UNIT 1 INTRODUCTION TO HYDROLOGY

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1.0 OBJECTIVES

After going through this unit, you should be able to:

- outline the concept of hydrologic cycle;
- describe different forms of precipitation;
- explain the significance of Rainfall Intensity-Duration frequency relationship; and
- identify the factors influencing rainfall and runoff.

1.1 INTRODUCTION

Hydrology is the science dealing with various phases of the hydrologic cycle. We have already spoken about the phenomenon of hydrologic cycle in the Block Introduction. Read the first paragraph of said introduction once again you will get a glimpse of what we are going to study in this unit.

The next unit will cover the hydrological losses, their characteristic features, concept and importance of water balance equation.
1.2 HYDROLOGIC CYCLE

The unending process of circulation and redistribution of water by the atmosphere and the earth is called the hydrologic cycle or water cycle. Hydrologic cycle is defined as the circulation of water from the sea, through the atmosphere to the land and then, often with many delays, back to the sea or ocean through various stages and processes. Fig.1.1 illustrates the complete hydrologic cycle which continually keep striking a balance between the waters of the earth and the moisture in the atmosphere. Evaporation and precipitation are the driving forces in the hydrologic cycle with solar radiation as the source of energy.

There are six major components of this cycle: evapotranspiration, condensation, precipitation, infiltration, percolation and runoff. It takes place by the movement of water through the hydrosphere. Water evaporates from the oceans and the land surface; it is carried over the earth in atmospheric circulation as water vapours, precipitates again as rain or snow. Rain or snow is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater, discharges into streams, and ultimately, flows out into the oceans from which it eventually evaporates once again (Fig.1.1). This immense water engine fuelled by solar energy, driven by gravity, proceeds endlessly - irrespective of human activity.

The earth’s total available supply of moisture and water, except for some deep groundwater supplies, is constantly in circulation. It is a gigantic system operating in and on the ground surface, oceans and in the atmosphere surrounding the earth. The cycle begins with the waters of ocean, the large source of water covering about three-fourth of the earth’s surface. The entire process is very simple, divided into the following parts;

1) Evaporation
   a) Evaporation from surface of oceans, lakes and swamps. 80% of the precipitation in India is considered to be contributed by evaporation from the oceans;
   b) Evaporation from the surface of the soil; and
   c) Evaporation from plants through transpiration.

2) Lifting of the moisture to the atmosphere and eventual condensation and falling back to the earth’s surface as precipitation.

3) Distribution of a portion of the precipitated water by surface to the ocean and inland bodies.

4) Part of the precipitation after interception on the foliage and wetting the ground surface runs off the surface to streams and rivers.

5) Part of the precipitation infiltrates into the ground, some of which again evaporates while the other is available for growing plants, infiltration to the deeper zones which slowly percolates into springs and streams as dry period flow.

6) Streams and rivers eventually lead back the water to the oceans, from where it originated.
The oceans are the primary source of precipitation over the earth’s surface as the annual volume of evaporation from the ocean is seven times more than from the land surface. The oceans contain 96.5% of earth’s water whereas land contains only 3.5% water. Out of this, about 1% water is contained in deep, saline groundwaters or in saline lakes, leaving only 2.5% of the earth’s water as fresh water. 68.6% of fresh water is frozen into the polar ice caps and 30.1% contained in shallow groundwater aquifers, leaving only 1.3% of the earth’s fresh water mobile in the surface and atmospheric phases of the hydrologic cycle.

Fig. 1.1: Hydrologic Cycle

Activity 1

1) During monsoon period observe the formation of clouds and occurrence of rainfall.

You may now like to do a Check Your Progress.

Check Your Progress 1

Note: a) Compare your answers with those given at the end of unit.
    b) Use the space below for your answers.

1) List the components of hydrological cycle.

2) Fill in the blanks:
   a) Ocean occupies .....................% of the earth’s surface.
   b) Only ....................% of the earth’s water is fresh water.
   c) Out of total fresh water on the earth, ............% is frozen into the polar ice caps.
1.3 PRECIPITATION

The term “precipitation” denotes all forms of water like rainfall, snowfall, hail, frost and dew reaching the earth’s surface from the atmosphere. Only the rainfall and snow contribute significant amounts of water. Rainfall, the predominant form of precipitation causes stream flow particularly the flood flow in most of the rivers in India. The spatial and temporal variation in rainfall in the country is mainly responsible for many hydrological problems, such as floods and droughts.

