CHAPTER 3
GEOHYDROLOGY OF STUDY AREA

Doon valley is situated in Uttarakhand state of India and southwest of Himalaya Shiwalik region and extends for a length of about 80 km with its average width of 20 km occupying an area of about 2245 km\(^2\). The area lies between longitude 77\(^0\) 35'E to 78\(^0\) 19'E and latitude in the north –western limit of state Uttarakhand and adjoining the state of Himachal- Pradesh. The valley is bounded in the northeast by lesser Himalayan belt and Shiwalik region on the south west. Two important rivers of north India Yamuna and Ganga demarcate the south –eastern and north –western boundaries of Doon valley. Maximum east-west length for the valley is approximately 70 km and the width varies from about 2.5 km in the extreme west, 25 km in the central part of nearly 45 km in the east.

The valley comprises of mainly 6 sub watersheds: Asan (left), Asan (right), Suarna Tons, Song, Ramau and Chandrabhaga. A north- south divide divide roughly corresponding to Mussorie- Saharanpur road bifurcates the valley into the major subwatersheds of Song and Asan which flow to their master systems in the east and west respectively.

3.1 CLIMATE

The climate of Dehradun is more temperate and humid than that of the adjoining districts, the maximum day and night temperatures being 3 to 6\(^\circ\)C lower throughout the year. Only the the months of May and June are hot though they are seldom oppressive.

The valley enjoys a salubrious climate almost throughout the year. The summer maximum and minimum temperature vary from 36.6\(^\circ\) C to minimum range between 23.4\(^\circ\) and 5.2\(^\circ\) C respectively. The total annual rainfall is about 1800 mm of which bulk precipitates in the month of July- August.

The district has within its limits lofty peaks of the Outer Himalayas as well as the Dun Valley with climatic conditions nearly similar to those in the plains. The temperature depends on the elevation. The climate of the district, in general, is temperate. In the hilly regions, the summer is pleasant but in the Doon Valley, the heat is often intense. The temperature drops below
freezing point not only at high altitudes but also even at places like Dehradun during the winters, when the higher peaks are under snow.

The summer starts by March and lasts up to mid of June when the monsoon sets in. Generally, the month of May and early part of June is hottest with mean temperatures shooting upto 36.2°C at Dehradun and 24.8°C at Mussoorie. The maximum temperature rises to over 42°C at Dehradun while at Mussoorie it doesn’t exceed 32°C. Winter starts from November and continue upto February. The highest maximum temperature recorded at Dehradun was 43.9°C on June 4, 1902 and that at Mussoorie was 34.4°C, on May 24th 1949. The mean daily maximum temperature during winter is 19.1°C at Dehradun and 10.2°C at Mussoorie. The mean daily minimum temperature in January is 6.1°C at Dehradun and 2.5°C at Mussoorie. In Mussoorie the temperature drops to about -6°C to -7°C when snow fall occurs. The lowest minimum temperature at Dehradun during winter was -1.1°C, on February 1st, 1905 and January 1945 while at Mussoorie it was -6.7°C, on February 10th, 1950. Monsoon starts by the mid of June and lasts upto September.

Frost is quite common in winter nights. Severe frost occurs in January and February and cause damage to young sal regeneration. There are many places especially in the low grasslands and within two miles on each sides of the Suswa and Song rivers, where the night temperature during October to April are several degrees lower than those at Dehradun. In these places frost occurs as early as the first week of November.

The prevailing wind come from the west and are generally of moderate velocity, except when severe storms occur during the hot weather, in April and May. In the evening there is always a light breeze coming down the hills generally from the north. The hot ‘loo’ rarely manages to cross the Shiwalik ridge. Nightly dews prevail uninterrupted throughout the year except for April, May and part of June. (Kumar, 2004)

The monsoon generally breaks out by the end of June and the rains continue until about the middle of September, the heaviest falls normally occurring in July and August. Occasional showers may continue in September and October after which, there is usually little rain until about the end of December. Some rain usually falls in January and February after which there is very little rain except for occasional thunderstorms until the break of the monsoon. Few months, however, pass without any rain at all; however, bad drought years are rare in Doon valley.
The district receives an average annual rainfall of 2073.3 mm. Most of the rainfall is received during the period from June to September, July and August being the wettest months. The region around Raipur gets the maximum rainfall, while the southern part receives the least rainfall in the district. About 87% of the annual rainfall is received during the period June to September. The climatic average data for last 25 years of Doon Valley is summarized below.

