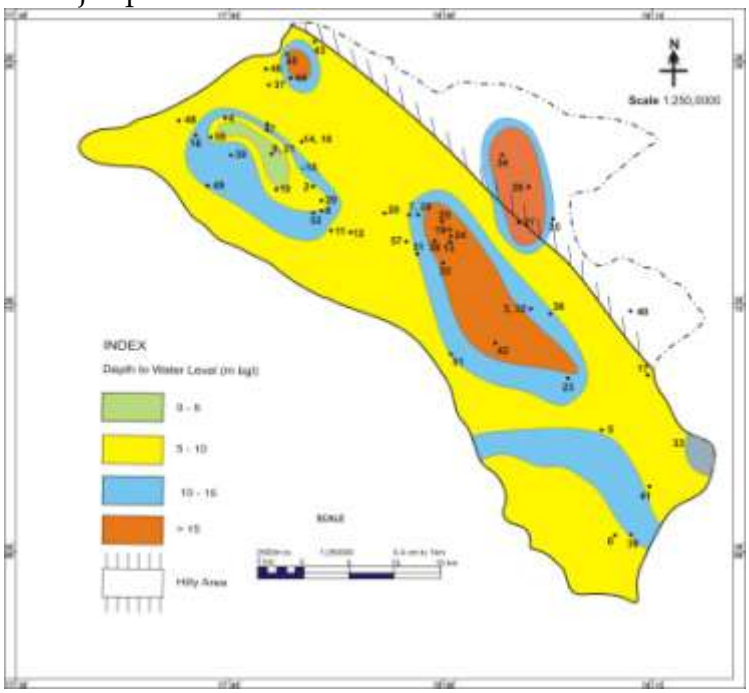


Figure 7 Depth To water Level Map (August 2018), Dehradun District

A perusal of Fig. 8 indicates that major part of the Haridwar district shows shallow water levels (in the range of 5-10 m bgl). The minimum depth to water level i.e 0-5 m is observed in southern part of the Haridwar district in and around Dhanpura- Panjanheri-Gurukul Narsan- Lakhnauta- Shyampur- Bhikkampur- Bhogpur- Laksar- Dalupuriand also as patches around the northern part of the district.The water levels in the range of 10-15 m (in and around in and around Landhaura- Libberhedi, Jhabreda- Iqbalpur- Bahadarabad- Rathaura- Kota Muradnagar) are observed as patches rimming the deepest water level of greater than 15 m bgl (in and around Chudiyala- Bhagwanpur and Laldhang) in the westernand eastern parts of the district.

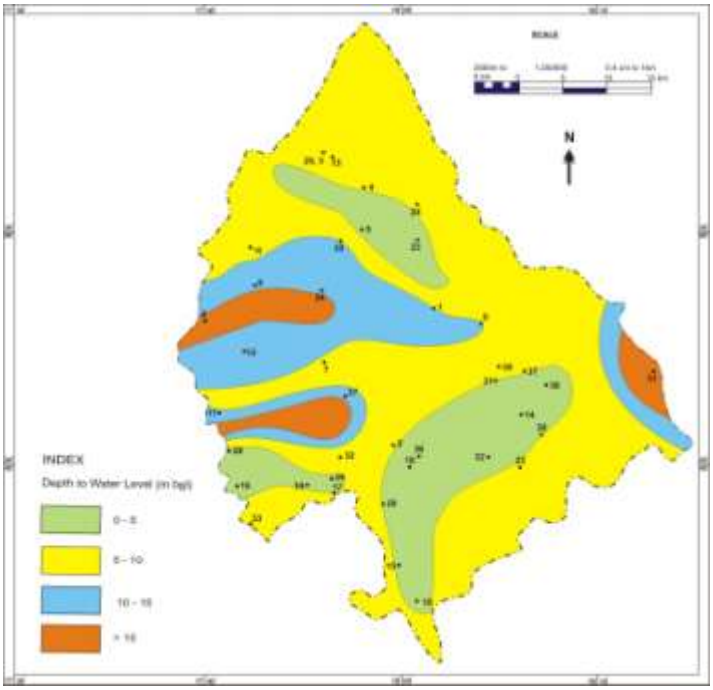


Figure 8 Depth To water Level Map (August 2018), Haridwar District

Interpretation of **Fig. 9** has again revealed that depth to water level generally increases from south to north in Udham Singh Nagar- Nainital-Champawat section. The shallowest water level (0-5 m) is observed as a continuous band stretching from the western to the eastern part of the Udham Singh Nagar district and covering the southern part of the Champawat district along with isolated patches in and around Ramnagar- Maldhan Colony- Garjiya in the Nainital district.The water level in the range of 5-10m is observed as isolated patches in the USN district(in and around Sandkhera- Kashipur- Barkhare Pande) rimming the water level zone of 10-15 m (in and around Angadpur- Patrampur-Bharatpur) and greater than 15 m (in and around Jaspur). Thewater level zone of 5-10 m is also observed as narrow band running from North Western part of the Nanital district covering central part of district and extending till eastern part of the Champawat district.

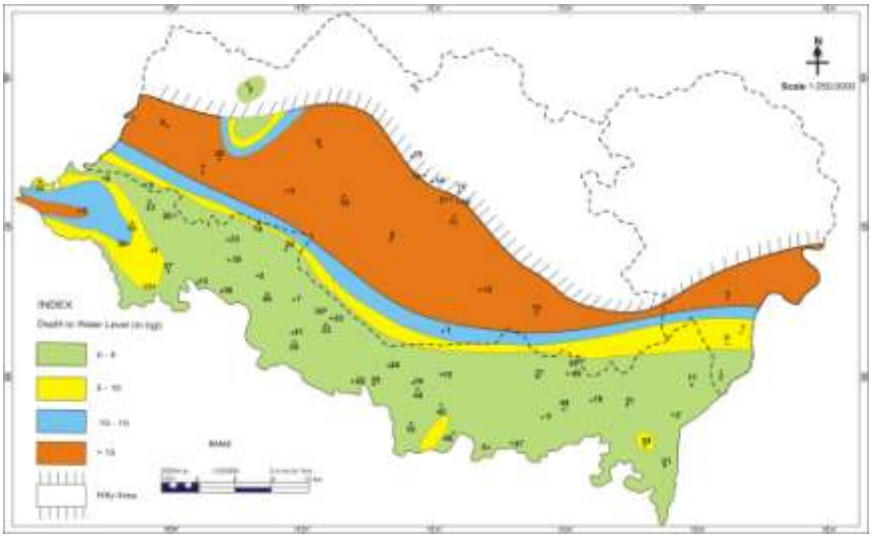


Figure 9 Depth To water Level Map (August 2018), Udham Singh Nagar-Nainital-Champawat District

The water level in the range of 10-15m occurs as continuous bands paralleling theband of 5-10 m water level and extending from north western part of the Nainital section to eastern part of the Champawat section. The deepest water level (>15 m)is running parallel to the 10-15 m water level zone stretching from the north western part of the Nainital section to eastern part of the Champawat section.

5.1.3. November 2018

The depth to water level data is available for 162 Ground Water Monitoring Wells of Uttarakhand during November 2018. The data has been analyzed and shown in ***Table 8***. During this period, the deepest water level of 76.47 m bgl was observed at Ladpur Piezometer (Dehradun district) while the shallowest water level of 0.43 m bgl was observed at Dandi in Dehradun district. The analysis of depth to water level data shows that out of 162 wells, 60 wells (37.04% of total number) have recorded shallowest water level in the depth range of 0–5 m whereas water level in the range of 5-10 m was recorded in 40 monitoring wells (24.69% of the total number). Deeper water level of 10–15 m was observed in 16 wells, which was 9.88% of the total number whereas the deepest water level of >15 m bgl was recorded in 46 wells (28.40% of total wells) in Uttarakhand during November 2018.

Table 8: District wise categorization of depth to water level data, November 2018

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	52	0.43	76.47	7	13.46	15	28.85	8	15.38	22	42.31
Haridwar	40	1.32	54.83	14	35.00	13	32.50	5	12.50	8	20.00
U. S. Nagar	45	0.77	16.01	35	77.78	7	15.56	2	4.44	1	2.22
Nainital	13	2.2	70.68	2	15.38	2	15.38	1	7.69	8	61.54
Champawat	4	3.21	22.74	1	25.00	2	50.00	0	0.00	1	25.00
Uttarkashi	7	4.96	41.23	1	14.29	1	14.29	0	0.00	5	71.43
Pauri Garhwal	1	29.24		0	0.00	0	0.00	0	0.00	1	100.00
Total	**162**	**0.43**	**76.47**	**60**	37.04	**40**	24.69	**16**	9.88	**46**	28.40

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for November 2018 is shown in **Fig. 10** (Dehradun Section), and **Fig. 11** Haridwar Section) and **Fig. 12** (Nainital, Udham Singh Nagar and Champawat Section

A perusal of **Fig. 10** reveals that the shallowest water levels (0-5m) are observed as isolated patches in and around Sahaspur- Redapur and Dandi-Rishikesh. The major part of the Dehradun district shows shallow water levels in the range of 5-10 m bgl.The water levels in the range of 10-15m rims the deepest water level of greater than 15 m in the central part of the Doon Valley.

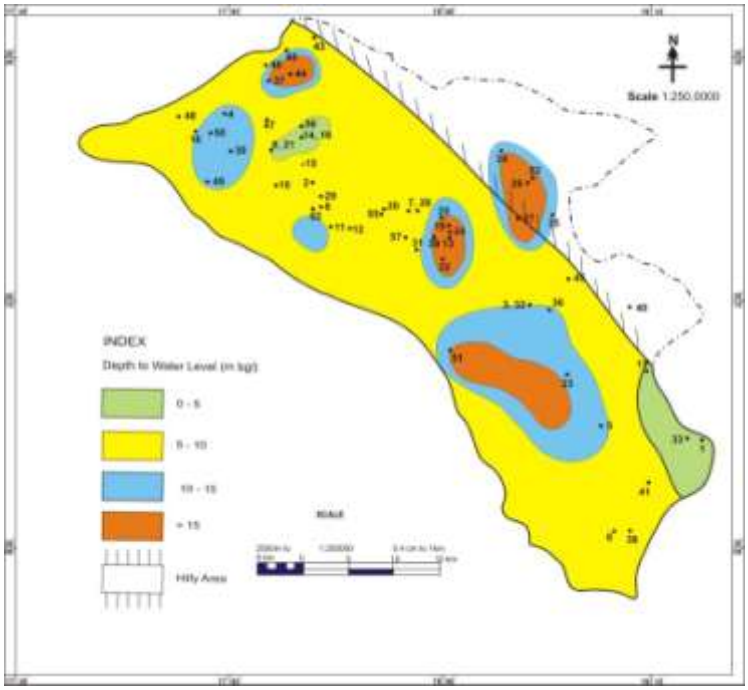


Figure 10 Depth To water Level Map (November 2018), Dehradun District

A perusal of Fig. 11 indicates that major part of the Haridwar district shows shallow water levels (in the range of 5-10 m bgl). The minimum depth to water level i.e 0-5 m is observed in southern part of the Haridwar district in and around Bhikkampur- Bhogpur-Laksar- Dalupuri and also as patches around the northern part of the district. The water levels in the range of 10-15 m are observed as patches (in and around Landhaura- Libberhedi , Jhabreda-Iqbalpur- Bahadarabad- Rathaura) extending from the western to central part of the district and rimming the deepest water level of greater than 15 m (in and around Chudiyala- Bhagwanpur and Laldhang**).**

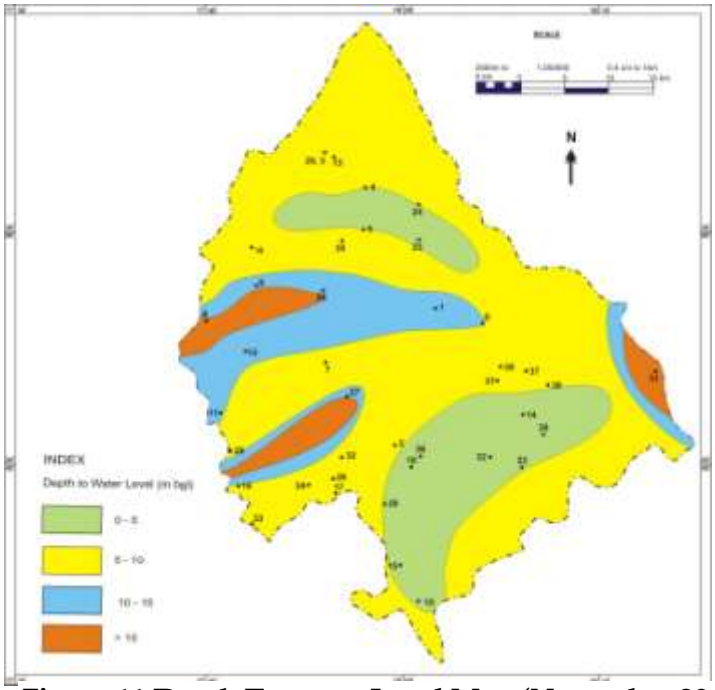


Figure 11 Depth To water Level Map (November 2018), Haridwar District

Interpretation of **Fig. 12** has again revealed that depth to water level generally increases from south to north in Udham Singh Nagar-Nainital- Champawat section. The shallowest water level (0-5 m) is observed as a continuous band stretching from the western to the eastern part of the Udham Singh Nagar district and covering the southern part of the Champawat district along with isolated patches in and around Garjiya in the Nainital district.The water level in the range of 5-10m is observed as isolated patches in the Udham Singh Nagar district (in and around Sandkhera-Bharatpur- Misserwala) rimming the water level zone of 10-15 m (in and around Jaspur-Angadpur) .Thewater level zone of 5-10 m is also observed as narrow band running from North Western part of the Nanital district covering central part of district and extending till eastern part of the Champawat district.

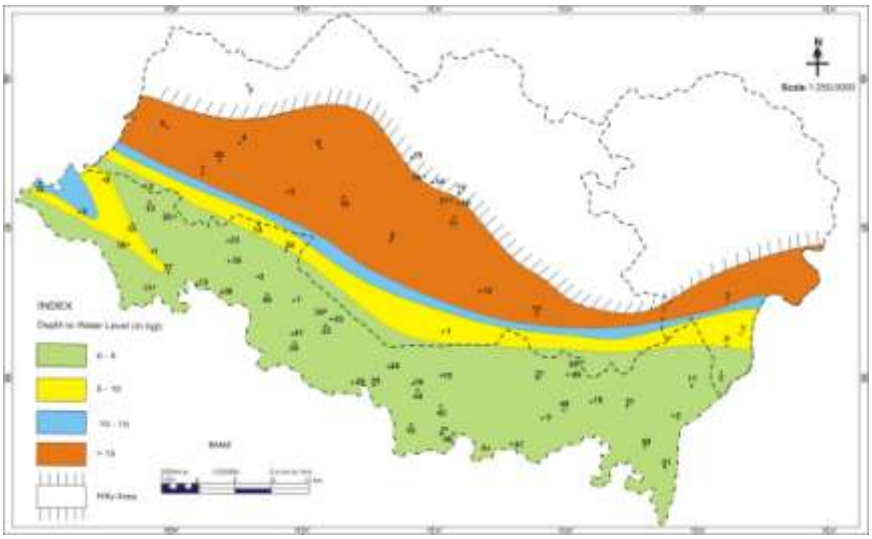


Figure 12 Depth To water Level Map (November 2018), Udham Singh Nagar-Nainital-Champawat District

5.1.3 January 2019

The depth to water level data was analysed for 165 Ground Water Monitoring Wells in Uttarakhand during January 2019 and is given in ***Table 9.*** Analysis of depth to water level data given in the table indicates that the deepest water level was 85.47 m bgl in Tarla Nagal, Dehradun district whereas the shallowest water level was 0.71m bgl at Hussainpur in Haridwar. The shallowest depth to water level of 0–5 m bgl was recorded by 52monitoring wells, which was 31.52 % of the total number of wells. Water level in the range of 5-10 m bgl was also shown by 40 wells (24.24% of total number of wells), whereas deeper water level of 10–15 m bgl was recorded by 21 monitoring wells, which was 12.73% of the total number of wells. The deepest water level of >15 m bgl was shown by 52 monitoring wells, which was 31.52% of the total number of wells in Uttarakhand monitored in January 2019.

Table 9: District wise categorization of depth to water level data, January 2019

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	53	1.37	85.47	4	7.55	14	26.42	11	20.75	24	45.28
Haridwar	40	0.71	59.9	11	27.50	14	35.00	6	15.00	9	22.50
U. S. Nagar	45	1.38	13.68	34	75.56	9	20.00	2	4.44	0	0.00
Nainital	13	2.31	71.17	2	15.38	2	15.38	0	0.00	9	69.23
Champawat	4	4.43	36.74	1	25.00	1	25.00	1	25.00	1	25.00
Uttarkashi	8	10.46	45.28	0	0.00	0	0.00	1	12.50	7	87.50
Pauri Garhwal	2	60.25	66.74	0	0.00	0	0.00	0	0.00	2	100.00
Total	**165**	**0.71**	**85.47**	**52**	31.52	**40**	24.24	**21**	12.73	**52**	31.52

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for ***January 2019*** is shown in ***Fig. 13*** *(Dehradun Section),* ***Fig. 14*** *(Haridwar Section)* and ***Fig. 15*** *(Nainital, Udham Singh Nagar and Champawat Section).*

A perusal of **Fig. 13** reveals that the shallowest water levels (0-5m) are observed as isolated patches in and around Sahaspur- Redapur -Rishikesh. The major part of the Dehradun district shows shallow water levels in the range of 5-10 m bgl.The water levels in the range of 10-15m rims the deepest water level of greater than 15 m starting from the northern to the southern part of the Doon Valley.

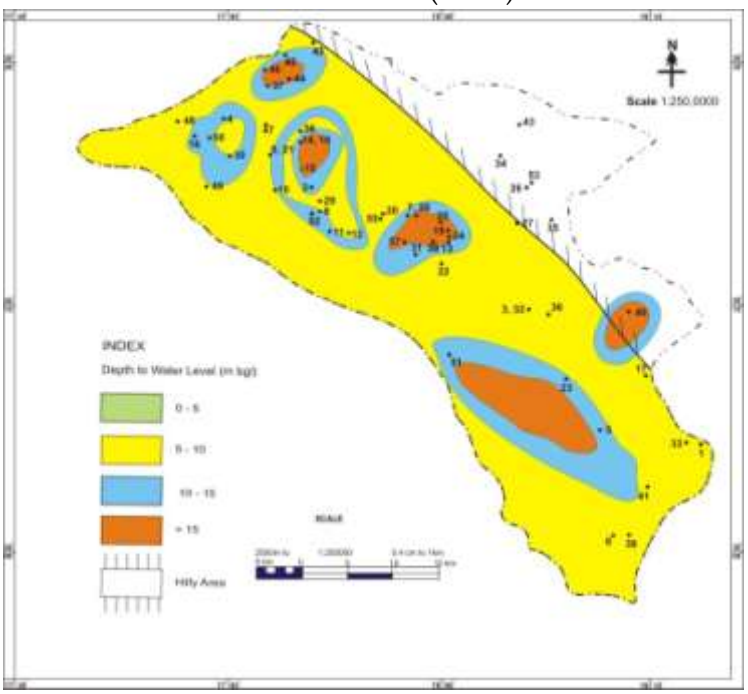


Figure 13 Depth To water Level Map (January 2019), Dehradun District

A perusal of Fig. 14 indicates that major part of the Haridwar district shows shallow water levels (in the range of 5-10 m bgl). The minimum depth to water level i.e 0-5 m is observed as pathches in southern and northern part of the Haridwar district. The water levels in the range of 10-15 m are observed as patches (in and around Landhaura-Kota Muradnagar-Libberhedi , Jhabreda- Iqbalpur-Bahadarabad- Rathaura) extending from the western to central part of the district and rimming the deepest water level of greater than 15 m (in and around Chudiyala- Bhagwanpur – Sikhar- Iqbalpur and Laldhang).