1.3.1 Forms of Precipitation

Under proper weather conditions, the water vapour condenses over nuclei to form tiny water droplets of sizes less than 0.1 mm in diameter. The nuclei normally available in plenty are usually salt particles or products of combustion. Wind speed facilitates the movement of clouds while its turbulence retains the water droplets in suspension. Water droplets in a cloud are somewhat similar to the particles in a colloidal suspension. Precipitation results when water droplets come together to form larger drops. The net precipitation and its form depend upon a number of meteorological factors, such as the weather elements like wind, temperature, humidity and pressure in the volume region enclosing the clouds and the ground surface at the given place.

The following conditions are required for precipitation formation:

- The atmosphere must have moisture,
- There must be sufficient nuclei present to aid condensation,
- Weather conditions must be good for condensation of water vapour to take place, and
- The products of condensation must reach the earth.

For the formation of clouds and subsequent precipitation, it is necessary that the moist air masses cool leading to condensation. Under certain favourable conditions when a warm air mass and cold air mass meet, the warmer air mass is lifted over the colder one with the formation of a front. The ascending warmer air cools with the consequent formation of clouds and precipitation. Some of the terms and processes connected with the weather systems associated with precipitation are given below:

**Rain:** It is the principal form of precipitation in India. The term “rainfall” is used to describe precipitation in the form of water drops of sizes larger than 0.5 mm. The maximum size of a raindrop is about 6 mm. The larger drops tend to break up into small drops during their fall from the clouds.

**Snow:** Snow is another important form of precipitation. Snow consists of ice crystals which usually combine to form flakes. New snow has an initial density varying from 0.06 to 0.15 g/cm³ with an average value of 0.1 g/cm³. In India, snow occurs only in the Himalayan regions.

**Drizzle:** The water droplets are less than 0.5 mm in diameter and rainfall intensity (rate at which rainfall occurs) less than 1 mm per hour. The drops being very small appear to be floating in the air.
Glaze: When rain or drizzle come in contact with cold ground with around 0°C temperature, the water drops freeze to form an ice coating called glaze or freezing rain.

Sleet: Sleet may occur when a warm layer of air lies above a below-freezing layer of air at the earth’s surface and are generally transparent ice pellets with diameters of 5 mm or less formed as a result of the freezing of raindrops or the freezing of mostly melted snowflakes.

Hail: It is a showery precipitation in the form of irregular pellets or lumps of ice of size more than 8 mm. Hails occur in violent thunderstorms in which vertical currents are very strong.

### 1.4 RAINFALL INTENSITY AND DURATION

#### 1.4.1 Rainfall Intensity

Rainfall intensity is one of the most important rainfall characteristics and defined as the rate at which rainfall occurs, expressed in depth per unit time, usually mm per hour. The fundamental unit of rainfall is depth measured by rain gauges. The average intensity is calculated by dividing rainfall depth by the duration, the time over which the rainfall accumulated.

\[
\text{Intensity} = \frac{\text{Rain Depth}}{\text{Duration}}
\]

Rainfall intensity is classified into light, moderate and heavy intensity as under:

<table>
<thead>
<tr>
<th>Type of Intensity</th>
<th>Range (mm/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity</td>
<td>&lt; 2.5</td>
</tr>
<tr>
<td>Moderate intensity</td>
<td>2.5 – 7.5</td>
</tr>
<tr>
<td>Heavy intensity</td>
<td>&gt; 7.5</td>
</tr>
</tbody>
</table>

Very intense storms are not necessarily more frequent in areas having a high annual rainfall. Storms of high intensity generally last for short periods and cover small areas. The infrequent combination of relatively high intensity and long duration producing large amounts of rainfall causing erosion and devastating floods. The rainfall intensity is used in the preparation of hydrographs of maximum probable and maximum possible flood flows. The peak intensity produces the largest runoff rate. If rainfall were constant throughout a storm, any duration less than the storm duration would produce the same intensity. However, rainfall is rarely constant for the storm duration and intensity varies.