Table 3.1.1 Climate Data of Doon Valley

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature Ranges (°C)</th>
<th>Relative Humidity (%)</th>
<th>Normal Rainfall (mm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
<td>Average</td>
</tr>
<tr>
<td>January</td>
<td>19.3</td>
<td>3.6</td>
<td>10.9</td>
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<tr>
<td>February</td>
<td>22.4</td>
<td>5.6</td>
<td>13.3</td>
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<tr>
<td>March</td>
<td>26.2</td>
<td>9.1</td>
<td>17.5</td>
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<tr>
<td>April</td>
<td>32.0</td>
<td>13.3</td>
<td>22.7</td>
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<td>35.3</td>
<td>16.8</td>
<td>25.4</td>
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<td>34.4</td>
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<td>27.1</td>
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<td>July</td>
<td>30.5</td>
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<td>28.5</td>
<td>13.3</td>
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<tr>
<td>November</td>
<td>24.8</td>
<td>7.6</td>
<td>15.7</td>
</tr>
<tr>
<td>December</td>
<td>21.9</td>
<td>4.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

3.2 PHYSIOGRAPHY

In the shiwalik range of outer Himalaya, there are a number of longitudinal valleys, called the Duns. One of the largest is the Doon valley (Dehradun). The Doon valley is a synclinal depression between the lesser Himalayan mountains in the north and sub-Himalayan hills in the south. Aligned parallel to the general trends of Himalaya, it is a veritable intermontane valley, bottom of which is filled up with thick detritus shed from overlooking hill slopes. Broadly the Doon valley can be divided into three different slopes; northeastern slopes of the Shiwalik, Doon valley proper and southwestern slopes of Shiwaliks are quite steep in higher reaches and have easy gradient lower down. These are cut by a large number of shorts, shallow and boulder streams which carry their discharge into Asan, Suswa and Song rivers. The southwestern slopes are very steep and carry poor vegetation.

3.3 GEOLOGY
Geological structure of Doon valley is characterized by two major faults, crustal and fractures along which rock slabs of mountain mass have been uplifted and moved southward. The doon valley and Shiwalik range is principally composed of the rocks of the Shiwalik groups. The rocks of the Shiwalik groups are classified into the lower, the middle and the upper Siwaliks. The southern limb of the Doon -valley and the Shiwalik.

Rishikesh and some parts of Mohand is found in Doon valley, within the Himalayan ranges of mountain in the outer (Sub) Himalayan division. The southernmost zone of the outer Himalaya consists of 9500m thick piles of Tertiary sedimentary rocks (conglomerate, sandstone, mudstone, phyllites, shale, limestone ranging in age from Paleocene to lower Pleistocene (Thakur 1992). The breakdown of the rising central Himalaya has resulted in deposition of the Shiwalik group in the form of Molasses deposits, overlain by late Pleistocene Doon gravels (Parkashetal,1980).

In the Shiwalik region a number of longitudinal valleys occur, of which one of the largest is in the Doon valley having 80 km length and 20km width (Nosition, 1971). The Doon valley and its environ were studies as one hydrogeologic system to understand the ground water recharge, movement, storage and discharge on the regional hydrogeologic context. The valley having more than 1600 km² area enjoying up to 2800 mm rainfall during rainy season from June – September. Knowledge of this regional geology and hydrogeology of the areas played a lot on selection of specific sites for Vertical electrical resistivity sounding and Seismic refraction profile as well as hydrogeological interpretation of the geophysical data.