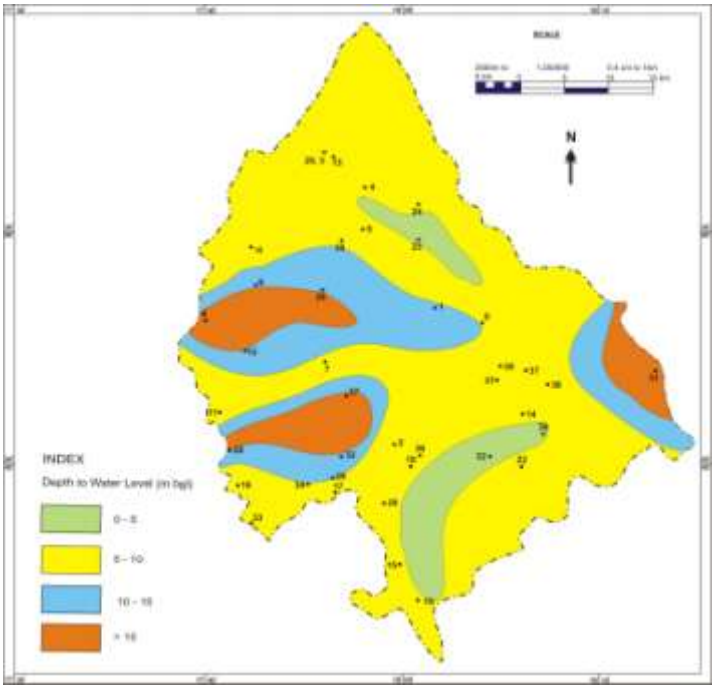


Figure 14 Depth To water Level Map (January 2019), Haridwar District

Interpretation of **Fig. 15** has again revealed that depth to water level generally increases from south to north in Udham Singh Nagar-Nainital- Champawat section. The shallowest water level (0-5 m) is observed as a broad continuous band stretching from the western to the eastern part of the Udham Singh Nagar district along with isolated patches in and around Garjiya in the Nainital district.The water level in the range of 5-10m is observed as isolated patches in the USN district (in and around Sandkhera-Bharatpur- Misserwala and Angadpur) rimming the water level zone of 10-15 m (in and around Jaspur- Pattrampur)and water level zone of depth beyond 15 m.Thedepth to water level in the range of 5-10 m is also observed as narrow continuous band running parallel to bands of water level depth in the range of 10 to 15 m and beyond 15 m from North Western part of the Nainital district to Champawat district.

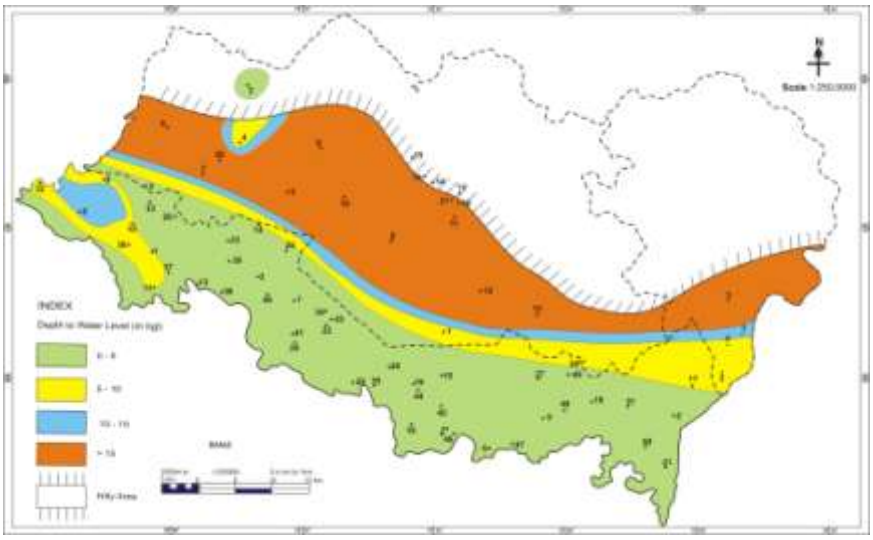


Figure 15 Depth To water Level Map (January 2019), Udham Singh Nagar-Nainital-Champawat District

5.2 DISCHARGE OF SPRINGS

The discharge data of thirty-fix cold-water springs in Dehradun, Nainital, Uttarkashi and Almora districts for the months of May, August, November 2018 and January 2019 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 2018-January 2019 varies from a minimum measurable discharge of 0.245 LPM at Soda Sarauli in May 2018 to a maximum of 500 LPM at Sipahidhara (August 2018). Discharge of springs varies within wide limits during the intervening period.

In Dehradun district, spring discharge varies between 0.245 LPM at Soda Sarauli in May, 2018 and 30.10 LPM at Khandoli in November 2018. In Nainital district, spring discharge varies from a minimum of 0.75 LPM at Salari (May 2018) to a maximum of 500 LPM at Sipahidhara (August 2018). In Almora district, the spring discharge was found to be varying from a minimum of 0.52 LPM at Mehragaon in May 2018 to a maximum of 85.71LPM at Peepaldhar in November, 2018. In Uttarkashi district, spring discharge was varying from 4.9 LPM at Dharasau in November, 2018 to a maximum of 280 LPM in Ganganani in January 2019.

Table 10: Discharge of Springs in May, August, November 2018 and January 2019

Sl. No.	***District***	***Block***	***Location Details***	**Type of Well**	**May-18**	**Aug-18**	**Nov-18**	**Jan-19**
1	Dehradun	*Raipur*	Soda Saroli	Spring	0.245 lpm	18.75 lpm	20 lpm	10.7 lpm
2			Bhatta	Spring	2.43 lpm	18.29 lpm	12 lpm	7.5 lpm
3		*Sahaspur*	Khandoli	Spring	15.41 lpm	17.89 lpm	30.10 lpm	16.67 lpm
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**May-18**	**Aug-18**	**Nov-18**	**Jan-19**
1	Nainital	*Bhimtal*	Amritpur (Ranibagh)	Spring	2 lpm	60 lpm	3 lpm	14.71 lpm
2			Salari	Spring	0.75 lpm	15 lpm	7.5 lpm	4.88 lpm
3			Dogaon	Spring	10 lpm	30 lpm	20 lpm	8.63 lpm
4			Sipahidhara	Spring	24 lpm	500 lpm	150 lpm	68.97 lpm

5			Garampani	Spring	10 lpm	30 lpm	17.14 lpm	6.70 lpm
6			Jyolikot	Spring	8.57 lpm	85 lpm	21.43 lpm	11.22 lpm
7			Kudaghat	Spring	Dry	60 lpm	24 lpm	1.15 lpm
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**May-17**	**Aug-17**	**Nov-17**	**Jan-18**
1	Almora	*Tarikhet*	Patali Talla	Spring	5 lpm	5.2 lpm	5 lpm	1.15
2			Patali Malla	Spring	2.22 lpm	7.08 lpm	Dry	7.67
3			Baniyadiggi	Spring	4 lpm	4.38 lpm	8.82 lpm	8.5
4		*Hawalbagh*	Katarmal	Spring	17.14	11.43 lpm	26.07 lpm	10.08
5			Dharanaula	Spring	12	27.33 lpm	10 lpm	27.04
6			Palna	Spring	1.71	7.33 lpm	0.89 lpm	5.25
7			Bhagtola	Spring	0.62 lpm	2.66 lpm	Dry	Dry
8			Jholi	Spring	12 lpm	9.67 lpm	7.5 lpm	8.32
9			Itola	Spring	1.87 lpm	6.19 lpm	3.53 lpm	2.84
10		*Takula*	Chanoda	Spring	0.80 lpm	4.20 lpm	1.72 lpm	1.65
11			Guruda-I	Spring	1.33 lpm	17.20 lpm	24 lpm	13.6
12			Chhani Bartola	Spring	6 lpm	24.16 lpm	8.57 lpm	5.74
13		*Chaukhutiya*	Dhansari	Spring	8.57 lpm	18.10 lpm	35.29 lpm	25.64
14			Deepakot	Spring	6 lpm	10.77 lpm	12 lpm	11.32
15			Dhalnagaon	Spring	7.5 lpm	17.34 lpm	18.75 lpm	9.99
16			Simalkhet	Spring	1.87 lpm	56.81 lpm	15 lpm	4.64
17			Peepal Dhar	Spring	20 lpm	65.21 lpm	85.71 lpm	19.51
18		*Bhikiasain*	Ramghat	Spring	3.53 lpm	0.93 lpm	Dry	Dry
19			Naula	Spring	7.5 lpm	6.90 lpm	6 lpm	6.6
20		Someshwar	Mehragaon (Someshwar)	Spring	0.52 lpm	2.56 lpm	0.80 lpm	0.56
21			Lodh	Spring	3 lpm	8.14 lpm	2.40 lpm	2.17
22			Bhoolgaon	Spring	25 lpm	58.68 lpm	16.66	37.95
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**May-17**	**Aug-17**	**Nov-17**	**Jan-18**
1	*Uttarkashi*	*Dunda*	Dharasu	Spring	4.66 lpm	7.05 lpm	4.9 lpm	11.45 lpm
2		*Bhatwari*	Nagal	Spring	16.9 lpm	NA	34 lpm	30 lpm
3			Ratodi Sar	Spring	8 lpm	39.21 lpm	19 lpm	20 lpm
4			Ganganani Spring	Spring	75.39 lpm	23.35 lpm	105 lpm	280 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 2008 to 2017 and January for the period from 2009 to 2018). The average depth to water level data available for Ground Water Monitoring Wells is given in ***Table 11.***

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

Sl. No.	**Location**	AVG May 2008-17	AVG Aug 2008-17	AVG Nov 2008-17	AVG Jan 2009-18
STATE UTTARAKHAND					
		Dehradun			
1	Badripur	9.28	7.49	8.49	8.05
2	Balliwala	55.80	54.83	54.26	8.00
3	Bhaniawala	32.22	18.89	21.65	16.83
4	CGWB Office	58.20	55.54	51.22	12.32
5	Chandmari	NA	21.83	26.26	NA
6	Dakpatthar	26.54	4.15	26.75	21.65
7	Dandi	6.44	10.39	5.05	NA
8	Dhakrani	17.60	3.56	17.51	17.51
9	Dharmawala	4.94	8.42	4.13	54.26
10	Duggiawala	NA	49.77	2.74	8.51
11	Gularghati	13.06	5.52	NA	4.13
12	Harbanswala	54.32	6.16	10.70	8.29
13	Herbertpur	10.02	6.16	45.21	8.59
14	Jhajra	12.76	11.07	8.05	24.31
15	Jhajra	13.44	9.12	7.43	5.95
16	Judli	12.92	12.90	6.90	5.93
17	Kanwali	14.41	11.29	12.84	26.26
18	Khadiri (Khadak Maf)	15.60	9.33	12.32	10.70
19	Khandgaon	NA	13.51	13.73	5.05
20	Kotimachak	20.87	20.55	NA	45.21
21	Kuanwala	14.67	4.60	16.83	60.91
22	Lal Tappar	18.37	7.42	5.23	8.25
23	Majra	22.33	9.22	12.81	13.02
24	Maldeota	12.81	67.13	19.82	69.03
25	Nanda ki Chowki	14.54	16.79	8.00	51.22
26	Nanda ki Chowki	15.38	3.99	8.29	6.90
27	Nanurkhera	69.40	6.94	8.59	5.13

28	Purukulgaon	27.63	6.21	60.91	8.49
29	Ramgarh	7.30	3.56	23.61	12.84
30	Rampura	13.11	3.82	5.95	12.81
31	Redapur	8.94	5.37	10.72	19.59
32	Redapur	6.94	6.88	5.13	7.39
33	Rishikesh	7.29	10.59	3.59	10.72
34	Sabhawala	9.27	17.04	5.93	3.59
35	Selakui	11.26	6.77	7.39	7.43
36	Selakui	15.48	67.04	8.25	23.61
37	Shankarpur	23.35	53.45	13.02	19.82
38	Singhniwala	9.67	21.07	19.59	26.75
39	Tarla Nagal	76.11	NA	8.51	2.74
40	Tarla Nagal	NA	NA	69.03	5.23
41	Vikas Nagar	26.06	NA	24.31	13.73
Haridwar					
Sl. No.	**Location**	**AVG May 2008-17**	**AVG Aug 2008-17**	**AVG Nov 2008-17**	**AVG Jan 2009-18**
1	Bahabalpur	3.10	2.30	2.58	3.00
2	Bahadrabad	8.96	13.08	12.53	11.70
3	Bandarjud	10.49	8.19	7.86	8.55
4	Bhagwanpur	18.93	16.89	16.79	13.82
5	Bhikkampur	4.10	2.08	2.83	4.18
6	Bhogpur	4.25	1.88	2.65	3.41
7	Budhwa Shahid	4.57	2.77	2.77	3.07
8	Bugawala	7.37	5.55	5.04	5.71
9	Chudiala	20.51	18.36	18.71	18.85
10	Dallawala	1.99	NA	1.62	1.92
11	Dhanpura	9.03	4.74	9.09	6.07
12	Govardhanpur	4.18	2.06	3.02	2.02
13	Gurukul Narsen	6.09	3.62	5.11	5.82
14	Hussainpur	4.04	1.44	2.39	2.41
15	Imlikhera	17.50	13.63	11.74	13.78
16	Iqbalpur	16.29	13.15	14.47	13.85
17	Jaswawala	NA	NA	3.98	4.34
18	Jhabreda	10.20	7.45	9.09	8.30
19	Khanpur		NA	NA	2.17
20	Khera Jat	6.85	15.31	6.03	6.01
21	Lakhnauta	6.33	5.34	5.13	6.64
22	Laksar	4.11	2.15	2.64	2.85
23	Laldhang	63.12	61.31	56.27	57.64
24	Landhaura	18.08	16.61	16.47	17.93
25	Libhrahedi	8.74	5.68	5.90	6.49
26	Mudlana	17.56	NA	17.51	17.77
27	Nizampur	10.76	18.76	10.32	10.40
28	Rathora	5.26	4.29	4.13	5.24
29	Roorkee	7.67	5.46	6.03	6.02

30	Sahidwala Grant	11.61	8.77	9.17	9.06
31	Sarai	11.67	9.52	10.81	12.03
32	Shahidwala Grant	11.56	10.56	10.24	10.96
33	Shahpur Shitlakhera	5.03	2.77	3.53	3.93
34	Sikhar	19.53	18.32	16.50	16.50
Nainital					
Sl. No.	**Location**	**AVG May 2008-17**	**AVG Aug 2008-17**	**AVG Nov 2008-17**	**AVG Jan 2009-18**
1	Belparao	NA	53.4	53.7	54.1
2	Chilkiya	NA	NA	52.1	NA
3	Dhela	65.90	NA	66.2	57.8
4	Dohniya	NA	NA	NA	58.3
5	Garjiya	4.57	3.1	4.2	4.7
6	Kaladungi	27.60	26.9	27.0	28.0
7	Kathgodam	20.64	15.1	17.7	19.7
8	Khaat Baans	30.71	23.9	28.4	26.6
9	Lalkuan	NA	8.4	7.3	7.4
10	Lamachaur	NA	48.5	38.0	38.8
11	Maldhan Colony	NA	2.4	4.3	3.5
12	Peeru Madara	26.91	22.2	19.4	20.5
13	Ram Nagar	NA	NA	NA	6.8
Udham Singh Nagar					
Sl. No.	**Location**	**AVG May 2008-17**	**AVG Aug 2008-17**	**AVG Nov 2008-17**	**AVG Jan 2009-18**
1	Angadpur	6.67	6.60	6.22	4.66
2	Badaripur	NA	NA	3.56	4.55
3	Banna Khera	5.15	3.66	3.59	3.66
4	Bara	2.27	0.94	1.72	1.95
5	Barianjaniya	NA	NA	3.45	4.15
6	Barkhare Pande	8.77	5.53	4.01	6.25
7	Bazpur	2.76	0.70	1.45	1.80
8	Begur Mod	NA	NA	2.86	3.38
9	Beria Daulat	3.63	2.05	2.77	2.98
10	Bhagwanpur	6.82	4.84	3.38	3.75
11	Bharatpur	9.75	7.96	6.84	6.48
12	Chakarpur	5.93	4.69	4.42	NA
13	Dhanauri Patti	4.76	2.69	2.60	2.84
14	Dhyanpur	NA	NA	1.42	1.89
15	Durgapur	5.70	3.30	3.09	3.36
16	Gangapur	3.45	2.87	2.39	2.64
17	Jaspur	10.75	11.66	9.70	12.00
18	Jhagarpuri	3.17	1.29	1.93	2.44
19	Jharkhandi	2.19	1.43	1.23	1.23
20	Jogipura	6.80	4.02	3.97	4.41
21	Kalyanpur	NA	1.49	2.00	2.13

22	Kamaria Pakki	7.40	4.15	3.78	5.17
23	Kanakpur	NA	NA	2.64	2.85
24	Kanchanpur (Majhola)	4.90	3.09	3.82	4.47
25	Kashipur	6.78	3.54	4.69	4.44
26	Khatima	3.32	1.32	1.69	2.49
27	Kichha	7.54	6.57	6.66	7.04
28	Lalpuri	NA	NA	1.70	1.97
29	Mahabir Nagar	2.71	1.24	2.15	2.69
30	Missarwala	NA	NA	8.06	5.82
31	Nanak Mata	5.46	2.36	2.88	3.61
32	Patrampur	10.61	7.99	7.01	7.27
33	Patthar Chatta	3.13	2.06	2.69	2.69
34	Pattharpui	NA	NA	NA	3.66
35	Pipaliya	NA	NA	NA	2.97
36	Pritpur	NA	NA	3.40	3.53
37	Nanak Mata	NA	NA	3.13	2.25
38	Rudrapur	3.86	1.90	3.15	2.97
39	Sarasariya	6.23	4.51	3.16	3.81
40	Shand Khera	NA	NA	5.18	5.20
41	Shantipuri	2.25	1.00	1.57	1.59
42	Sitarganj	3.32	1.09	1.65	1.69
43	Sultanpur Patti	NA	NA	0.95	1.50
44	Tukri	3.71	3.95	3.01	2.54
Champawat					
Sl. No.	**Location**	**AVG May 2008-17**	**AVG Aug 2008-17**	**AVG Nov 2008-17**	**AVG Jan 2009-18**
1	Banbasa	76.39	7.68	5.53	NA
2	Bastia	296.33	7.79	23.92	31.42
3	Bichai	NA	NA	11.19	10.97
4	Tanakpur	NA	7.57	9.21	10.43
Pauri Garhwal					
Sl. No.	**Location**	**AVG May 2008-17**	**AVG Aug 2008-17**	**AVG Nov 2008-17**	**AVG Jan 2009-18**
1	Kaudia (Kotdwar)	54.15	56.03	51.89	53.77

A perusal of the long-term (decadal) depth to water level data given in ***Table11*** indicates that the depth to water level varies widely. The minimum long-term water level is 0.698 m at Bazpur in Udham Singh Nagar District in August whereas the maximum was 76.11 m bgl at Tarla Nagal in Dehradun district in May.