#### 1.4.2 Rainfall Intensity-Duration

Rainfall Intensity-Duration (ID) relationship is commonly required for designing of the water resource projects. There has been considerable attention and research on the ID relationship. Rainfall intensity-duration comprises of the estimates of rainfall intensities for different durations.
Table 1.1 shows the calculated intensity for various durations. Intensities are calculated using the rainfall depth and storm times in the first two rows. Each of the duration rows show intensities calculated based on different durations. For example, $I_5$ is the intensity calculated over a period of 5 minutes starting at $t = 0$ and ending at $t = 5$ minutes, or starting at $t = 5$ and ending at $t = 10$ minutes, etc. Table 1.1 shows a decrease of maximum intensity as duration increases for a storm with non-uniform precipitation.

### Table 1.1: Rainfall Intensity for Different Durations

<table>
<thead>
<tr>
<th>Storm Time (min.)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative Precipitation (mm)</td>
<td>0</td>
<td>10</td>
<td>40</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Rainfall Intensity (mm/hr)</td>
<td>$I_5$</td>
<td>-</td>
<td>120</td>
<td>360</td>
<td>240</td>
<td>180</td>
<td>180</td>
<td>120</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td></td>
<td>$I_{10}$</td>
<td>-</td>
<td>240</td>
<td>300</td>
<td>210</td>
<td>180</td>
<td>150</td>
<td>120</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td></td>
<td>$I_{30}$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>200</td>
<td>180</td>
<td>120</td>
<td>80</td>
<td>50</td>
<td>20</td>
<td>00</td>
</tr>
<tr>
<td></td>
<td>$I_{60}$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### 1.4.3 Recurrence Predictions and Return Periods

Recurrence predictions are generally made in terms of return periods or recurrence interval ($T$). A return period is the frequency with which, on average, a given rainfall event is expected to recur. The period within which the depth of rainfall for a given duration will be equalled or exceeded once on the average, is known as return period or recurrence interval which is expressed as:

$$T = \frac{1}{F} \quad \text{(where F = frequency of occurrence)}$$

For example 1-hour rainfall of 5 cm with a 5-year return period at a particular location, means that one rainfall event of 5 cm of rainfall within one hour to occur once every 5 years on average.

For calculation of return period, the rainfall data may be ranked in either ascending or descending order. For descending order, the following procedure is followed (Table 1.2).

1) Rank the ($n$) data ($P$) in descending order; the highest value first, and the lowest last.
2) Assign a rank number ($r$) to each value ($P_r$, $r=1,2,...,n$), the highest value being $P_1$, the lowest, $P_n$.
3) Divide the rank number ($r$) by the total number of observations plus 1 to obtain the frequency of exceedence as:

$$F(P > P_r) = \frac{r}{n+1}$$

Calculate the frequency of non-exceedence

$$F(P < P_r) = 1 - \left( \frac{r}{n+1} \right)$$

The return period can be calculated as reciprocal of $F$. 