District Dehradun is situated in NW corner of Uttarakhand state and extends from N Latitude 29°58’ to 31°02’ 30" and E Longitude 77°34’ 45” to 78°18’ 30”. It falls in Survey of India Toposheets Nos. 53E, F, G, J and K. The district is bounded by Uttarkashi district on the north, Tehri Garhwal and Pauri Garhwal districts on the east and Saharnpur district (UP) on the south. Its western boundary adjoins Sirmour district of Himachal Pradesh separated by Rivers Tons and Yamuna.

The total area of Dehradun district is 3088 km² with an average altitude of 640 m above MSL. The district comprises of six tehsils, namely Dehradun, Chakrata, Vikasnagar, Kalsi, Tiuni and Rishikesh. Further, it is divided into six developmental blocks, viz: Chakrata, Kalsi, Vikasnagar, Sahaspur, Raipur and Doiwala.
Geologically, Doon valley is a synclinal trough within the Shiwalik system. The limbs of the syncline consist of the middle and upper Shiwalik rocks followed by the northerly dipping pre-tertiary formations of Lesser Himalaya in the north. On basement of Shiwalik rocks, Dun gravels are deposited.

**Geologically Doon valley can be categorized as**

### 3.3.1 LESSER HIMALAYA

The lesser Himalayan zone can be represented by the rocks of Pre – Tertiary and Tertiary age. The Pre- Tertiary rocks have come in contact with the Tertiary rocks by the NW-SE trending Main Boundary Thrust (MBT) and with the Eocene rocks by the Krol Thrust. Towards the east of Yamuna River the Krol belt directly override the Shiwalik Group along MBT with the overlapping of intervening zone of Lower Tertiaries.

### 3.3.2 SHIWALIKS

Middle Shiwalik sandstone and upper Shiwalik boulder beds are exposed in the south of Main Boundary Thrust. The middle Shiwalik is represented by conglomerates, which show an upward – coarsening succession in the alluvial fan system.

**MIDDLE SHIWALIK**

It is composed of grey, salts and peeper textured poor to moderately sorted, fine to coarse grained multistoried sandstones with subordinate amount of mudstone. Multistory sandstone complex of Middle Shiwalik exhibits vertical facies variation from sandstone –mudstone to sandstone to mudstone –conglomerate. A very characteristics feature of the multistoried sandstone is the repetitive occurrence of selective cementation layers of varying thickness and sharp contacts with the under and overlying friable sandstone.

**UPPER SHIWALIKS**

The Upper Shiwalik is predominantly made up of thick succession of Pre Tertiary clasts derived from the Lesser Himalaya with subordinate sandstone and mudstone facies represented by Boulder Conglomerate Formation.

### 3.3.3 DOON GRAVELS
The valley areas are filled by the alluvium belonging to Holocene to Pleistocene age which overlie the Shiwaliks. There are primarily gravels and are known as the Doon Gravels. On the basis of lithology and structural framework the Doon gravels are further categorized into three units (A, B, and C)

UNIT–A: It is mainly composed of clast derived from Lesser Himalayan limestone, shale, slate, and Lower Tertiary purple and buff coloured green sandstone. The clasts are sub–angular to sub rounded granular to pebble size, embedded in fine grained matrix.

UNIT –B: It is predominantly composed of rounded to sub- rounded boulders and pebbles mainly of quartzite together with sandstone and phyllite. This composition of clast indicates that Unit- B is derived from the upper Shiwalik Boulder Conglomerate along with Middle Shiwalik sandstone and Lesser Himalayan phyllite and quartzite.

UNIT–C: This unit consist of poorly sorted angular to sub-angular granules and pebbles interlayered with large pebbles and sometimes boulders. Unit- C gravels is widely distributed along the south of Santaurgarh thrust and represent the youngest gravel unit of fan away from the thrust clast size decreases the mud and silt content increases.
Figure 3.1: Geological Map of Study Area
3.4 DRAINAGE

District Dehradun is drained by Ganga, Yamuna and their tributaries. The two basins are separated by a ridge starting from Mussoorie and passing through Dehradun. The easterly flowing rivers join River Ganga and the westerly flowing rivers join River Yamuna. Ganga River enters the district near Rishikesh where Chandrabhaga River joins it. Song and Suswa are two main tributaries of the Ganges. Suswa flows SE, draining the eastern Doon along with its ephemeral tributaries like Bindal Rao, Rispana Rao etc. and joins River Song SE of Doiwala. Song River has its origin from the adjoining Tehri district. Initially it runs parallel to the Mussoorie Mountain chain in NW direction for few kilometers and then takes a sudden turn in SE direction and joins Suswa River south of Doiwala.