The table also shows that for Dehradun district, the minimum long-term water level is 1.9 m bgl at Duggiawala in January whereas the maximum is 76.11 m bgl at Tarla Nagal in May. In Haridwar district, decadal water level is varying from 1.45 m bgl at Hussainpur in August to the maximum of 63.12 m bgl at Laldhang in May. In Udham Singh Nagar district, the long-term depth to water level is varying from 0.69 m bgl at Bazpur in August to 12.00 m bgl at Jaspur hand pump in January viz. in the pre-monsoon period. The decadal water level in Nainital district was varying from 2.41 m bgl at Maldhan Colony in August to a maximum of 66.22 m bgl at Dhela hand pump in November. Long-term depth to water level in Champawat district was ranging from 7.56 at Tanakpur in August to 31.42 m bgl at Bastia Handpump in January.

5.4 WATER LEVEL FLUCTUATION

The changes in ground water level in response to recharge and ground water withdrawal are important aspects for study of the overall hydrogeological scenario of an area. The water level fluctuation is calculated in each case under the following three categories.

- Changes in water level during each period of observation with respect to average water level for the last ten years for that period.
- Changes in water level during each season/period with respect to observed data of pre-monsoon water level during the same year.
- Changes in water level during each season/period with respect to water levels observed in previous year of the same period.

Tables and maps, which show the long-term (decadal), yearly and seasonal water level fluctuations, were prepared for the monitoring wells of Dehradun, Haridwar, Udham Singh Nagar, Nainital and Champawat district. The analysis of water level fluctuation data and conclusion drawn from it are discussed below.

5.4.1 DECADAL (LONG-TERM) WATER LEVEL FLUCTUATION

5.4.1.1 Water Level Fluctuation (May 2008-2017 versus May 2018)

The analysis of decadal depth to water level data for s ground water monitoring wells is given in ***Table 12***. A perusal of the table indicates that the minimum long-term rise in the range of 0-2 m is observed in 27 monitoring wells (30.34 % of the total number) whereas higher rise in the range of 2-4 m is observed in 2 wells (2.25 % of total). The4 nos. of well (4.49%) recorded the decadal rise in water level (>4 m). The lowest long-term decline in the range of 0-2 m is recorded in 33 wells, which is 37.08 % of the total number. Higher long-term decline in the range of 2-4 m is recorded in 8 wells, which is8.99 % and the highest decline of >4 m is recorded in 15 wells, which is 16.85 % of the total number. Analysis of the decadal data also shows that the lowest decadal rise is 0.018 m at Bannakhera in Udham Singh Nagar district while the highest rise is 14.06 m at Imlikhera in Haridwar district. The lowest long-term decline in water level is 0.03 m at Roorkee in Haridwar district while the highest is 14.77 m at Kanwali in Dehradun district.

The decadal water level fluctuation map for average (May 2008-2017) versus May 2018 is shown in ***Fig.16*** *(Dehradun Section),* ***Fig.17*** *(Haridwar section)* and ***Fig. 18*** *(Nainital-Udham Singh Nagar-Champawat section)*.

A study of **Fig. 16** reveals that the minimum rise of 0-2 m is observed in the northern part of the Doon valley.Higher decadal rise of 2-4 m is observed around Rampura,Selaqui,Herbertpur areas only. The highest decadal rise of >4 m is observed in Dhakrani,Singhniwala of Dehradun district according to the available data. Decadal decline in water level in the range of 0-2 m is observed in the southern part of the Doon valley. The decadal decline in the range of 2-4 m is observed in Ladpur,Balliwala areas. The decline in water levels >4m is observed in and around Kanwali-Nanurkhera-Bhaniawala-Majra-Maldeota. section.

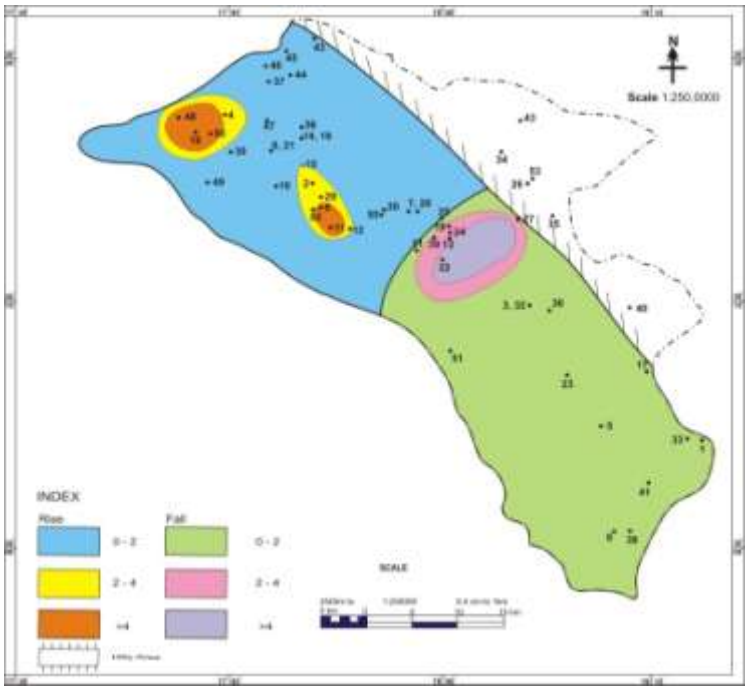


Figure 16 Decadal Water Level Fluctuation Map (May 2008-2017 vs 2018), Dehradun District

A study of **Fig. 17** reveals that the minimum rise of 0-2 m is observed around sikhar-Liberhedi-Husainpur-Bhadrabad-Lakhnauta-dhanpura-Rathaura-Bhikkampur-Kherajatt-Grukul Narsen areas only. Higher decadal rise of 2-4 m is observed around the Jhabreda area and the highest decadal rise of >4 m is observed in Imlikhera area. Decadal decline in water level in the range of 0-2 m

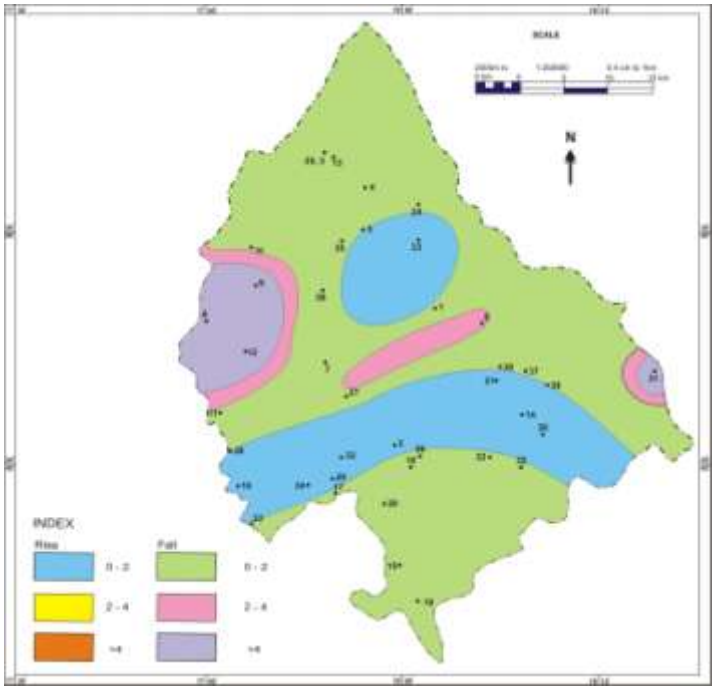


Figure 17 Decadal Water Level Fluctuation Map (May 2008-2017 vs 2018), Haridwar District

is observed in 60% of the Haridwar District in and around Lakshar-Goverdhanpur-Bhogpur-Budhwa sahid-Sahidwala grant-Bahabalpur-Dallwala. Decline in the range of 2-4 m is observed aroundLandhaura-Shahpur shitlakhera-Sarai; whereas the decline in water levels >4m is observed inChudiala, Bhagwanpur, Iqbalpur areas.

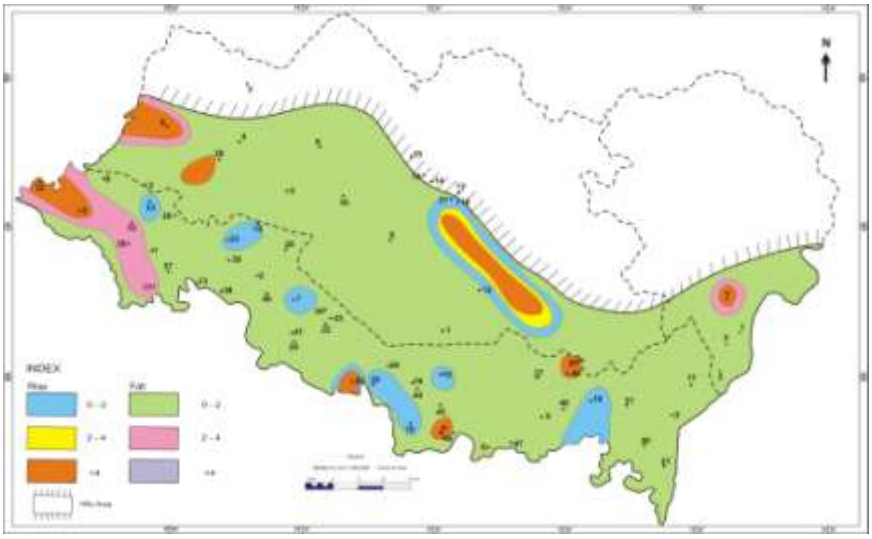


Figure 18 Decadal Water Level Fluctuation Map (May 2008-2017 vs 2018), US Nagar – Nainital - Champawat

Interpretation of **Fig. 18** has shown that decadal rise of 0-2 m is observed around Durgapur-Rudrapur-Kamariapakki- section of Udham Singh Nagar district and in Sitapur-Jhagarpuriof Nainital district. Rise of 2-4 m is observed as outlier to the >4 m water level zone. Highest decadal rise of >4 m is observed in khatban,Peeru Madara,kathgodam,Garjiya in Nainital District.Decadal decline in water level in the range of 0-2 m is observedinmajority of the areas in the entire Udham Singh Nagar-Nainital-Champawat section. Decadal decline in the range of 2-4 m is observed around Kichha, and Barkhare pande,Tukri,Bharatpur in udham Singh Nagar District. Highest decadal decline of >4 m is observed around Angadpur,Jaspur,Bhagwanpur in Udham Singh Nagar,Dhela in Nanital district and Bastia in Champawat district.

Table 12. Decadal Water Level Fluctuation (May 2008 –May 2017 versus May 2018)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2 to 4*		*>4*		*0-2*		*2 to 4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	21	0.09	5.50	0.16	14.77	5	23.81	1	4.7619	2	9.52	7	33.33	1	4.76	5	23.81
Haridwar	31	0.14	14.06	0.03	13.17	11	35.48	1	3.23	1	3.23	10	32.26	3	9.68	5	16.13
Udham Singh Nagar	29	0.018	1.361	12.181	0.262	8	27.59	0	0.00	0	0.00	14	48.28	4	13.79	3	10.34
Nainital	6	0.468	13.206	1.824	4.068	3	50.00	0	0.00	1	16.67	1	16.67	0	0.00	1	16.67
Champawat	2	NA	NA	0.671	13.777	0	0.00	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
Total	**89**	**0.018**	**14.06**	**0.03**	**14.77**	**27**	30.34	**2**	2.25	**4**	4.49	**33**	37.08	**8**	8.99	**15**	16.85

5.4.1.2 Water Level Fluctuation (August 2008-2017 versus August 2018)

Long-term water level data for 107 monitoring wells is analyzed and is shown in ***Table 13***. A perusal of the data shows that the minimum decadal rise is 0.003 m at Patharchatta in Udham Singh Nagar district whereas the maximum decadal rise is 19.01 m at Nanukhera Hand pump in Dehradun district. The minimum long-term decline in water level is 0.042 m at Shahidwala Grant in Haridwar district; whereas the maximum decadal decline of 25.61 m is recorded at Harbanswala Hand Pump in Dehradun district.

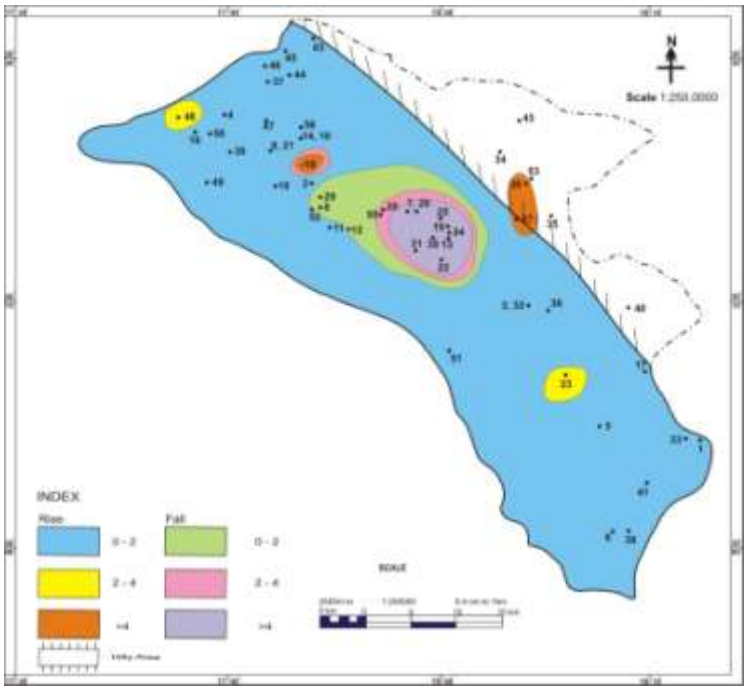


Figure 19 Decadal Water Level Fluctuation Map (August 2008-2017 vs 2018), Dehradun District

A perusal of **Table 13** indicates that the minimum long-term rise in the range of 0-2 m is observed in 47 monitoring wells (43.93% of the total number), whereas higher rise in the range of 2-4 m is observed in 7 wells (6.54% of total) and the highest rise of >4 m is observed in 7 monitoring wells (6.54% of total). The lowest long-term decline of water level in the range of 0-2 m is recorded in 21 monitoring wells, which is 19.63 % of the total number. Higher long-term decline in the range of 2-4 m is recorded by 12 wells (11.21 % of total) whereas the highest decline of >4 m is observed in 13 monitoring wells, which is 12.15 % of the total number of wells.The decadal water level fluctuation map for average (August 2008-2017) versus August 2018 is shown in ***Fig.19*** *(Dehradun, Section),* ***Fig.20*** *(Haridwar section)* and ***Fig. 21*** *(Nainital -Udham Singh Nagar-Champawat section).*

Visual interpretation of **Fig. 19** has shown that minimum decadal rise of 0-2 m is found in major part of the district. Decadal rise of 2-4 m is observed as isolated patches in Dhakrani,Bhaniawala and >4 m is observed around Nanukhera,Tarla Nagal,Shankarpur in Doon valley. The long-term decline of 0-2 m is observediaround

Nanda Ki Chowki, Selaqui, Rishikesh,Jhajra,Ramgarh areas of Doon Valley. Higher decline of 2-4 m is observed as Circular rim around water level in the range of greater than 4minaroung Cgwb office. Long term deeper water level decline (>4m) is observed around Harbanswala,Balliwala,Majra section of Doon Valley.

Visual interpretation of **Fig. 20** has shown that minimum decadal rise of 0-2 m is observed in major part of the district. Higher decadal rise in the range of 2-4m lakhnauta,Iqbalpur,bandarjud,Siukhar ares of Haridwar district.Highest decadal rise of greater than 4 m is observed in Kherajat,Nizampur areas of Haridwar District. The minimum long-term decline of 0-2 m is observed as continuous bands in Sahidwala grant,Dhanpura, Rathaura, Bahadrabad, Gurukul Narsen,Buggawala,Roorkee,Landhauraareas of Haridwar District. Higher water level decline of 2-4 m is observed around Chudiala,Sarai,Imlikhera areas of Haridwar district. Long term deeper water level decline (>4m) is observed around Laldhang,Bhagwanpur.

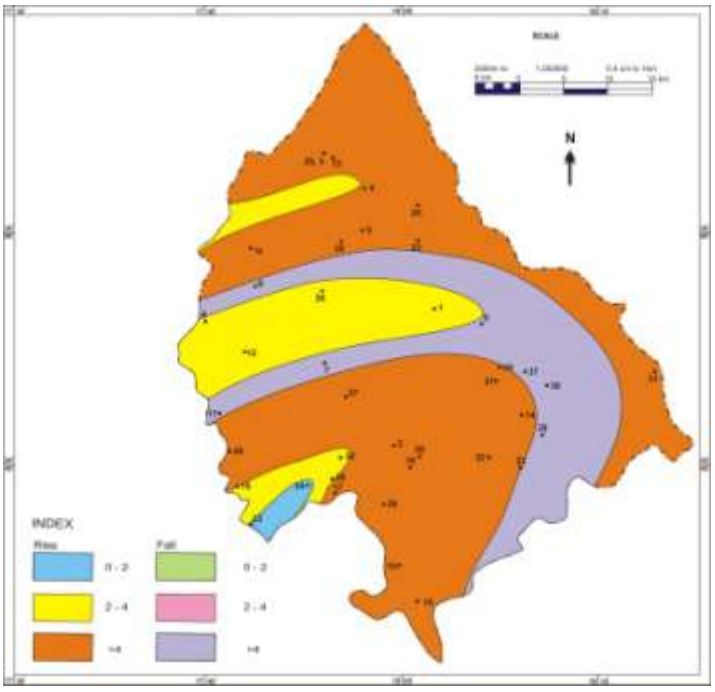


Figure 20 Decadal Water Level Fluctuation Map (August 2008-2017 vs 2018), Haridwar District

Visual interpretation of **Fig. 21** reveals that minimum decadal rise of 0-2 m is seen dominantly in major part of the section .The lowest decadal decline of 0-2 m is observed

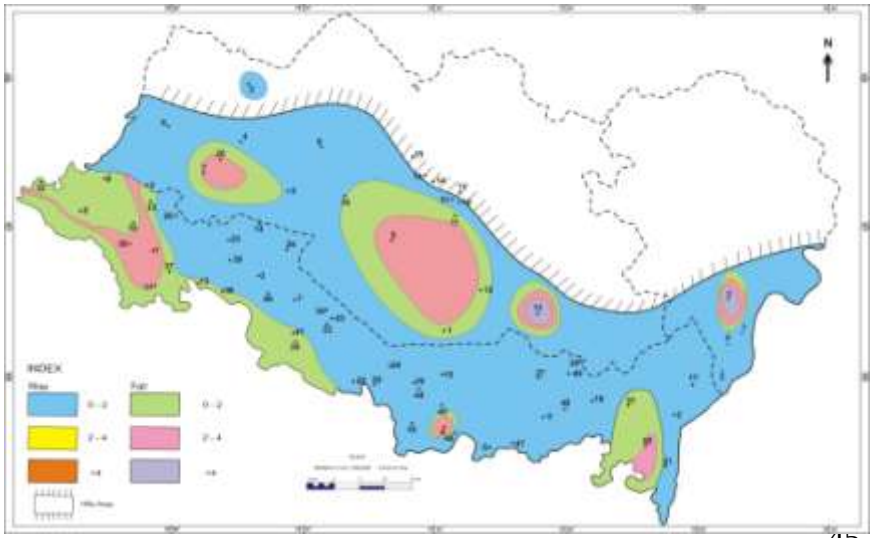


Figure 21 Decadal Water Level Fluctuation Map (August 2008-2017 vs 2018), US Nagar – Nainital - Champawat

around Jhagarpuri,Durgapur,Sarsaraiya in Udham Singh Nagar district and Kaladhungi and Maldhan colony of Nainital district . Higher decadal decline of 2-4 m is observed around Patharpur, Kanchanpuriand Barkhare Pande in Udham Singh Nagar district and around Lamachaur, Peeru Madara, Kathgodam and Lalkuan in Nainital district. The highest decadal decline of >4 m is observed around Bharatpur, Patrampur, Angadpur and Japur (Udham Singh Nagar district), Belparao and Khat Bans (Nanital district) and Bastia (Champawat district).