10
Table 1.2: Frequency Analysis based on Rainfall Depth

<table>
<thead>
<tr>
<th>Rank No.</th>
<th>Rainfall (mm)</th>
<th>Year</th>
<th>$F(P&gt;P)$ $r/n+1$</th>
<th>$I - F(P&gt;P)$</th>
<th>$T$, Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>176.4</td>
<td>1995</td>
<td>0.071</td>
<td>0.929</td>
<td>14.08</td>
</tr>
<tr>
<td>2)</td>
<td>123.0</td>
<td>1983</td>
<td>0.123</td>
<td>0.877</td>
<td>8.13</td>
</tr>
<tr>
<td>3)</td>
<td>114.0</td>
<td>1991</td>
<td>0.214</td>
<td>0.786</td>
<td>4.67</td>
</tr>
<tr>
<td>4)</td>
<td>106.4</td>
<td>1988</td>
<td>0.286</td>
<td>0.714</td>
<td>3.49</td>
</tr>
<tr>
<td>5)</td>
<td>101.0</td>
<td>1993</td>
<td>0.357</td>
<td>0.643</td>
<td>2.80</td>
</tr>
<tr>
<td>6)</td>
<td>100.0</td>
<td>1986</td>
<td>0.429</td>
<td>0.571</td>
<td>2.33</td>
</tr>
<tr>
<td>7)</td>
<td>96.4</td>
<td>1990</td>
<td>0.500</td>
<td>0.500</td>
<td>2.00</td>
</tr>
<tr>
<td>8)</td>
<td>93.8</td>
<td>1987</td>
<td>0.571</td>
<td>0.429</td>
<td>1.75</td>
</tr>
<tr>
<td>9)</td>
<td>78.0</td>
<td>1994</td>
<td>0.643</td>
<td>0.357</td>
<td>1.56</td>
</tr>
<tr>
<td>10)</td>
<td>72.0</td>
<td>1992</td>
<td>0.714</td>
<td>0.286</td>
<td>1.40</td>
</tr>
<tr>
<td>11)</td>
<td>54.0</td>
<td>1985</td>
<td>0.786</td>
<td>0.214</td>
<td>1.27</td>
</tr>
<tr>
<td>12)</td>
<td>43.4</td>
<td>1989</td>
<td>0.857</td>
<td>0.143</td>
<td>1.17</td>
</tr>
<tr>
<td>13)</td>
<td>38.4</td>
<td>1984</td>
<td>0.929</td>
<td>0.071</td>
<td>1.08</td>
</tr>
</tbody>
</table>

1.5 RAINFALL INTENSITY-DURATION – FREQUENCY RELATIONSHIPS

The rainfall Intensity-Duration-Frequency (IDF) relationship is one of the most commonly used tools in water resources engineering for planning, designing and operating water resource projects. In design problems related to watershed management such as runoff disposal and erosion control, the estimation of rainfall intensities of different durations and return periods is essential. It is a characteristic of a storm that its intensity decreases with increase in duration and larger the return period, larger is the intensity of a storm for given duration. Intensity is the average rate at which rainfalls throughout a given period of time. Presented as intensity-duration curve, the results are the average rates or rainfall $I'$ for duration of 't' minutes, reached or exceeded once on the average in 'T' years. The intensity-duration-frequency relation in general form is as follows:

$$I = \frac{KT^n}{t^n}$$

Where,

- $I$ = average rainfall intensity (cm/hr)
- $T$ = recurrence interval or frequency (yr) with which average intensities are reached or exceeded
- $t$ = duration of rainfall (minutes)
- $K, x, n$ = constants for a given geographical location
From the rainfall records, the magnitudes of rainfall intensities of various frequencies are derived for selected durations of say 5, 15, 30, 60 minutes and so on, average intensity is plotted against the duration of a particular frequency (Fig.1.2).

**Fig. 1.2: Rainfall Intensity-Duration-Frequency relationship**

### 1.5.1 Significance of Intensity- Duration- Frequency Analysis

1) Estimation of future rainfall trends and its reliability based on past performances.
2) Prediction of probability of flood producing storms.
3) Comparative analysis of rainfall and runoff.
4) Estimation of runoff from an area without stream flow data.
5) Study of variations in rainfall over an area on a storm, seasonal or other basis for adjustment of the records.
6) Estimation of long term average rainfall for a station having a short record.
7) Estimation of mean annual precipitation at intervening places where it is not measured but where the physiographic parameters can be measured.

### 1.6 FACTORS AFFECTING RAINFALL AND SURFACE RUNOFF

#### 1.6.1 Rainfall

The following factors affect rainfall amount and distribution:

**i) Proximity to Ocean:** Air being in constant contact with water naturally has an opportunity of absorbing moisture and becoming saturated. Any slight disturbance or change of conditions, once it is saturated, causes precipitation of the moisture in the form of rain. Proximity to oceans and other large bodies of water means a greater local precipitation.