Figure 3.2 Drainage map of Study area

Yamuna River emerges from Yamnotri, which falls in district Uttarkashi. It enters Dehradun district at the point called Khat Bhondar which is about 20km east of Deoban. Tons is the main tributary of Yamuna which has its emerging point in the north of Yamnotri and receives water from Supin and Rupin (tributaries of Tons). River Tons separates Uttarakhand from Himachal Pradesh. The western part of Doon Valley is drained by Asan and its tributaries; it joins...
Yamuna near Rampur Mandi. Yamuna River roughly divides the district in two halves, the hilly region in the north and Doon valley in the south.

Both surface and subsurface sources are being developed for irrigation purpose. The perennial rivers/ springs/ gadheras are being developed by constructing canals and guls. Canals in District Dehradun run for a length of 786 km. There are four main canal systems namely Bijapur, Rajpur, Kalanga and Jakhan. These canal systems were developed during the British period and now being maintained by the state irrigation department. The Rajpur canal system, Jakhan canal system, Kalanga canal system, and Bijapur canal system have 7, 5, 7 and 10 number of canals, respectively. Canal system, Jakhan canal system, Kalanga canal system, and Bijapur canal system have 7, 5, 7 and 10 number of canals, respectively.

Sub surface water is developed through tubewells. There are 118 functional Irrigation tubewells in District Dehradun (as on 31.3.2009). Most of these tubewells are located in the intermontane Doon Valley tapping the Doon Gravels. Besides the canals and tubewells, there are other irrigation practices like pump sets, hydrom, hauz, tanks etc.

3.5 GEOMORPHOLOGY:
GEOMORPHIC DIVISIONS

Dehradun district may be divided into four geomorphological units namely alluvium, piedmont fan deposits, structural and denudational hills and residual hills.

3.5.1 ALLUVIM

This unit is represented by unconsolidated and loose admixture of sand, gravel, pebbles, silt and clay of varied grades deposited in the form of terraces along Asan, Song, Tons, Yamuna, Ganges etc. and in the intermontane valley as well. These are represented by unconsolidated material like sand, gravel, silt and clay. The terraces are formed by river cuttings followed by deposition of eroded and transported material in step like features along the river.

3.5.2 PIEDMONT FAN DEPOSITS

The area comprising of Dun gravels formed of numerous coalesced fans constitute this unit. The older Dun gravels belong to the upper realm of principal Doon fans whereas the younger and youngest duns belong to lower realm of principal Doon fans and dip controlled pedimont fans respectively.
3.5.3 DENUDATIONAL AND STRUCTURAL HILLS:

The denudational and structural hills comprise Siwalik and Lesser Himalayan Ranges. The Shiwaliks are exposed as a narrow band all along the southern boundary of Doon Valley and also in isolated patches. These hills have undergone severe denudation, weathering and erosion, making steep to moderate slopes.

3.5.4 RESIDUAL HILLS:

The residual hills are mostly formed by erosion and are the remnants of post Upper Siwalik deposits. These are called Older Doon Gravels or Langha Boulder Beds. Boulder beds, shales and red clay represent this unit. The residual hills are present in Doiwala and Vikas Nagar blocks.

![Figure 3.3: Geomorphological Map of Study area](image)

3.6 SOIL TYPES

Due to wide variation in topography, intensity of erosion, parent material and other factors, the soils show wide variation in many characteristics specially textures, depth, stoniness, colour, drainage, moisture status, organic matter contents and cation exchange capacity. In fact soil are the products of original geological formations hence three geological zones exhibit difference
in their soil types. On the basis of geological belts soil types of Doon valley has been categorized in three main categories:

**3.6.1 LESSER HIMALYAN BELT**

The Himalayan belt contains only a small bit of the tract especially in Nahan formation of the sub Himalayan series. It consist principally of loose sandstone and hence soil is arenaceous in nature. It is well suited to forest growth by providing a good foothold to trees even where there is no soil.