Table 13. Decadal Water Level Fluctuation (August 2008 –August 2017 versus August 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	35	0.046	19.01	0.14	25.61	16	45.71	3	8.57	4	11.43	7	20.00	1	2.86	4	11.43
Haridwar	30	0.024	9.988	0.042	6.785	10	33.33	4	13.33	2	6.67	9	30.00	3	10.00	2	6.67
Udham Singh Nagar	30	0.003	1.188	0.074	7.961	19	63.33	0	0.00	0	0.00	3	10.00	4	13.33	4	13.33
Nainital	9	0.077		0.118	5.914	1	11.11	0	0.00	0	0.00	2	22.22	4	44.44	2	22.22
Champawat	3	0.376	6.287	14.152		1	33.33	0	0.00	1	33.33	0	0.00	0	0.00	1	33.33
Total	**107**	**0**	**11.84**	**0.035**	**9.26**	**47**	43.93	**7**	6.54	**7**	6.54	**21**	19.63	**12**	11.21	**13**	12.15

5.4.1.3 Water Level Fluctuation (November 2008-2017 versus November 2018)

Long-term water level data for 126 monitoring wells is analyzed and is shown in ***Table 14***. A perusal of the data shows that the minimum decadal rise is 0.034 m at Garjiya in Nainital District while the maximum decadal rise is 7.532 m at Chilkiya in Nainital District. The minimum decadal decline in water level is 0.007 m at Gurukul Narsen in Haridwar district while the maximum decadal decline is 18.37 m at Balliwala in Dehradun district. The table also indicates that 71 monitoring wells out of 126 (56.35 % of total) had shown decadal rise of 0-2 m, 9 monitoring wells (7.14 % of total) had shown rise of 2-4 m and 3 monitoring wells(2.38 % of total) had shown the highest decadal rise of >4 m. As far as decadal decline in water level is concerned, 33 wells out of 126 (26.19 % of total) had recorded decadal decline in the range of 0-2 m, 5 monitoring wells (3.97% of total) had shown higher decadal decline of 2-4 m and 5 monitoring wells (3.97% of total) had shown the highest decadal decline of >4 m in Uttarakhand in the post-monsoon period.

The decadal water level fluctuation map for average (November 2008 -2017) versus November 2018 is shown in **Fig. 22 (***Dehradun District),* **Fig 23** *(Haridwar District)* and ***Fig. 24*** *(Nainital-Udham Singh Nagar-Champawat section)*.

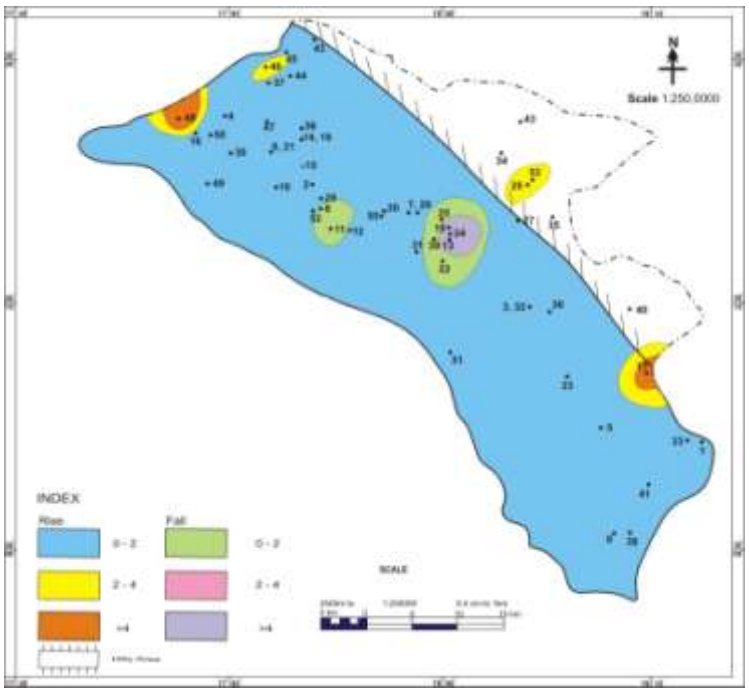


Figure 22 Decadal Water Level Fluctuation Map (November 2008-2017 vs 2018), Dehradun District

A perusal of **Fig. 22** reveals that minimum decadal rise of 0-2 m is observed in major portion of the Doon valley. Higher decadal rise of 2-4 m is observed around Tarla Nagal, Dakpathar, Harbanswala areas and highest Rise of >4m are observed around Dhakrani and Dandi areas. The figure also shows that minimum decadal decline of 0-2 m is observed in isolated patches around Badripur,Majra, Selaqui and Singhniwala. The decadal decline in the range of 2-4m is

observed in Nanda Ki Chowki, CGWB office, Khadiri khadakmaaf and Duggiawala. The highest decadal decline of >4 m is observed around Balliwala area.

A perusal of Fig. 23 reveals that minimum decadal rise of 0-2 m is observed in >70% parts of Haridwar District. Higher decadal rise of 2-4 m and highest decadal rise of >4 m are not seen in any area as per the available data. The minimum decadal decline of 0-2 m is observed as isolated patches in and around Laksar-Buggawala-Bandarjud-Chudiala-Bhagwanpur-Lnadhaura-Sarai-Goverdhanpur-Bhikkampur-Lakhnauta-Libbertheri – Jhabrera-Nizampur areas of the section. Higher decadal decline of 2-4 m is highest decadal decline of >4 m is not observed in any part of the section.

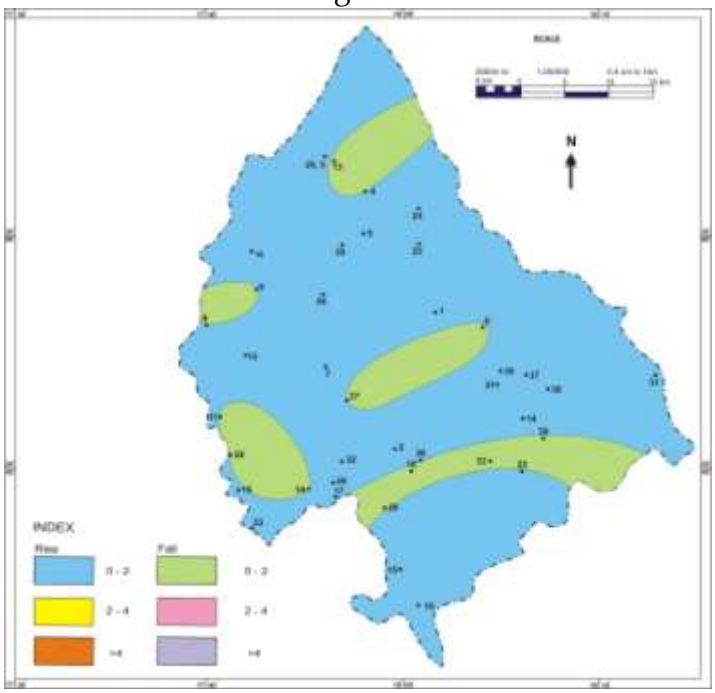


Figure 23 Decadal Water Level Fluctuation Map (November 2008-2017 vs 2018), Haridwar District

Visual interpretation of **Fig. 24** has shown that minimum decadal rise of 0-2 m is observed in major portion of the section. Higher decadal rise of 2-4 m is seen as isolated patches in and around Maldhan colony-Khatbans-kathgodam areas of Nainital district and Banbasa-Bichayee of Champawat district. The highest decadal rise of >4 m is not observed in any part of the section as per

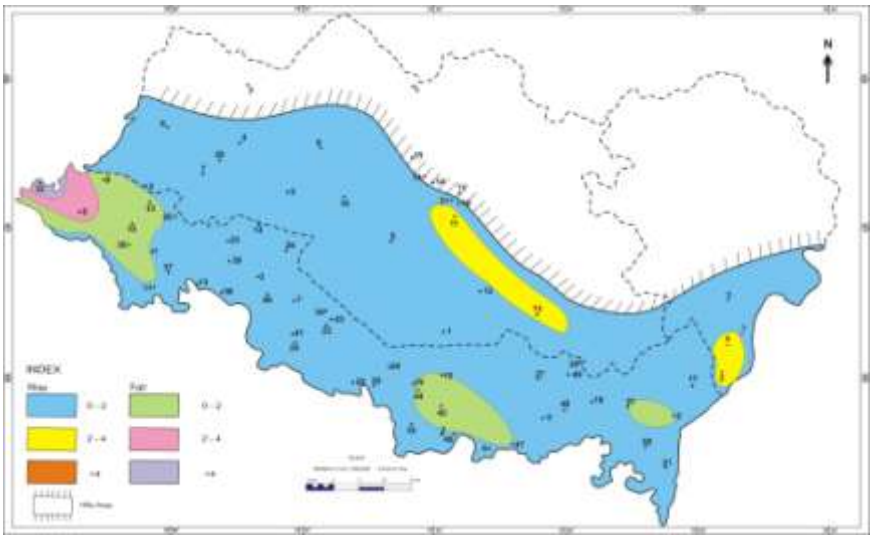


Figure 24 Decadal Water Level Fluctuation Map (November 2008-2017 vs 2018), US Nagar – Nainital - Champawat

available data. The minimum decadal decline of 0-2 m is observed as isolated patches in and around Patrampur-Bharatpur-barkhare Pande ,Gangapur-Kichha-Shantipuri-BegurMod,Sarasaraiya-Khatima areas of Udham Singh Nagar district. Higher decadal decline of 2-4 m is observed around Jaspur in Udham Singh Nagar district. The highest decadal decline of >4 m is observed as patch in and around Angadpur in Udham Singh nagar district

Table 14. Decadal Water Level Fluctuation (November 2008-November 2017 versus November2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	36	0.088	6.918	0.05	18.37	22	61.11	3	8.33	2	5.56	4	11.11	4	11.11	1	2.78
Haridwar	33	0.044	1.693	0.007	4.35	19	57.58	0	0.00	0	0.00	13	39.39	0	0.00	1	3.03
Udham Singh Nagar	42	0	3.002	0.034	6.049	26	61.90	1	2.38	0	0.00	13	30.95	1	2.38	1	2.38
Nainital	11	0.034	7.532	0.357	8.34	2	18.18	3	27.27	1	9.09	3	27.27	0	0.00	2	18.18
Champawat	4	0.235	3.444	NA		2	50.00	2	50.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**126**	**0.034**	**7.532**	**0.007**	**18.37**	**71**	**56.35**	**9**	**7.14**	**3**	**2.38**	**33**	**26.19**	**5**	**3.97**	**5**	**3.97**

5.4.1.4 Water Level Fluctuation (January 2008-2017versus January 2018)

Decadal (long-term) water level data for 141 ground water monitoring wells is analyzed and is given in ***Table 15***. Analysis of the data reveals that the lowest decadal rise is 0.003 m at Shankarpur in Dehradun Districtwhereas the highest decadal rise is 10.27 m at Majra in Dehradun District. As far as decadal decline in water level is concerned, the highest is 30.75 m at Tarla Nagal in Dehradun district while the lowest is 0.002m at Judli in Dehradun district.

A perusal of the table also indicates that out of 141 monitoring wells, 51 wells (36.17% of the total number) had shown the minimum decadal rise in the range 0-2 m, 3 wells (2.13% of the total number) of monitoring wells had shown a higher rise in the range 2-4 m while only 5 well (3.55 % of total) had shown the highest decadal rise of >4 m. The minimum decadal decline in the range of 0-2 m is shown by 53 wells (37.59% of total) while 15 wells (10.64%) had shown higher decadal rise of 2-4 m. 14 monitoring well (9.93 %) has recorded the highest decadal decline (>4 m) in Uttarakhand State.

The decadal water level fluctuation map for average (January 2009-2018 versus January 2019) is shown in ***Fig. 25*** *(Dehradun section), Fig.26 (Haridwar section)* and ***Fig. 27*** *(Nainital-Udham Singh Nagar-Champawat section)*.

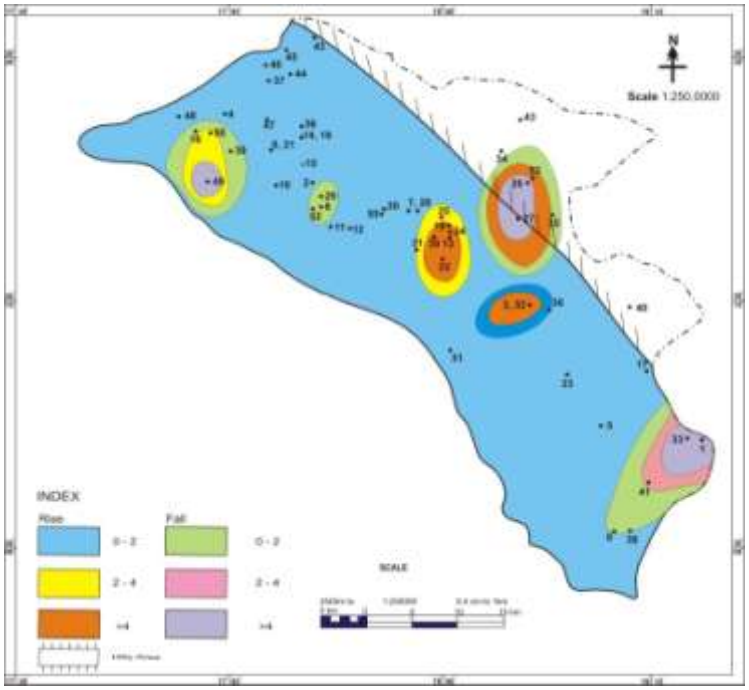


Figure 25 Decadal Water Level Fluctuation Map (January 2008-2017 vs 2018), Dehradun District

A perusal of **Fig. 25** (Dehradun District) reveals that minimum decadal rise of 0-2 m is observed in major part of the Doon Valley. Higher decadal rise of 2-4m is observed around harbanswalaAnd greater than 4m s observed around Cgwb Office-laltappar-Kuanwala- The minimum decadal decline of 0-2 m is observed in isolated patches at Judli – Herbertpur – Redarpur and Lal Tappar. The decadal decline in the range of 0-2 m is observed around SElaqui-Purukulgaon-

Badripur-Dandi-Judli areas of Doon valley. The decadal decline in the range of 2-4m is observed in Maldeota-Dharmawala-Kahadirikhadakmaf-Balliwala. The decadal decline in the range of >4 m is observed around Tarla Nagal-Timli-Rishikesh-Nanurkhera-Nanda ki Chowki .

A perusal of Fig. 26 (Haridwar District) reveals that minimum decadal rise of 0-2 m is observed around Lakhnauta-Laksar-Nizampur-Gurukul Narsen-roorkee-Libberheri-Hussainpur-Jaswawala-Bahablapurareas.decadal rise of 2-4 m and greater than 4 m is not observed in any part of the Doon valley. The decadal decline in the range of 0-2m is observed around Khanpur-Goverdhanpur-Bahadrabad-Jhabrera-Bhikkampur-Bhogpur-Rathaura-Sahidwala grant-Bandarjud areas. The decadal decline in the range of 2-4m is observed around Imlikhera-Chidiala-Ladhang-Dallawala areas. The decadal decline in the range of greater than 4m is observed at Bhagwanpur-Iqbalpur areas.

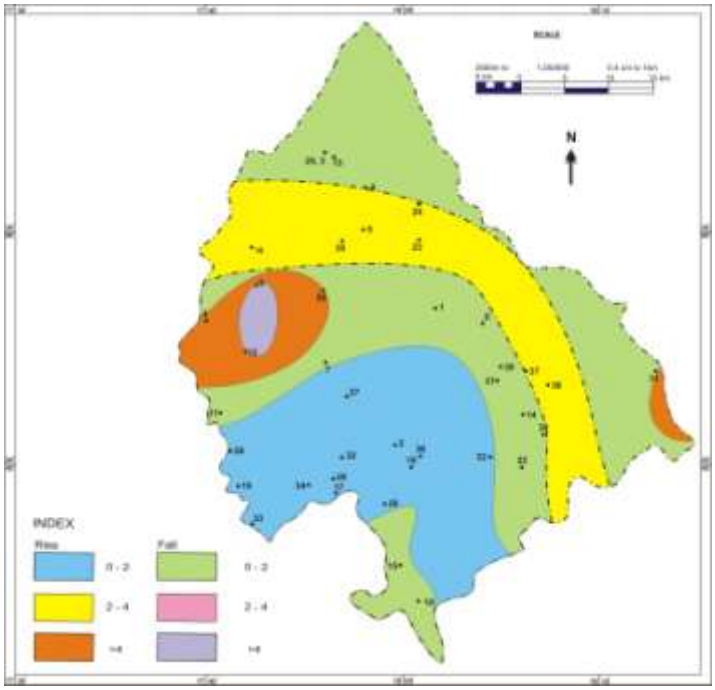


Figure 26 Decadal Water Level Fluctuation Map (January 2008-2017 vs 2018), Haridwar District

Visual interpretation of **Fig. 27***(Nainital-Udham Singh Nagar-Champawat section)* has shown that minimum decadal rise of 0-2 m is observed in major part of Udham Singh Nagar district and Champawat district.Higher decadal rise of 2-4 m is observed in and around Bazpur-Sitarganj-Patharchatta-Kamariapakki-Nanakmata-Patharpur areas.Highest decadal rise of >4m is not seen in any part of the section.. The minimum decadal decline of 0-2 m is observed in Ramnagar-Lalkuan-Belparao areas of Nainital district. Higher decadal decline of 2-4 m is observed in Patrampur-Missarwala-Tukri-Angadpur-Sulatnpur patti(Udham Singh Nagar District) and Khatbans-Kaladhungi (Nainital district) areas. Whereas the highest decadal decline of >4 m is observed around Dhoniya-Dhela-Peeru Madara-Lamachaurareas in Nainital District.