**ii) Mountain Formation:** The pattern of rainfall in India is greatly influenced by mountain formation. Elevation and alignment of hills with respect to prevailing winds, especially if they are at right angles to the directions of the moisture bearing winds, have profound influence on the distribution of rainfall. More rainfall is received on windward than on leeward slopes, the variation
being greatest with steepest slopes. On West Coast of India, there is heavy rainfall along the slopes of Western Ghats on the windward side but rapidly diminishes on the eastern side of Western Ghats.


iv) Tract of Cyclones: Cyclones are accompanied by heavy winds, often with high rainfall. Much of winter precipitation is cyclonic. The precipitation is induced by feeble cyclones in winter. In India, heavy rainfall occurs in coastal regions and coastal parts of the country in association with the movements of depressions and cyclonic storms.

1.6.2 Runoff

Runoff is the fraction of the rainfall (rainfall excess) that moves over the surface or through the soil toward surface water features (ponds, lakes, streams, rivers, etc.). For most purposes, runoff refers to surface runoff only. Runoff occurs when the rainfall exceeds the demands of interception, evaporation, infiltration and surface storage. Before runoff can occur, rainfall must satisfy the immediate demands of infiltration, evaporation, interception, surface storage, surface detention and/or channel detention.

The climatic and physiographic factors affect the runoff rate and volume from the catchments.

1) Climatic Factors

Type of precipitation: The type of precipitation is of great importance, for instance, if precipitation falls in the form of rain, its influence is felt almost immediately provided its intensity and magnitude are capable to generate runoff while snow causes runoff only on melting.

Rainfall intensity: The rainfall intensity impacts both rate and volume of runoff. The total volume of runoff is much higher for the high intensity rainfall even if the total rainfall for the two events is the same. Fig. 1.3 shows the relationship between rainfall intensity and rainfall depth with runoff in a case study. The rainfall depth greater than 25 mm and intensities greater than 37 mm/hr produced higher percentages of runoff than the corresponding percentages for rainfall groups.

![Figure 1.3: Relationship of runoff to rainfall depth and intensities](image)
Duration of rainfall: The infiltration rate of soil decreases with time and attains a constant rate. Thus, even a low rainfall of longer duration results in large amount of runoff.

Wind direction: A rainfall storm moving in the direction of stream slope generates higher peak runoff in shorter duration than the storm moving in the opposite direction.

Other climatic factors: Temperature, wind and humidity also affect the runoff. High temperature and greater wind velocities give rise to greater evaporation loss and reduce the runoff. The evaporation decreases with increase in atmospheric pressure. Wind velocity is important in varying the rate of evaporation. If the catchment is located on the windward side of the mountains, it receives greater precipitation and hence gives a greater runoff.

2) Physiographic Factors

Important physiographic factors related to watershed and channel characteristics influencing runoff are discussed below:

Shape and Size of Catchments: For equal sized watersheds, runoff decreases as overland flow length increases. This results from the increased time of concentration. Longer duration storms, needed to produce runoff from all points in watershed, have lower average intensities. For a fixed return interval, as watershed size increases, the runoff per unit area decreases (Fig. 1.4). This occurs primarily because average rainfall amount decreases with increasing area; secondarily, increased travel time for runoff allows more infiltration and other losses.

SAQ 1

Using above figure, determine the peak runoff for both the watersheds and indicate the months during which it might occur.

Orientation: Long and narrow watersheds generate lower runoff rates than more compact watersheds of the same size. The runoff from the long and narrow watersheds does not reach the outlet from the most remote point as fast as it does from the compact areas.

Topography: Topographic features such as slope of upland areas, degree of development and channel slope and extent and number of depressed areas affect
runoff. Watersheds with extensive flat areas or depressed areas without surface outlets produce less runoff than areas with steep, well defined drainage patterns. Steep slopes reduce time of concentration and detention volume.

**Land form and land cover:** Rocky and stony surfaces with impervious basement generate higher runoff, whereas land covered with vegetation promotes infiltration, slow runoff and reduces the antecedent water content of soils prior to a storm event. Surface roughness increases surface storage and promotes greater infiltration, both of which decrease runoff.

**Soil type:** The infiltration rate depends on the soil texture. Therefore, surface runoff will be much higher in case of a heavy soil than light soil.

**Soil moisture:** The extent of soil moisture at the time of a rainfall event affects the magnitude of runoff. If the soil moisture at the time of rainfall is considerably high, the runoff will be less due to low infiltration rate.