**3.6.2 SHIWALIK BELT**

The Shiwalik belt consist of sanstone and conglomerates, which are often soft and friable. Bands of clay are interceded with these sandstone and conglomerates, giving cohesion to the soil and thereby improving its physical qualities. The soil resulting from the Shiwalik sandstone is a sandy loam, with sometimes a large proportion of clay. In higher regions with steep slopes the soil is very shallow and dry. Consequently the vegetation as a whole is more xerophytic. It is however, deep on northerly aspects and in lower slopes. The best soil occur on the lowest slopes where the proportion of clay is large and the drainage is adequate. But such conditions do not prevail over large areas.

**3.6.3 THE BOULDER BELT OF THE VALLEY**

The boulder belt is characterized by underlying beds of boulders and shingles of great thickness. Thin bands of clay are also intruded in these deposits causing swamps where they crop out. The soil, overlying the boulder mass, is very variable both in depth and richness and is altogether absent in rau beds. It is generally, sandy and poor with varying proportions of clay locally. Because of great thickness of underlying boulders, the water table is at a great depth.

Soils of Lachhiwala, in the south of the valley in Eastern Doon are generally silty loam to silty clay in texture and acidic to near neutral in reaction containing a high amount of organic carbon. The higher percentage of base saturation indicates adequate level of available nutrient in them. Non-calcareous soils are acidic to neutral and the texture varies from loam to loamy sands.

The soils of Jhajra in western Doon differ considerably due to physiography and relief. The soils are highly eroded. Soil cover is thin; texture is very coarse and nutrient status very poor. The soils however, at the lower portion of gentle slopes are fine loamy to coarse loamy in
texture and acidic in nature. The soils of Barkot range in the Golatappar area in Eastern Doon do not exhibit abrupt change in texture. These are acidic to near neutral in nature and fine loamy in texture.

The nature and soil type play an important role in agriculture and have direct relation with groundwater recharge. Physiography, climate, drainage and geology of the area are the factors responsible for the nature and type of soil and soil cover. The soil type also depends upon the slope and rate of erosion.

![Figure 3.4 Soil Type map of study area](image)

### 3.7 LAND –USE /LAND COVER

The forests are predominant land –use in the valley covering approximately 56 per cent of the valley. Cultivation is the second major land – use in the valley (27 per cent). About 19 per cent of this cultivation is practiced on hill slopes and rest being done on gentle slopes or in plains. Sal forests are predominant forest type in the valley, Shiwalik belt, valley proper and residual hills. The southern slopes of Lesser Himalayan region as covered with pine forests at lower altitudes and banj-oak forests at higher altitudes, found mixed at places with rhododendron, fir and pine. The gravelly alluvium of streams and river is covered with Khair – sissoo forests. The degraded forests cover much as 29 per cent area of the valley. The distinct topographic,
climatic and edaphic factors of Doon valley, characterized by their vicinity to tropics in the south and Himalayan highlands in the north, has bestowed the region with rich biological diversity.

3.8 HYDROGEOLOGY:

WATER BEARING FORMATIONS:

The hydrogeology of the district is mainly controlled by the geology and geomorphology. A wide variation in the geology and land forms, in the area, gives rise to different hydrogeological conditions. Broadly Dehradun district is divided into three hydrogeological units, viz. (1) Himalayan Mountain Belt (2) Siwalik zone and (3) Doon Gravels

3.8.1 HIMALAYAN MOUNTAIN BELT:

Groundwater, in this unit, occurs as disconnected local bodies both under confined and unconfined conditions. Quartzite, schist, shale, slate, phyllite, compact sandstone, limestone and dolomite of Jaunsar, Baliana, Krol and Tal Groups are the main rock types. The rock
formations are characterized by fissures, fractures, veins and joints which provide the secondary porosity. The secondary porosity and permeability help forming the local bodies of groundwater. The weathered veneers found on hill tops, ridges, spurs etc. give rise to large groundwater repositories, under perched conditions. The alluvial deposits of fluvial and colluvial origin in the lower reaches of streams/rivers in the form of fans and terraces are highly porous and permeable and hold promising areas for ground water exploration.