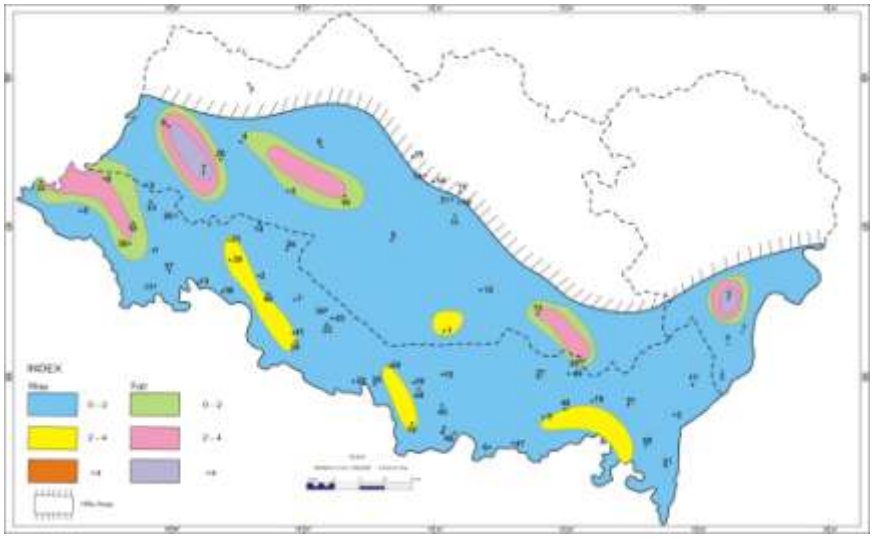


Figure 27 Decadal Water Level Fluctuation Map (January 2008-2017 vs 2018), US Nagar – Nainital - Champawat

Table 15. Decadal Water Level Fluctuation (January 2009 -January 2018 versus January 2019)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2 to 4*		*>4*		*0-2*		*2 to 4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	41	0.003	10.27	0.002	30.75	20	48.78	1	2.44	4	9.76	6	14.63	5	12.20	5	12.20
Haridwar	34	0.0125	1.7	0.02	6.62	13	38.24	0	0.00	0	0.00	15	44.12	4	11.76	2	5.88
Udham Singh Nagar	43	0.02	1.53	0.004	3.61	12	27.91	0	0.00	0	0.00	27	62.79	4	9.30	0	0.00
Nainital	12	0.58	1.22	1.15	12.87	3	25.00	0	0.00	0	0.00	3	25.00	2	16.67	4	33.33
Champawat	3	0.08	1.49	0.37	6.4	2	66.67	0	0.00	0	0.00	0	0.00	0	0.00	1	33.33
Pauri Garhwal	1	--		6.48		0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	100.0
Uttarkashi	7	3.09	24.41	0.13	11.31	1	14.29	2	28.57	1	14.29	2	28.57	0	0.00	1	14.29
Total	**141**	**0.003**	**24.41**	**0.002**	**30.75**	**51**	36.17	**3**	2.13	**5**	3.55	**53**	37.59	**15**	10.64	**14**	9.93

5.4.2 ANNUAL WATER LEVEL FLUCTUATION

5.4.2.1 Water Level Fluctuation (May 2017 versus May 2018)

The analysis of data for 127 Ground Water Monitoring Wells for May 2017 versus May 2018 is given in ***Table 16.*** A perusal of the table shows that the minimum annual rise in water level is 0.005 m at Shantipuri in Udham Singh Nagar district while the maximum annual rise is 11.2 m at Chilkiya, Nainital district. The minimum annual decline in ground water level is 0.04 m at Shahidwala grant in Haridwar district while the maximum annual decline is 10.98 m at Nanurkhera in Dehradun district.

A perusal of ***Table 16*** reveals that out of 118 monitoring wells 41 (34.75% of total) has shown minimum rise in the range 0-2 m whereas higher rise of 2-4 m is shown by 3monitoring wells (2.54% of the total) and the highest rise of >4 m is recorded by 8monitoring wells (6.78%) for calculating the annual fluctuation in ground water level for the pre-monsoon period. The minimum decadal decline in the range of 0-2 m is shown by 53 out of 118 monitoring wells (44.92% of the total number) had recorded annual decline in the range of 0-2 m. Higher annual decline of 2-4 m is recorded by 5 monitoring wells (4.24% of total) whereas the highest decline of >4 m is recorded by 8monitoring wells (6.78% of the total number).

The annual water level fluctuation map during the period May 2017 versus May 2018 has been shown in ***Fig. 28*** *(Dehradun District), Figure. 29 (Haridwar section)* and ***Fig. 30*** *(Nainital- Udham Singh Nagar-Champawat section).***Fig. 28** (Dehradun District) reveals that minimum Annual rise of 0-2 metres is observed as narrow band and isolated patchin Northern and Central part of Doon valley covering areas such

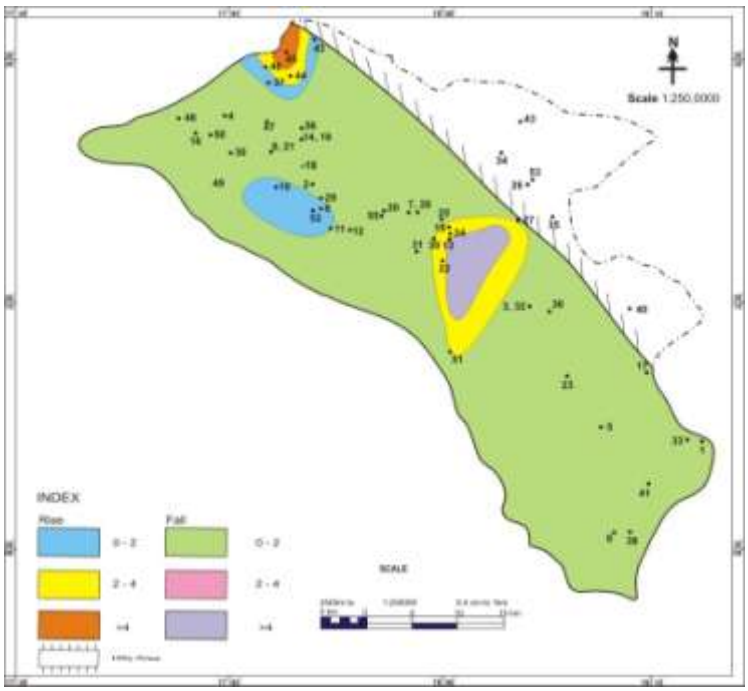


Figure 28Annual Water Level Fluctuation Map (May 2008-2017 vs 2018), Dehradun District

as Vikasnagar,Haripur,Selaqui,Sabhawla,Singhniwala. Higher annual rise of 2-4 m is observed as narrow band in the Northern part of the Doon valley covering laxmipur,Dakpathar areas. The highest annual rise of >4 metres is observed in Northern part of the section covering Baluwala,Dhakrani areas.The minimum annual decline of 0-2 m is observed in major part of the valley (Khandgaon-Laltappar-Maldeota-Judli–Shankarpur – Rampura-Ramgarh areas) of Dehradun district. Higher annual decline of 2-4 m is observed as isolated encircling highest water level decline of greater than 4 metres around Chandmari-CGWB office areas and the highest annual decline of >4 metres is observed as isolated patch around Nanurkhera-Kanwali-majra-Bhaniawala areas as per available data.

A perusal of **Fig. 29** (Haridwar District) shows that the water level in the range of 0-2 metres is observed as isolated patches in Southwestern and Northeastern part of the section covering Dandi ibrahimpur-Bahdrabad-Dhanpura-Rathaura-Budhwa Sahid-Husainpur-Sikhar-Gurukul Narsen-Roorkee-Jhabrera-Libberhedi-lakhnauta-Kherajat-Landhaura-Mudlana areas. The annual rise of 2-4 m is not observed in any part of the section as per availabale data. The annual water level rise of greater than 4metres is observed around Imlikhera. The minimum annual decline of 0-2 m is observed in major part of the section covering areas such as Bhikampur-Buggawala-Laksar-Panjanheri-Khanpur-Dalupuri-Chudiala-Shyampur-Dudhya Dayalwala areas.Higher annual decline of 2-4 m is not observedin nay part of the section. The highest annual decline of >4 m is observed around Bhagwanpur and Laldhang areas in the district.

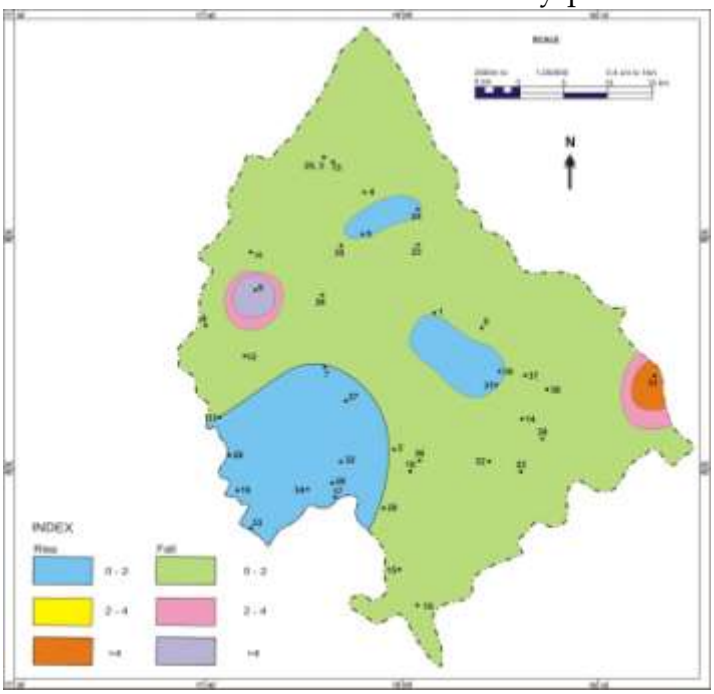


Figure 29 Annual Water Level Fluctuation Map (May 2017 vs 2018), Haridwar District

A study of **Fig. 30** shows that during the pre-monsoon period, the minimum annual rise of 0-2 m is observed as isolated patches in Udham singh district (Durgapur-Shenkhera-Kanaura-Dhanuri patti-Bharatpur-Badaripur-Patharpuri-Bidora-Sitarganj-Begur Mod-Dhyanpur areas),Nainital district (Kathgodam) and Champawat district(Banbasa).The annual rise of 2-4 and greater than 4 metres is not observed in any part of the section. The lowest pre monsoon annual decline of 0-2 m is observed in major part of the section.Higher annual decline of 2-4 m is observed encircling the >4m zone around Tukri-Kichha-Rajpura (Udham Singh Nagar District) ,Khatbans (Nainital district) and bastia(Champawat district) areas.

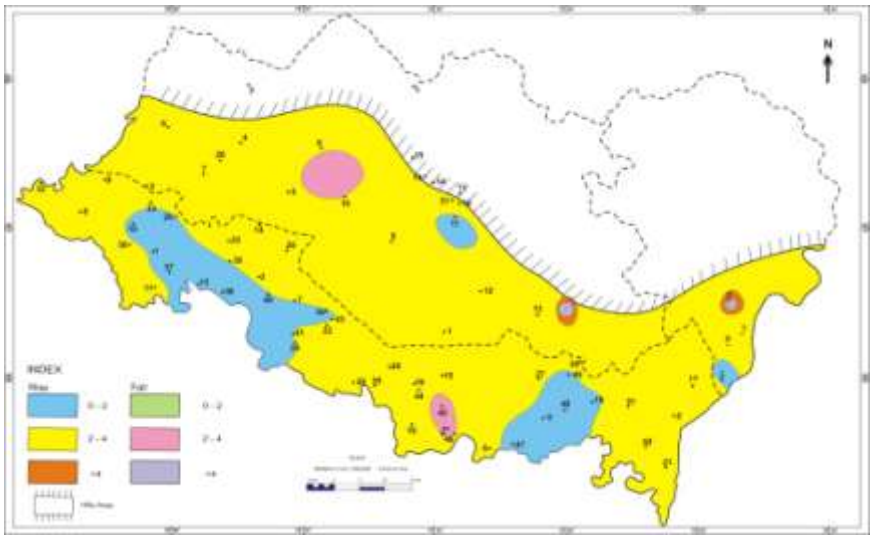


Figure 30 Annual Water Level Fluctuation Map (May 2017 vs 2018), US Nagar – Nainital - Champawat District

Table 16. Annual Water Level Fluctuation (May 2017versus May 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	28	0.165	8.81	0.08	10.98	6	21.43	1	3.57	3	10.71	13	46.43	1	3.57	4	14.29
Haridwar	37	0.055	7.655	0.04	7.69	12	32.43	0	0.00	1	2.70	22	59.46	0	0.00	2	5.41
Udham Singh Nagar	43	0.005	2.385	0.045	6.7	20	46.51	0	0.00	1	2.33	18	41.86	3	6.98	1	2.33
Nainital	8	0.37	11.2	4.5		2	25.00	2	25.00	3	37.50	0	0.00	0	0.00	1	12.50
Champawat	2	1.675		6.165		1	50.00	0	0.00	0	0.00	0	0.00	1	50.00	0	0.00
Total	**118**	**0.005**	**8.81**	**0.04**	**10.98**	**41**	34.75	**3**	2.54	**8**	6.78	**53**	44.92	**5**	4.24	**8**	6.78

5.4.2.2 Water Level Fluctuation (August 2017 versus August 2018)

The analysis of annual water level fluctuation data for 142 Ground Water Monitoring Wells for the periods August 2017 and August 2018 is given in ***Table 17.*** Analysis of the fluctuation data indicates that the minimum annual rise of 0.005 metres is observed at Jharkhandi,Udham Singh Nagar district. The maximum annual rise of 21.88 metres is observed at Timli in Dehradun district. The lowest annual decline is 0.02 metres at Barianjariyain Udham Singh Nagar district, whereas the highest decline is21.25 metres at Dhoniya in Nainital district.

Analysis of the fluctuation data has indicated that out of 142 monitoring wells, 49 wells (34.51% of total) had shown an annual rise in the range 0-2 m while higher rise of 2-4 m is observed in14 monitoring well (9.86% of total). The highest rise in the range >4 m is recorded by 17 monitoring wells, which is 11.97% of the total number of wells. It is also seen that majority of monitoring wells (47 out of 142, 33.10% of total) had recorded annual decline in the range of 0-2 m. Higher annual decline of 2-4 m is shown by 4 monitoring wells (2.82% of total) while the highest decline of >4 m is shown by 11 monitoring wells, which is 7.75% of the total number of wells.

The annual water level fluctuation map during the period August 2015 versus August 2016 is shown in ***Fig. 31*** *(Dehradun section),* ***Fig. 32*** *(Haridwar section)* and ***Fig. 33*** *(Nainital-Udham Singh Nagar-Champawat section).*

A perusal of Fig. 31 indicates that minimum annual rise of 0-2 m is seen in major part of the Doon valley. The higher annual rise of 2-4 m is observed as isolated patches around Herbertpur-Badripur,Haripur-Laxmipur-Baluwala-Dakpathar,Chandmari-Gularghati-Dudhli-Kuanwlala and also as circular patches encircling the annual the zone

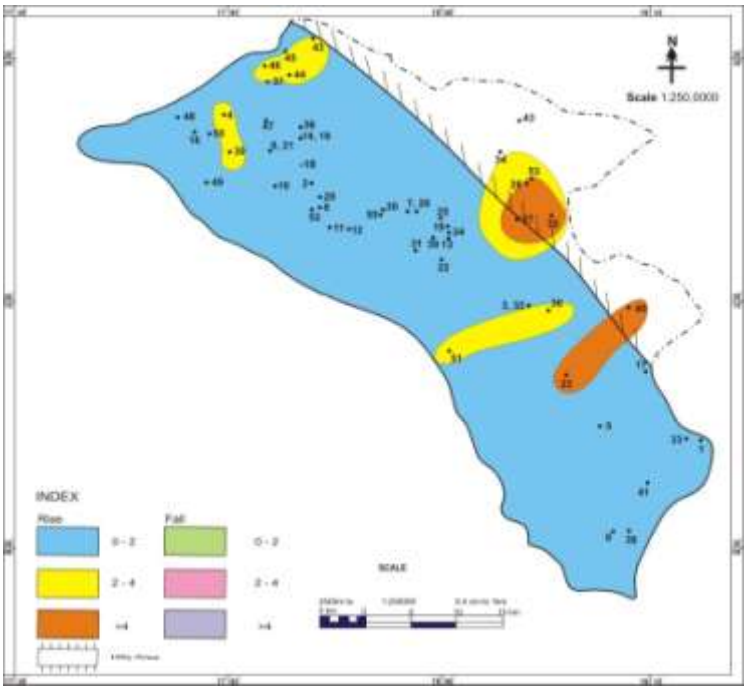


Figure 31 Annual Water Level Fluctuation Map (August 2017 vs 2018), Dehradun District

of water level rise in the range of greater than 4 metres around Purukulgaon-Tarlanagal .The highest water level rise in the range of greater than 4 metres is also observed as isolated patches around Kotimachak-Bhaniawala.The minimum annual decline of 0-2 m is observed as isolated patch around Ramgarh.The highest annual decline of greater than 4 metres is not observed in any part of the section.

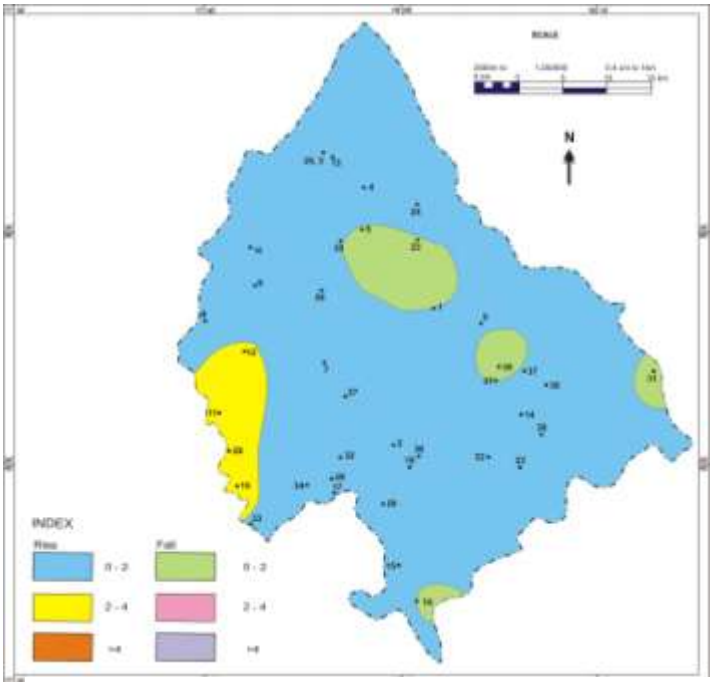


Figure 32 Annual Water Level Fluctuation Map (August 2017 vs 2018), Haridwar District

A perusal of Fig. 32 indicates that minimum annual rise of 0-2 m is observed in major parts of the district. The 2-4m water level zone is observed as isolated patch around Iqbalpur-Lakhnauta-Jhabrera. The highest annual rise of >4 m is not observed in any part of the section. The minimum annual decline of 0-2 m is observed as isolated patches around Rathaura-Kota Muradnagar-Jaswawala-Bhadrabad,Dhanpura-Panjanheri,Laldhang,Dallawala.Higher annual decline of 2-4 m is not observed in any part of the section.The highest annual decline of greater than 4 metres is observed around Dandi Ibrahimpur.

A perusal of **Fig. 33** indicates that minimum annual rise of 0-2 m is observed in major part of the section. Higher annual water level decline in the range of 2 to 4 metres is observed as isolated patch in Banbasa-Bastia areas of champawat district enveloping annual water level decline in the range of greater than 4 metres(around Lalkuan-Ramnagar of Champawat district)).The minimum annual decline of 0-2 m is observed as continuous band running from western part to North eastern part of the sectioncovering areas such as Bharatpur-Kashipur-Barkhare Pande-Sultanpurpatti-Jhagarpuri-Patharpuri-Sitrganj-Bidora-Barianjariya-Kanchanpuri(Udham Singh Nagar district).This zone is also observed as isolated patch rimming annual water level decline zones in the range of 2 to 4 meters(around Belparao of Nainital district) and greater than 4

metres(around Chilkiya-Dhoniya of Nainital district) covering areas such as Ramnagar-Kaladhungi-Peeru madara-Kathgodam of Nainital district.