**Conservation practices:** Conservation practices of various forms intercept excess rainfall, induce infiltration, enrich soil moisture regime and reduce runoff.

**Drainage density:** Drainage density refers to the ratio of channel length in the catchment to the total catchment area. Large drainage density results in fast disposal of runoff down the channels reflected in peak flow.

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**Check Your Progress 2**

**Note:**

a) Compare your answers with those given at the end of unit.
b) Use the space below for your answers.

1) List out the usual forms of precipitation.

2) Fill in the blanks:

a) The term ................. denotes all forms of water that reaches the earth from the atmosphere.

b) Rainfall amount per unit time is called ..................

c) The probability of an event with a specified intensity and duration is called ..................

d) Rainfall .................. relationship comprises the estimates of rainfall intensities of different durations and recurrence intervals.

3) List the factors affecting rainfall.

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................
4) What are the different factors on which the runoff from catchment area depends?

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

5) Indicate if the following statements are true or false by putting a tick mark (√) in the relevant box.

<table>
<thead>
<tr>
<th></th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Vegetation tends to increase the runoff from the catchment.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b) Runoff is slower from the flat surface than from the steep surface.</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

### 1.7 LET US SUM UP

- Hydrology is the science dealing with the never-ending hydrologic cycle.
- In the hydrologic cycle, water is constantly moves within and above the earth and is governed by six major components, viz., evapotranspiration, condensation, precipitation, infiltration, percolation, and runoff.
- Rainfall is one of the main forms of precipitation, others being snowfall, hail, frost, and dew.
- Rainfall is mainly responsible for replenishing surface (runoff) and groundwater resources.
- Rainfall intensity defined as the rate at which rainfall occurs is the most important factor to determine the volume of total and peak runoff.
- Rainfall Intensity-Duration-Frequency relationship is very important for planning, design, and management of a watershed.
- Watershed characteristics such as soil type, vegetation, topography, orientation etc., also contribute to runoff phenomena.

### 1.8 KEYWORDS

**Hydrologic Cycle**: A convenient term to denote the circulation of water from the sea, through the atmosphere, to the land and back to the sea by overland and subterranean routes, and in part by way of the atmosphere; also the many short circuits of the water that is returned to the atmosphere without reaching the sea.

**Hydrologic Equation**: The equation balancing the hydrologic budget.

**Precipitation**: The term precipitation is commonly used to designate the quantity of water that is precipitated. As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface.
Rainfall: Rainfall is described as total liquid product of precipitation or condensation from the atmosphere as received and measured in a raingauge.

Raingauges: The instrument (non-recording and recording) used for measurement of rainfall is called raingauge.

Rainfall Excess: The volume of rainfall available for direct runoff. It is equal to the total rainfall minus interception, depression storage, and absorption.

Runoff: It is that portion of precipitation that flows over land surfaces toward larger water bodies.

Streamflow: The actual flow in streams whether or not subject to regulation or underflow.

Time of Concentration: This is the time required to water to flow from most remote point of the area to the outlet after the soil has become saturated and minor depressions filled.

1.9 SUGGESTED READING


1.10 MODEL ANSWERS TO CHECK YOUR PROGRESS AND SAQs

Check Your Progress 1

1) a) Evapotranspiration
   b) Condensation
   c) Precipitation
   d) Infiltration
   e) Percolation
   f) Runoff
2) a) 96.5 
b) 2.5 
c) 68.6 

Check Your Progress 2 

1) a) Drizzle 
b) Rain 
c) Glaze 
d) Snow 
e) Hail 
f) Dew 
g) Frost 

2) a) Precipitation 
b) Intensity 
c) Return period or frequency 
d) Intensity-duration-frequency 

3) a) Proximity to ocean 
b) Mountain formation 
c) Wind 
d) Tract of cyclone 

4) a) Precipitation characteristics 
b) Shape and size of the catchments 
c) Watershed orientation 
d) Topography 
e) Land form and land cover 
f) Conservation characteristics 

5) a) False 
b) False 

Answers of SAQ 

SAQ 1 

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Peak runoff, cm</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>February</td>
</tr>
<tr>
<td>B</td>
<td>1.25</td>
<td>June</td>
</tr>
</tbody>
</table>