The springs and seepages are the main source for hilly areas. The springs show wide variation in discharge ranging from 1400 to 1507000 liters/day (Bartarya, 1995)

3.8.2 SHIWALIK ZONE

Groundwater occurs under confined and unconfined conditions in this unit. The water levels are comparatively deep. In spite of the boulder-conglomerate bed of Upper Siwalik Formation being highly porous and permeable most of the water goes as run off due to steep slopes and the sediments forming piedmont fans dipping into the Intermontane valley. About 70 gravitational type springs have been reported which have a varying discharge from less than a liter per second to 113 liters/second (0.002 m³/min). The fresh water bearing zones are present in the Upper Siwaliks due to the presence of pebble–gravel–conglomerate–boulder beds and act as good groundwater reservoirs when underlain by the Bhabar or Dun gravels. Exploration has revealed that the pebble - boulder and gravel - sand beds of Siwalik are capable of yielding copious quantities of water.

3.8.3 DOON GRAVELS

The intermontane valley portion, of district Dehradun, is underlain by alluvial fan deposits. The sediments descend from the Lesser Himalayan front as well as the North facing Siwalik hill slopes. These fan deposits are called ‘Doon Gravels’ and characterized by boulders and pebbles embedded in sandy and silty matrix. The clasts are mainly composed of quartzite, sandstone and phyllite, which are mainly derived from the Krol belt of the Himalayas. Pebbles from Siwalik conglomerates are also present in the Doon Gravels.

Doon Gravels are highly porous and they have a significant permeability. Groundwater occurs under unconfined and semi confined conditions. The saturated granular zones occur in a depth range between 35.50 and 138.68 mbgl. The piezometric head ranges from 20.0 to 125.0 mbgl. Transmissivity varies from 1648.0 to 3500.0 m²/day while the field permeability ranges from 5.86 to 104.0 m/day. The discharge from the tubewell varies from 600 to 3000 lpm for a tapped
thickness of 30 to 50 m with a drawdown of 2 to 7 m. The hydraulic conductivity, in the
district, varies from 13 to 583 m/day.

3.9. DEPTH OF WATER LEVEL

There are 19 hydrograph stations located in the southern half of the district. The northern part
is hilly where continuous water table is lacking and hence no hydrograph stations in this part.
Using the data of these hydrograph stations Depth to Water maps for pre-monsoon, 2006 and
Post monsoon, 2006 are prepared. Depth to Water, in the southernmost part of the district,
ranges between 5 and 10 m. The area close to the hills is represented by water table >15 mbgl.
The intermediate part has DTW in the range between 10 and 15 mbgl. During the post
monsoon period the 5-10 m and 10-15 m ranges of DTW increased and the >15 m group is
reduced.

A comparison of the shallow water levels of May, 2006 with the decadal average of May have
been made. This comparison reveals that larger part of the Doon Valley shows a rise in water
levels between 0 and 2 m. A small area in the SE part of the Valley close to the foot hills
shows water level decline between 0 and 2 m. The decadal fluctuation map shows that by and
large the area has groundwater potential with low development of shallow aquifers

3.10 GROUND WATER RESOURCES:

There are six developmental blocks in District Dehradun. Two blocks (Chakrata and Kalsi) fall
in mountainous terrain where the slopes are high and water resources are not estimated for
these blocks. Water Resources are estimated, using GEC 1997 methodology, for Raipur,
Doiwala, Sahaspur and Vikas Nagar blocks as the topography is by and large plain, in these
blocks. The block areas are divided into command and non-command. Draft for all uses and
recharge from all sources are calculated for command and non-command areas.