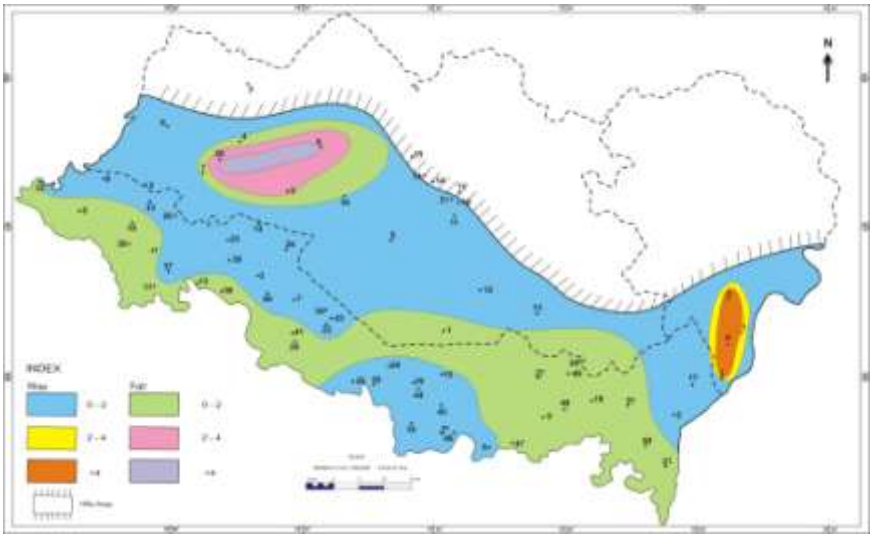


Figure 33 Annual Water Level Fluctuation Map (August 2017 vs 2018), US Nagar – Nainital - Champawat District

Table 17. Annual Water Level Fluctuation (August 2017 versus August 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	46	0.17	21.88	0.15	7.32	13	28.26	14	30.43	13	28.26	2	4.35	0	0.00	4	8.70
Haridwar	37	0.055	7.055	0.04	7.69	12	32.43	0	0.00	1	2.70	22	59.46	0	0.00	2	5.41
Udham Singh Nagar	44	0.005	1.845	0.02	4.72	23	52.27	0	0.00	0	0.00	18	40.91	2	4.55	1	2.27
Nainital	13	1.12	7.45	0.23	21.25	1	7.69	0	0.00	1	7.69	5	38.46	2	15.38	4	30.77
Champawat	2	5.135				0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00
Total	**142**	**0.005**	**21.88**	**0.02**	**21.25**	**49**	34.51	**14**	9.86	**17**	11.97	**47**	33.10	**4**	2.82	**11**	7.75

5.4.2.3 Water Level Fluctuation (November 2017 versus November 2018)

The analysis of annual water level fluctuation data for 146 Ground Water Monitoring Wells in Uttarakhand is available. Analysis of the data has shown that the lowest annual rise is 0.02 metresat Rathaura in Nainital district and Bara in Udham Singh Nagar district while the highest annual rise is 6.625 m at Tarla Nagal in Dehradun district. During the post-monsoon period the lowest annual decline is 0.005 m at Badripur in Dehradun district while the highest annual decline is 8.97 m at Balliwala in Dehradun district.

A study of the water level fluctuation data has revealed that 93 monitoring wells out of 146 wells (63.70 % of the total number) has recorded a rise in the range of 0-2 m. 7 monitoring well (4.79% of the total) had shown the higher rise of 2-4 m and 2 monitoring well (1.37 % of the total) had shown the highest rise of>4 m during this period. The 39 nos. of monitoring well (26.71% of the total) had recorded an annual decline in the range of 0-2 m during the post monsoon period. 3 wells (2.05% of total number) had shown higher decline of water level in the range of 2-4 m whereas only 2 wells (1.37 % of total) had shown the highest annual decline of >4 m in water level.

The annual water level fluctuation map during the period November 2015 versus November 2016 is shown in ***Fig. 34*** *(Dehradun district), Fig.35 (Haridwar section)* and ***Fig. 36*** *(Nainital-Udham Singh Nagar-Champawat section)*.

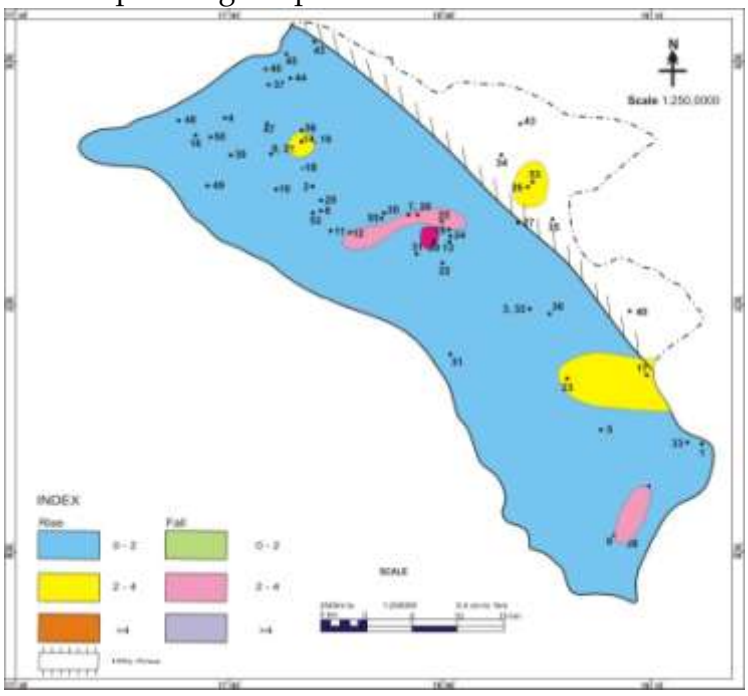


Figure 34 Annual Water Level Fluctuation Map (November 2017 vs 2018), Dehradun District

A perusal of Fig. 34 has shown that the minimum annual rise in post monsoon period in the range of 0-2 m is observed in major part of the valley.Higher annual rise of 2-4 m is observed as isolated patches around Dandi-Bhaniawala,Tarla

Nagal,Chorba areas.The minimum annual decline of 0-2 m is observed as isolated patchencircling annual water level rise of 2 to 4 metres(Selaqui) and annual water level rise of greater than 4 meters(Balliwala-Majra)around Nandi ki chowki-Khadiri Khadakmaf-Khandgaon-CGWB office-Ramgarh areas.

A perusal of **Fig. 35** has shown that the minimum annual rise in post monsoon period in the range of 0-2 m is major parts of the district; whereas the annual water level rise of 2-4 m and greater than 4 meters is not observed in any part of the district. The minimum annual decline of 0-2 m is observed as isolated patches around Bahabalpur, Buggawla-Bandarjud,Sarai-Dandi Ibrahimpur-Dhanpura-Bahadrabad, Shahpur Shitlakhera-Bhogpur-Bhikampur, Mudlana-Gurukul Narsen-Laksar-Nizampur areas during the post-monsoon period.

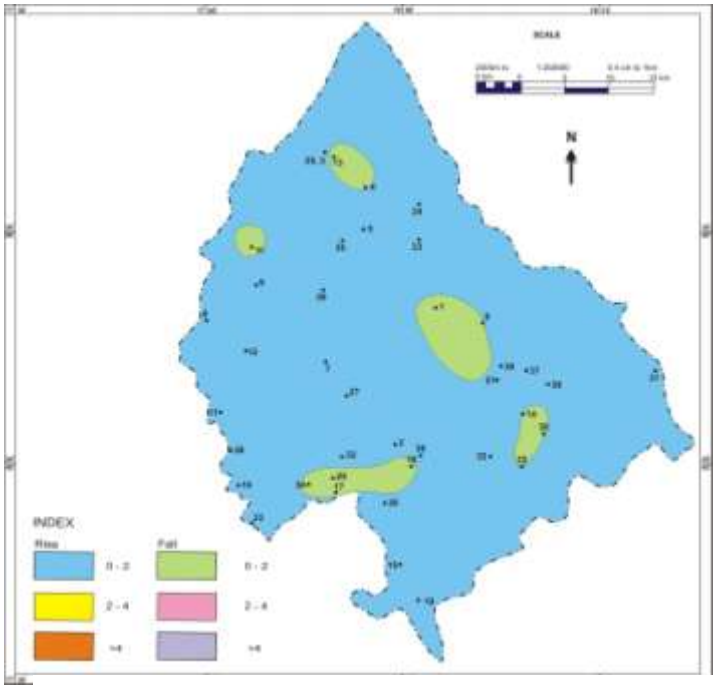


Figure 35 Annual Water Level Fluctuation Map (November 2017 vs 2018), Haridwar District

Interpretation of **Fig. 36** has shown that for the post monsoon period, the minimum annual rise of 0-2 m is observed in major part of the section.Higher annual rise of 2-4 m is observed as isolated patches chilkiya,Khatbans of Nainital district. The highest annual rise of >4 m is not observed in

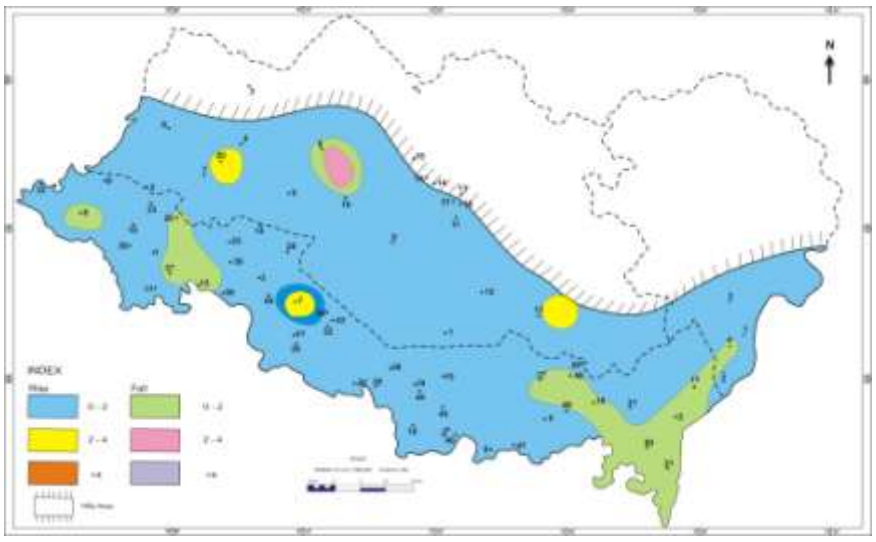


Figure 36 Annual Water Level Fluctuation Map (November 2017 vs 2018), US Nagar – Nainital - Champawat District

any part of the section.The minimum annual decline of 0-2 m is observed as isolated patches around Jaspur,Dhanauri Patti-Shenkhera-Sultanpur patti,Kalyanpur-Tukri-Dhyanpur-Nanakmata-Barianjariya-Khatima-Chakarpur(Udham Singh Nagar district) and Bastia (Champawat district) areas and as isolated patch around Kaladhungi area of Nainital district encircling annual water level decline zone of 2 to 4 metres. . The highest annual decline of >4 m is not observed in any part of the section.

Table- 18. Annual Water Level Fluctuation (November 2017versus November 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	45	0.045	6.625	0.47	8.97	29	64.44	5	11.11	2	4.44	5	11.11	2	4.44	2	4.44
Haridwar	39	0.02	1.295	0.05	1.305	26	66.67	0	0.00	0	0.00	13	33.33	0	0.00	0	0.00
Udham Singh Nagar	45	0.02	1.625	0.005	1.415	28	62.22	0	0.00	0	0.00	17	37.78	0	26.00	0	0.00
Nainital	13	0.1	3.25	0.09	3.625	7	53.85	2	15.38	0	0.00	3	23.08	1	7.69	0	0.00
Champawat	4	0.205	0.745	0.445		3	75.00	0	0.00	0	0.00	1	25.00	0	0.00	0	0.00
Total	**146**	**0.02**	**8.155**	**0.005**	**8.97**	**93**	63.70	**7**	4.79	**2**	1.37	**39**	26.71	**3**	2.05	**2**	1.37

5.4.2.4 Water Level Fluctuation (January 2018 versus January 2019)

The analysis of water level data of 148 ground water monitoring wells for the period January 2018 versus January 2019 is given in ***Table 19.*** A perusal of the table indicates that the minimum annual rise is 0.015 m at Dhanauri Pattiin US Nagar district whereas the maximum annual rise is 6.35 m at Tarla Nagal in Dehradun district. The minimum annual decline is found to be 0.015 m at Beria Daulat in US Nagar district and |Panjanheri of hardiwar district whereas the maximum decline is 7.01 m at Dhela in Nainital district.

A perusal of the table also reveals that out of 148 monitoring wells, 77 wells (52.03%) have recorded the minimum annual rise in the range 0-2 m whereas 8 wells (5.41% of total wells) had shown higher rise in the range 2-4 m. 3 nos. of monitoring well (2.03 % of the total) had recorded the highest annual water level rise of greater than 4 metres.Lowest annual decline of 0-2 m is recorded by 49 monitoring wells (33.11% of total) while 7 wells (4.73%) had recorded higher decline in the range of 2-4 m. The highest decline of greater than 4 metres is shown by 4 no of monitoring well (2.7% of total).

The annual water level fluctuation map during the period January 2017 versus January 2018 is shown in ***Fig. 37*** *(Dehradun district), Fig. 38 (Haridwar district)* and ***Fig. 39*** *(Nainital-Udham Singh Nagar-Champawat section).*

Visual interpretation of Fig. 37 has shown that the minimum annual rise in the range of 0-2 m is observed in major part of the section.The higher annual water level rise I the range of 2 to 4 metres is observed as isolated patches around Laxmipur-Baluwala-sahaspur-Chorba,Chnadmari-Bhaniawala-Dudhli areas and as circular patch around Telpura-Majra-Baronwala

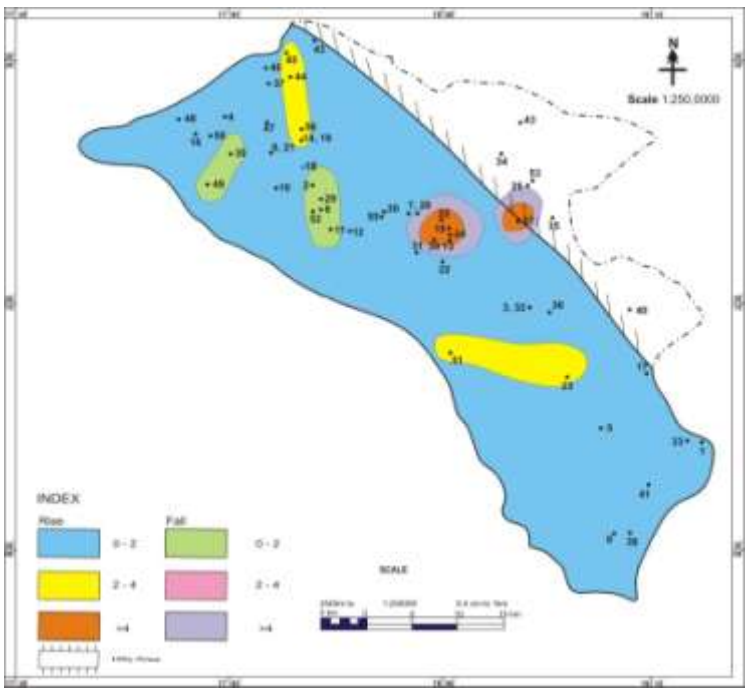


Figure 37 Annual Water Level Fluctuation Map (January 2018 vs 2019), Dehradun District

rimmimg annual water level rise zone of greater than 4 meters around Ladpur-Balliwala-Harbanswala-Kanwali-CGWB office areas. The minimal annual decline of 0-2 m is observed as isolatedpatches around Badripur-Timli, Selaqui-Rampura-Rishikesh whereas higher annual decline of 2-4 m is observed as circular rim in Tarla Nagal-Maldeota around annual water level zone having decline in the range of greater than 4 metres in Nanurkhera areas of the section.

Visual interpretation of Fig. 38 has shown that the minimum annual rise in the range of 0-2 m is observed in major prat of the district. The annual water level rise of 2-4 metres and greater than 4 meters is not observed in nay part of the Haridwar district. The minimal annual decline of 0-2 m is observed as isolated patches around Kota Muradnagar – Buggawala – Rathaura-Bahabalpur - Bhagwanpur - Iqbalpur , Dallawala , Laldhang and as elongated patches around landhaura- Roorkee,Bhogpur-Shahpur Shitlakahera-Shyampur-Panjanheri-Dhanpura encircling anuual water level zones showing decline in the range of 2 to 4 meters around Imlikhera,Dandi Ibrahimpur.

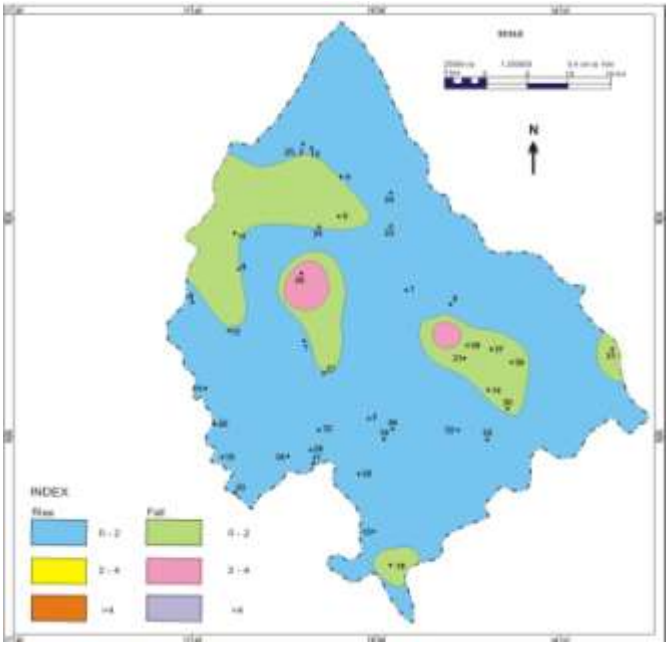


Figure 38 Annual Water Level Fluctuation Map (January 2018 vs 2019), Haridwar District

A perusal of **Fig. 39** indicates that the minimum annual rise of 0-2 m is observed in major partof the section. Higher annual rise of 2-4 m is observed as isolated patch Angadpur,Rajpura in Udham Singh Nagar District. The highest annual rise of >4 m is not observed in any part of the section. The minimum annual decline of 0-2 m is mostly observes as elongated patches around Mahabir Nagar-Kopa Signal–Lalpuri , Sultanpur patti- Kashipur-Missarwala-Jogipura-Pipaliya-Jharkhandi-Pritpur, rudrapur-Patharchatta-Gangapur-kanakpur-kichha-Peepli Chauraha –Shantipuri-,Sara saraiya-khatima- Tukri in Udham Singh Nagar district extending upto Bichyaee of Chamapawat district.This zone is also observed as lenticular shaped rim in Lalkuan-lamachaur-

Belparao-Chilkiya-Dhela of Nainital district around water level zone showing decline in the range of greater than 4 metres(Peeru Madara of Nainital district).Annual water level zone showing decline in the range of 2 to 4 metres and greater than 4 metres is not observed in any part of the section.

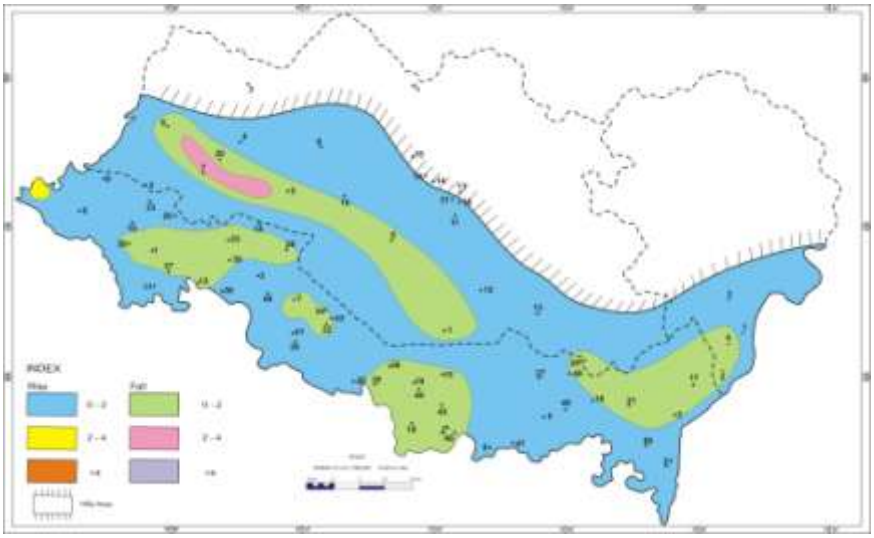


Figure 39 Annual Water Level Fluctuation Map (January 2018 vs 2019), US Nagar – Nainital - Champawat District

Table 19. Annual Water Level Fluctuation (January 2018 versus January 2019)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	49	0.02	6.35	0.05	5.30	24	48.98	6	12.24	3	6.12	10	20.41	3	6.12	3	6.12
Haridwar	40	0.03	1.1	0.015	4.38	21	52.50	0	0.00	0	0.00	17	42.50	2	5.00	0	0.00
Udham Singh Nagar	43	0.015	3.11	0.015	3.39	24	55.81	2	4.65	0	0.00	16	37.21	1	2.33	0	0.00
Nainital	13	0.1	1.505	0.25	7.01	6	46.15	0	0.00	0	0.00	5	38.46	1	7.69	1	7.69
Champawat	3	0.34	2.225	0.49		2	66.67	0	0.00	0	0.00	1	33.33	0	0.00	0	0.00
Total	**148**	**0.015**	**6.845**	**0.015**	**7.85**	**77**	52.03	**8**	5.41	**3**	2.03	**49**	33.11	**7**	4.73	**4**	2.70

5.4.3 SEASONAL WATER LEVEL FLUCTUATION

5.4.3.1 Water Level Fluctuation (May 2018 versus August 2018)

The seasonal fluctuation of water level during the period May 2018 versus August 2018 for 126 ground water monitoring wells in Uttarakhand State is given in ***Table 20.*** A perusal of the fluctuation data has shown that the minimum seasonal rise in ground water level was 0.015 m at Rathaura in Haridwar district whereas the maximum rise was 16.68 m at Nanurkherain Dehradun district. The minimum seasonal decline was 0.025 m at Sultanpur Patti in Udham Singh Nagar district while the maximum decline was 7.055 m at Imlikhera in Nanital district.

The perusal of Table 20 also reveals that rise in the range of 0-2 m was shown by 64 monitoring wells, which was 50.79% of the total number of wells. Higher rise in the range 2-4 m was shown by 31 wells (24.60% of total) while the highest rise of >4 m was shown by 13 wells (10.32% of total). The lowest seasonal decline of 0-2 m was recorded by 12 monitoring wells (9.52% of total). Higher seasonal decline of 2-4 m was shown by 1 monitoring wells, which was only 0.79% of the total number of wells during the period May versus August 2018. The highest seasonal decline of greater than 4 m was recorded by 5 monitoring wells (3.97% of total).

The seasonal water level fluctuation map during the period May 2016 versus August 2016 is shown in ***Fig. 40*** *(Dehradun District),* ***Fig. 41*** *(Haridwar section)* and ***Fig. 42*** *(Nainital-Udham Singh Nagar-Champawat section).*

Visual interpretation of **Fig. 40** has shown that the lowest seasonal rise of 0-2 m is observed in major parts of the Doon valley. The seasonal rise of

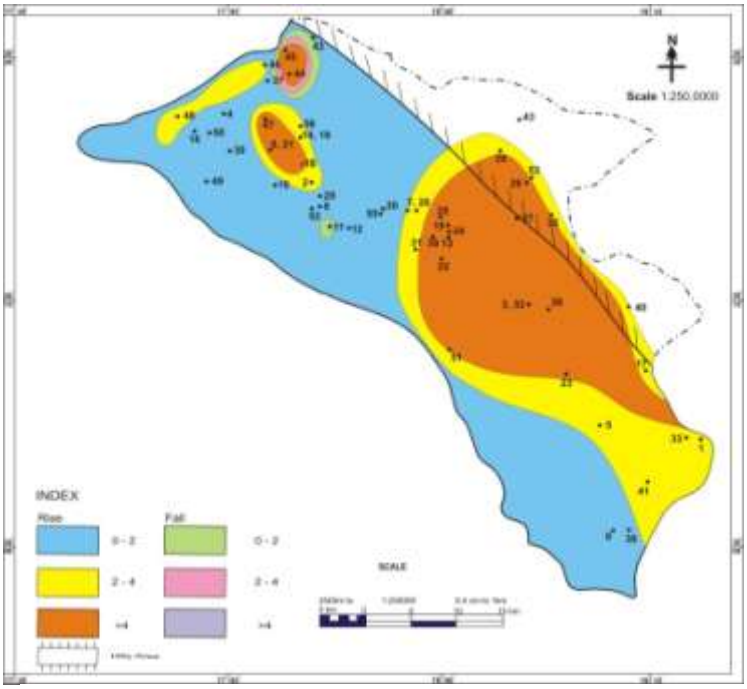


Figure 40 Water Level Fluctuation Map (May 2018 vs August 2018), Dehradun District

2-4 m is observed as isolated patch around Dakpathar-Dhakrani-Vikas Nagar and as elliptical rim(Rampura-Chorba-Sahaspur) around seasonal rise of greater than 4 meters(Shankarpur-Redapur).This seasonal rise zone in the range of 2 to 4 metres(around Rishikesh-khandgaon-laltappar-Nanda ki chowki-Tarla nagal) is also observed as narrow continuous band around water level rise zone in the range of greater than 4 metres(around Ladpur – Chandmari – Kanwali-Bhaniawala– KotimaichakMaldeota– Nanurkhera-Purukulgaon).The lowest seasonal water level decline in the range of 0 to 2 metres is observed as isolated patch around Singhniwala area of the section.

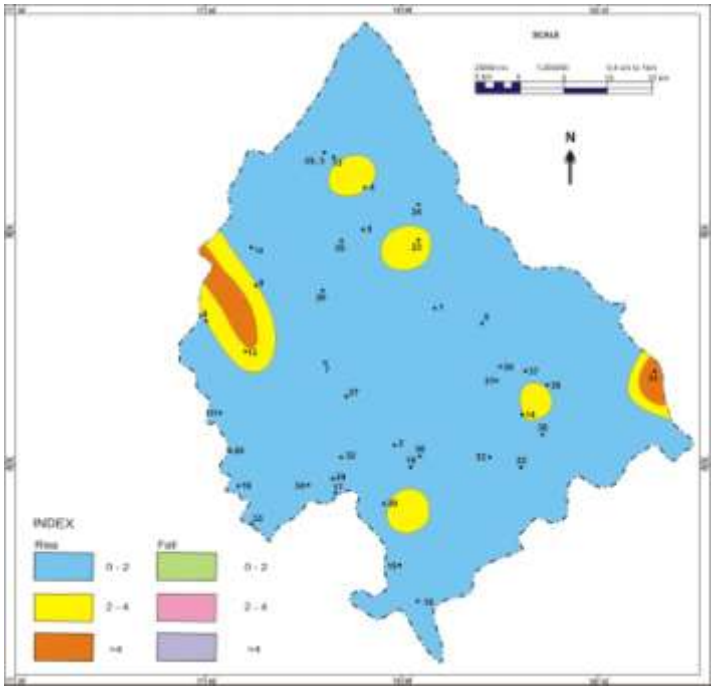


Figure 41 Water Level Fluctuation Map (May 2018 vs August 2018), Haridwar District

Visual interpretation of **Fig. 41** has shown that the lowest seasonal fluctuation of 0-2 m is observed major part of the district. The Seasonal rise of 2-4 m is observed as isolated patches around Goverdhanpur,Shahpur Shitlakhera,Bandarjud-Buggawala and as elongated rim around seasonal rise of greater than 4 metres in Bhagwanpur-chudiala-Iqbalpur,Laldhang areas of the district . The lowest seasonal decline of 0-2 m is observed as Kota Muradnagar-Jaswawala areas of the district.

A perusal of **Fig. 42** indicates that the lowest positive seasonal fluctuation of 0-2 m is observed in the major parts of the section. Higher seasonal rise of 2-4 m is observed as

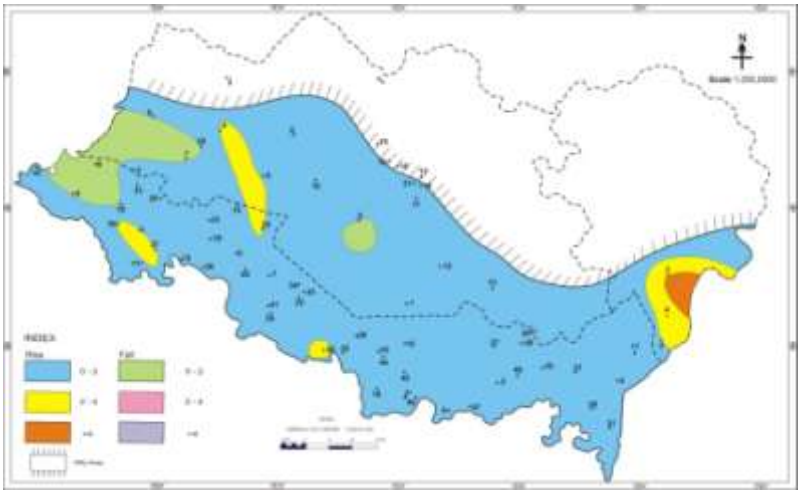


Figure 42 Water Level Fluctuation Map (May 2018 vs August 2018), US Nagar – Nainital - Champawat District

isolated patches around Misarawal - Shenkhera,Kanakpur, Pritpur, Pipaliya,Barianjariya of Udham Singh Nagar district and Belparao-Ramnagar areas of Nainital distric and as crest shaped narrow band enveloping the seasonal water level rise zone in the range of greater than 4 metres .The lowest seasonal decline of 0-2 m is observed as isolated patches in parts of Udham Singh Nagar and Nainital district covering areas such as Jaspur – Bharatpur -Peeru Madara–Chilkiya-
DhelaLamachaur.

Table 20. Seasonal Water Level Fluctuation (May 2018 Versus August 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	29	0.45	16.68	0.61	6.70	7	24.14	8	27.58	10	34.48	1	3.45	0	0.00	3	10.34
Haridwar	37	0.015	5.23	0.37	7.055	26	70.27	6	16.22	2	5.41	1	1.00	1	2.70	1	2.70
Udham Singh Nagar	43	0.24	3.72	0.025	1.12	30	69.77	8	18.60	0	0.00	5	11.63	0	0.00	0	0.00
Nainital	13	0.345	2.15	0.08	5.305	0	0.00	8	61.54	0	0.00	5	38.46	0	0.00	0	0.00
Champawat	4	1.615	10.735	3.595		1	25.00	1	25.00	1	25.00	0	0.00	0	0.00	1	25.00
Total	**126**	**0.015**	**16.68**	**0.025**	**7.055**	**64**	50.79	**31**	24.60	**13**	10.32	**12**	9.52	**1**	0.79	**5**	3.97

5.4.3.2 Water Level Fluctuation (May 2018 versus November 2018)

The water level fluctuation data of May 2018 was compared with that of November 2018 for 126 ground water monitoring wells in Uttarakhand and the result is given in ***Table 21.*** Analysis of the fluctuation data for the period May-November (pre-monsoon versus post-monsoon) indicates that the minimum seasonal rise was 0.05 m at Beria Daulat in Udham Singh |Nagar district while the maximum was 11.025 m at Bhaniawala in Dehardun district. The annual decline was 0.0450m at Garjiya in Nainital district whereas the maximum decline was 6.325 m at Imlikhera in Haridwar district.

A perusal of the fluctuation data also shows that seasonal rise of 0-2 m was shown by 73 monitoring wells out of 121 (57.94%), that in the range of 2-4 m by 29 monitoring wells (23.02% of total) and that in the range of >4 m by 13 wells (10.32 % of total) in Uttarakhand State. Seasonal decline in the range 0-2 m was recorded by 6 monitoring wells (4.76% of total). Higher seasonal decline in the range of 2-4 m had been recorded by 1 no of monitoring wells (0.79 % of total) and the highest decline of >4 m was recorded by 4 (3.17 %) monitoring well.

The seasonal water level fluctuation map during the period May 2017 versus November 2017 is shown in ***Fig. 43*** *(Dehradun district),* ***Fig.44*** *(Haridwar District)* and ***Fig. 45*** *(Nainital-Udham Singh Nagar-Champawat section).*

Visual interpretation of **Fig. 43** has revealed that the lowest seasonal rise of 0-2 m is observed in major parts of the Doon valley. Higher seasonal rise of 2-4 m is observed as continuous band with tapering end in the southern part of the district covering areas such as Rishikesh – Khandgaon – Lal tapper – Dandi – Kotimaichak

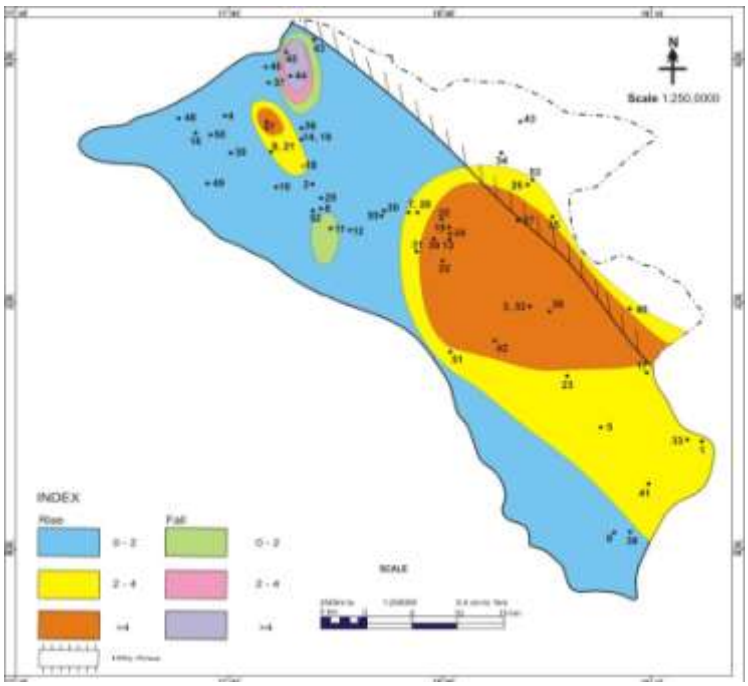


Figure 43 Water Level Fluctuation Map (May 2018 vs November 2018), Dehradun District

and as isolated rim around seasonal rise of greater than 4 metres in Shankarpur,Redapur areas of the district. The highest seasonal rise of >4 m is rimmed by seasonal rise of 2 to 4 metresin Chandmari,Bhaniawala,Ladpur,Maldeota areas. Seasonal decline in the range of 0-2m is observed as isolated patch around Singhniwala. The seasonal decline in the range of >4 m isobserved as enclosed by seasonal decline in the range of 2 to 4 metres and greater than 4metres.

Visual interpretation of Fig. 44 has revealed that the lowest seasonal rise of 0-2 m is observed in major part of the district.Higher seasonal rise of 2-4 m is observed as isolated patches around Chudiala-Iqbalpur,Buggawala, and Dalupuri-Shahpur Shitlalkhera. The highest seasonal rise of greater than 4 metres is observed around Bhagwanpur and Laldhang surrounded by seasonal rise of 2 to 4 metres.

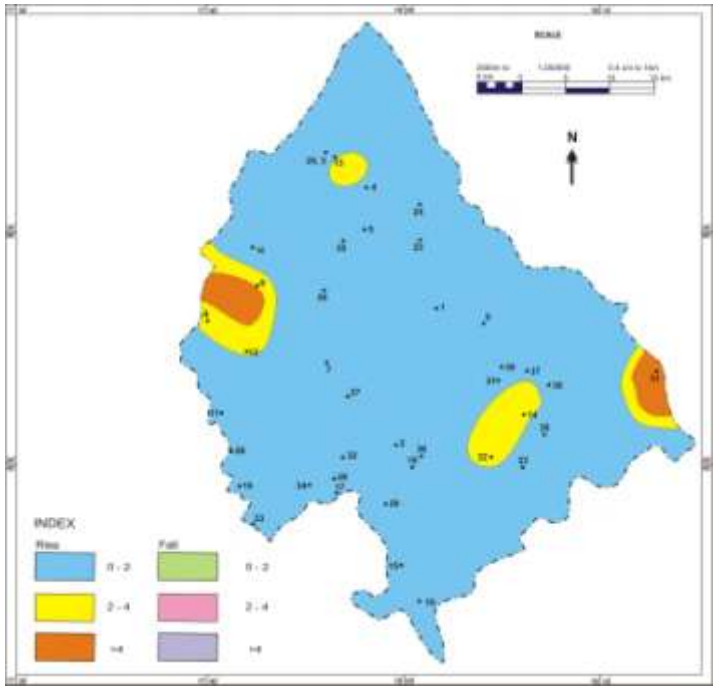


Figure 44 Water Level Fluctuation Map (May 2018 vs November 2018), Haridwar District

The lowest seasonal decline of 0-2 m is observed as isolated patches in iaround Jhabrera, Lakhnauta.

A perusal of **Fig. 45** has shown that the lowest positive seasonal fluctuation of 0-2 m is observed in major part of the section. Higher seasonal rise of 2-4 m is observed as isolated patches Shenkhera -

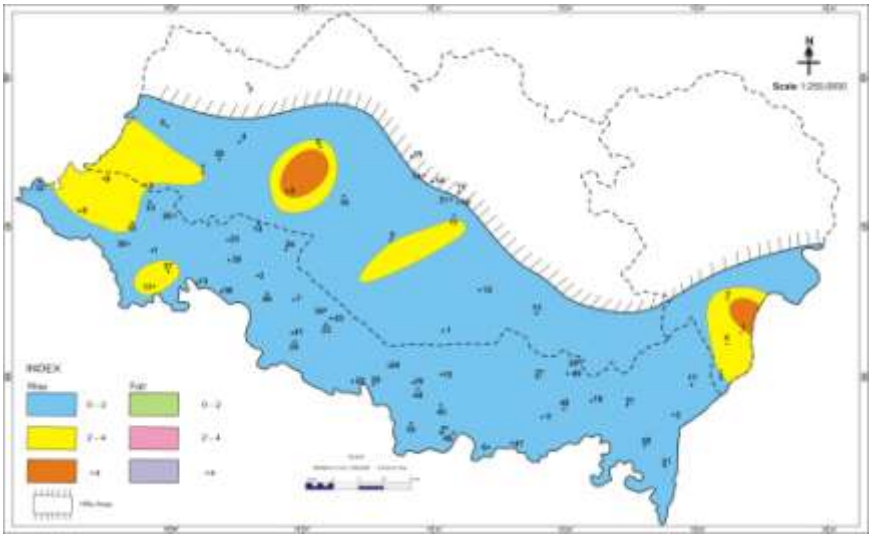


Figure 45 Water Level Fluctuation Map (May 2018 vs November 2018), US Nagar – Nainital - Champawat District

Barkhare Pande, Bharatpur – Jaspur – Angadpur – Patrampur of Udham Singh Nagar district and maldhan colony –lamcahaur – kathgodam areasof nainital district.The highest seasonal rise of water level (>4 m) is observed as patches around Belparao-Dhoniya(Nainital district), Bastia(Chamapwat district) enveloped by seasonal rise zone showing fluctuation in the range of 2 to 4 metres. The lowest seasonal decline of 0-2 m is observed as patches around Dhela, Garjiya.

Table 21. Seasonal Water Level Fluctuation (May 2018 Versus November 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	29	0.085	11.025	1.73	4.67	10	34.48	9	31.03	6	20.69	1	3.45	1	3.45	2	6.90
Haridwar	37	0.12	10.735	0.255	6.325	26	70.27	5	13.51	2	5.41	3	1.00	0	0.00	1	2.70
Udham Singh Nagar	44	0.05	4.885	0	0	32	72.73	10	22.73	2	4.55	0	0.00	0	0.00	0	0.00
Nainital	13	1.025	7.075	0.045	4.145	4	30.77	4	30.77	2	15.38	2	15.38	0	0.00	1	7.69
Champawat	3	1.23	10.335	_		1	33.33	1	33.33	1	33.33	0	0.00	0	0.00	0	0.00
Total	**126**	**0.05**	**12.295**	**0.045**	**6.325**	**73**	57.94	**29**	23.02	**13**	10.32	**6**	4.76	**1**	0.79	**4**	3.17

5.4.3.3 Water Level Fluctuation (May 2018 Versus January 2019)

The seasonal water level fluctuation for the period May 2018 versus January 2019is available for 124 monitoring wells in Uttarakhand State. The water level fluctuation data is given in ***Table 22.*** A perusal of the table indicates that the minimum rise was 0.005metres atKathgodamin Nainitaldistrict and Rudrapur in Udham Singh Nagar district while the maximum fluctuation was 9.015metres atMajra in Dehradun district. The minimum seasonal decline in ground water level was 0.06 m at Mahabir Nagar in Udham Singh Nagar District while the maximum decline was 6.495 m at Imlikherain Haridwar District.

A perusal of **Table 22** also reveals that that the lowest seasonal rise of 0-2 m was shown by 75monitoring wells (60.48% of total) whereas higher rise of 2-4 m was shown by 15wells (12.10% of total). The highest seasonal rise of >4 m was shown by 11wells, which was 8.87% of the total wells. Seasonal decline in the range of 0-2 m was shown by 17monitoring wells (13.71% of total) while higher decline of 2-4 m was shown by 2 wells (1.61% of total). The highest decline of >4 m was recorded by 4 monitoring wells (3.23% of total) for which the data is available in Uttarakhand State during the period May 2018 versus January 2019.

The seasonal water level fluctuation map during the period May 2018 versus January 2019 is shown in ***Fig. 46*** *(Dehradun district),* ***Fig 47(****Haridwar district)* and ***Fig. 48*** *(Nainital-Udham Singh Nagar-Champawat section)*.

Interpretation of Fig. 46 indicates that the minimum decadal rise of 0-2 m is observed in major part of the Doon valley. The seasonal rise of 2-4 m is observed as elongated band in South-eastern part of the district with inclusion of seasonal rise showing fluctuation in the range of greater than 4 meters covering areas such as Maldeota ,Rishikesh , Harbanswala , Nanda

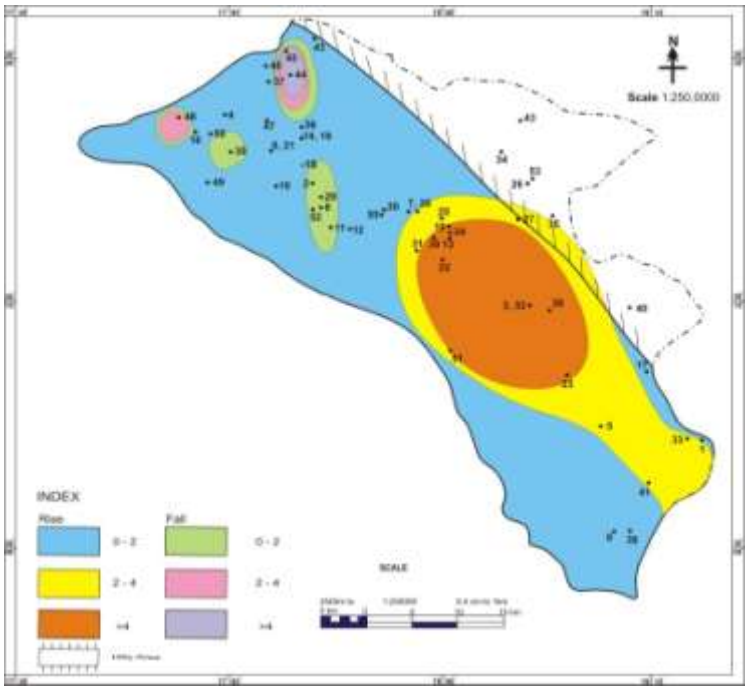


Figure 46 Water Level Fluctuation Map (May 2018 vs January 2019), Dehradun District

ki Chowki.The zone of seasonal rise of water level showing fluctuation in the range of greater than 4 metres is observed around Chandmari,Ladpur,Majra,Kanwali,Nanurkhera,Bhaniawala areas of the section. The lowest seasonal decline of 0-2 m is observed as isolated patches covering Singhniwala, Selaqui and Badripur areas. The seasonal decline in the range of greater than 4 metres is observed as isolated patch around laxmipur, Haripur rimmed by zones of seasonal rise showing fluctuation in the range of upto 2 meters and 2 to 4 metres.

Visual interpretation of Fig. 47 has revealed that the lowest seasonal rise of 0-2 m is observed in major parts of the district.Higher seasonal rise of 2-4 m is observed as isolated patches around Chudiala – Bhagwanpur. The highest seasonal rise of >4 m is observed around Laldhang in the district surrounded by zone of seasonal rise in the range of 2 to 4 metres. The lowest seasonal decline of 0-2 m is observed around Bahadrabad – Rathaura – Kota Muradnagar, Shyampur, Bhikampur, Dallawala, Lakhnauta – Jhabrera – Libberheri – Kherajat areas of the district.

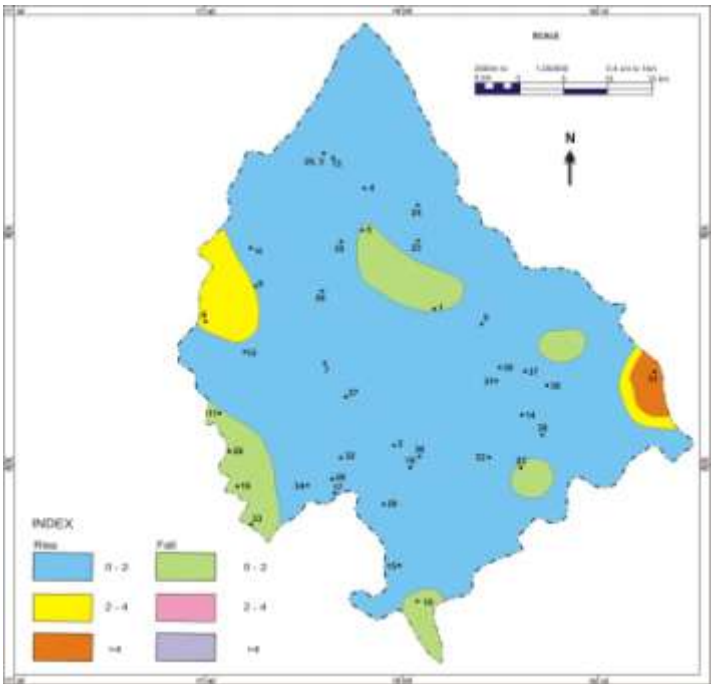


Figure 47 Water Level Fluctuation Map (May 2018 vs January 2019), Haridwar District

Visual interpretation of **Fig. 48** has shown that the minimum seasonal rise of 0-2 m is observed in major part of the district.Higher seasonal rise of 2-4 m is observed as isolated patches around Barkhare Pande – Shenkhera – Missarwala (Udham Singh Nagar district), Lamachaur(Nainital district) and Bastia(Champawat district).The minimum seasonal decline of 0-2 m is observed as patches around Shantipuri, Beria Daulat - Mahabir Nagar.This zone is also observed as elongated patch around Kaladhungi – Peeru Madara areas of Ninital district. Seasonal decline of 2 to 4 metres is observed as elongated patch around Chilkiya rimmed by zone of seasonal decline in the range of 0 to 2 metres.

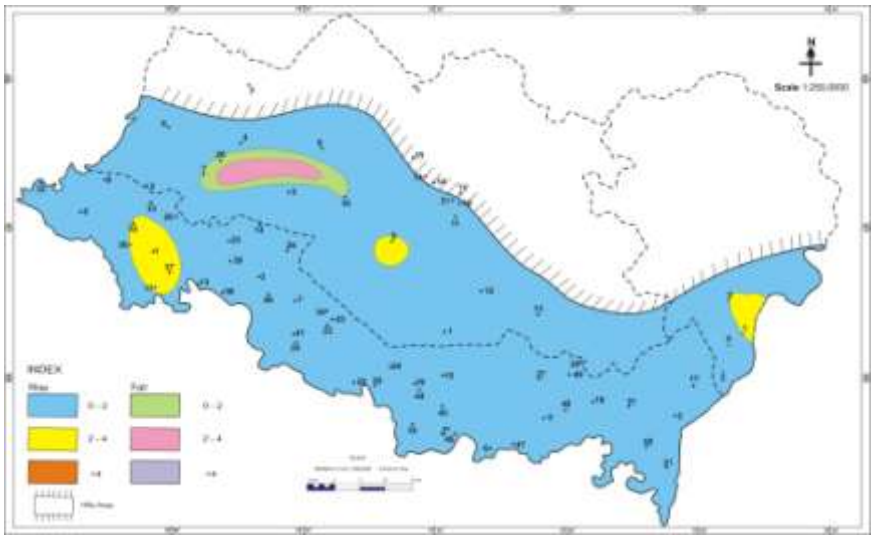


Figure 48 Water Level Fluctuation Map (May 2018 vs January 2019), US Nagar – Nainital - Champawat District

Table 22. Seasonal Water Level Fluctuation (May 2018 versus January 2019)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	27	0.055	9.015	0.10	5.36	10	37.04	4	14.81	7	25.93	3	11.11	1	3.70	2	7.41
Haridwar	37	0.22	8.2	0.33	6.495	23	62.16	4	10.81	1	2.70	8	1.00	0	0.00	1	2.70
Udham Singh Nagar	44	0.005	5.9	0.06	0.495	33	75.00	5	11.36	2	4.55	4	9.09	0	0.00	0	0.00
Nainital	13	0.005	4.21	0.565	6.385	7	53.85	1	7.69	1	7.69	2	15.38	1	7.69	1	7.69
Champawat	3	0.765	3.335	3.595		2	66.67	1	33.33	0	0.00	0	0.00	0	0.00	0	0.00
Total	**124**	**0.005**	**9.015**	**0.01**	**7.6**	**75**	60.48	**15**	12.10	**11**	8.87	**17**	13.71	**2**	1.61	**4**	3.23

The depth to water level contour map for the entire Uttarakhand state during pre-monsoon season of the year 2019 and post monsoon season 2019 is represented by Figure 49 and 50 respectively.

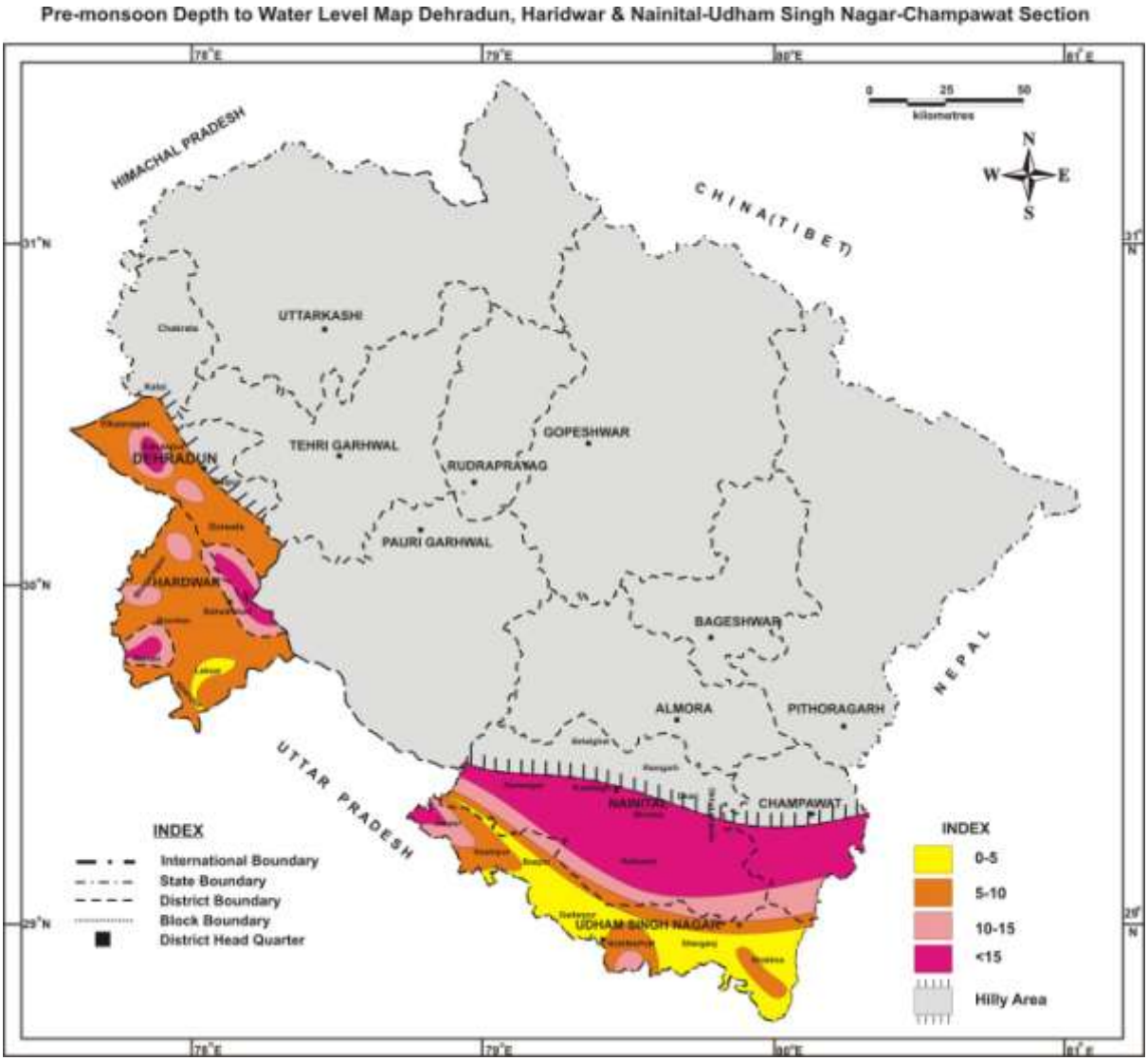


Figure 49 : Map showing depth to water level contours of the entire Uttarakhand state during pre-monsoon season of the year 2019

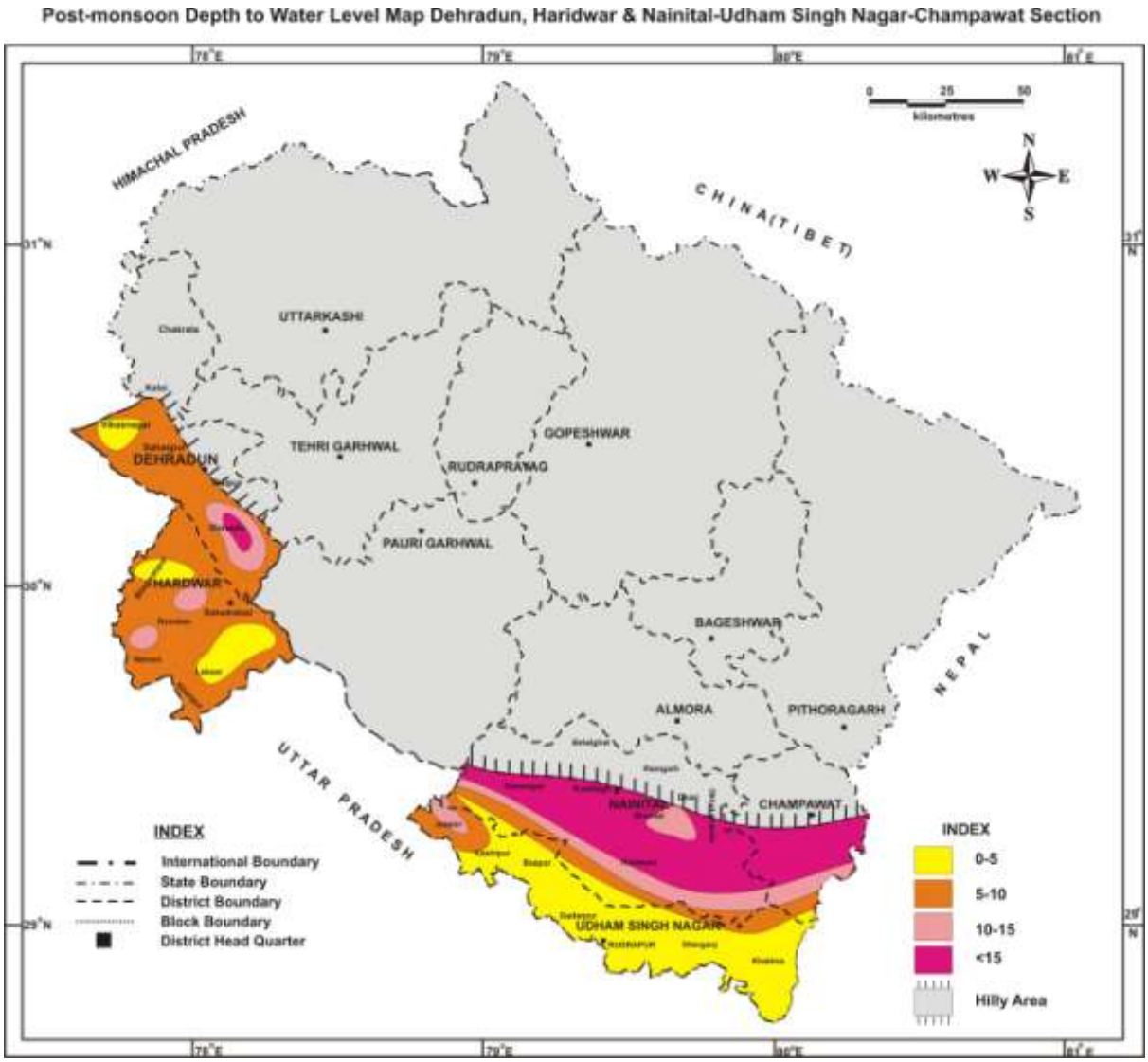


Figure 50 : Map showing depth to water level contours of the entire Uttarakhand state during post-monsoon season of the year 2019

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.

One hundred and eighty six (186) water samples collected during pre-monsoon period (May 2018) for Normal, Heavy and Arsenic analysis were deposited at Chemical Laboratory, North Region, Luckhnow. 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 analysis results are awaited till the compilation of the report.