# Water Resources Engineering

## Introduction

Water in our planet is available in the atmosphere, the oceans, on land and within the soil and fractured rock of the earth's crust Water molecules from one location to another are driven by the solar energy. Moisture circulates from the earth into the atmosphere through evaporation and then back into the earth as precipitation. In going through this process, called the Hydrologic Cycle (Figure 1), water is conserved – that is, it is neither created nor destroyed.

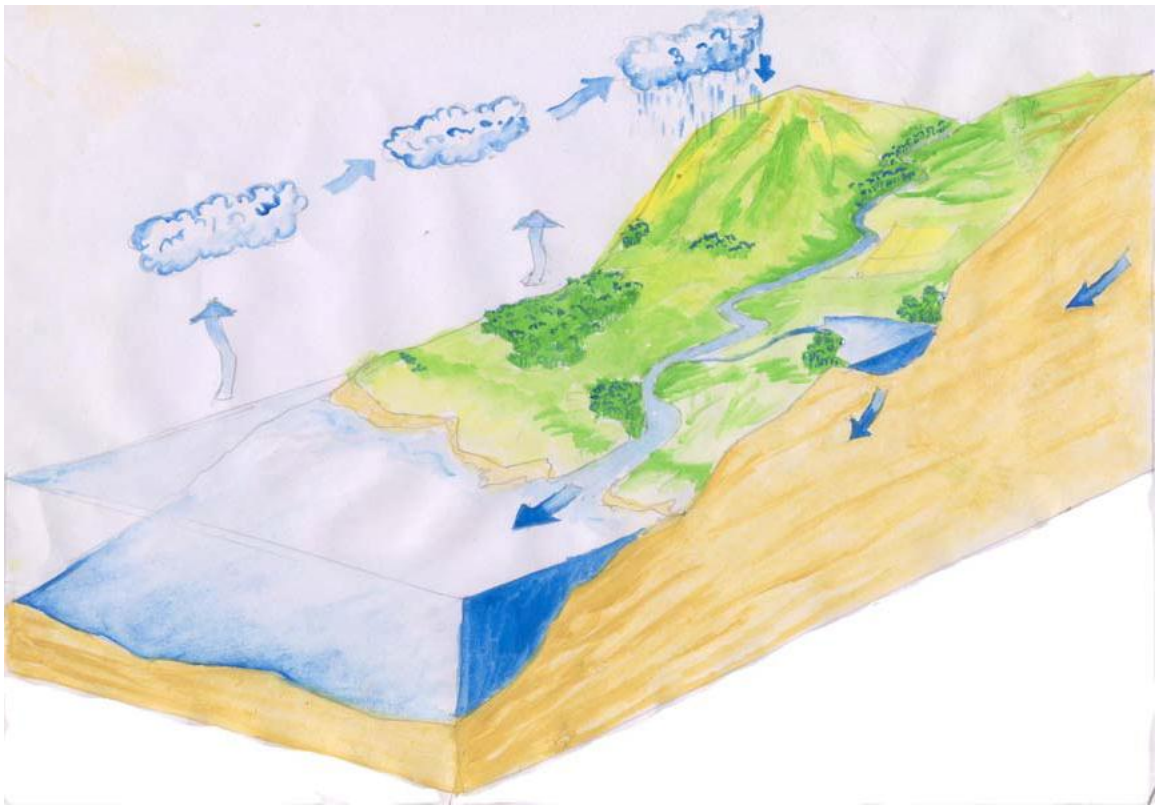

**Figure 1.** Hydrologic cycle

Hydrologic Cycle would perhaps be interesting to note that the knowledge of the hydrologic cycle was known at least by about 1000 BC. The earth's total water content in the hydrologic cycle is not equally distributed (Figure 2).

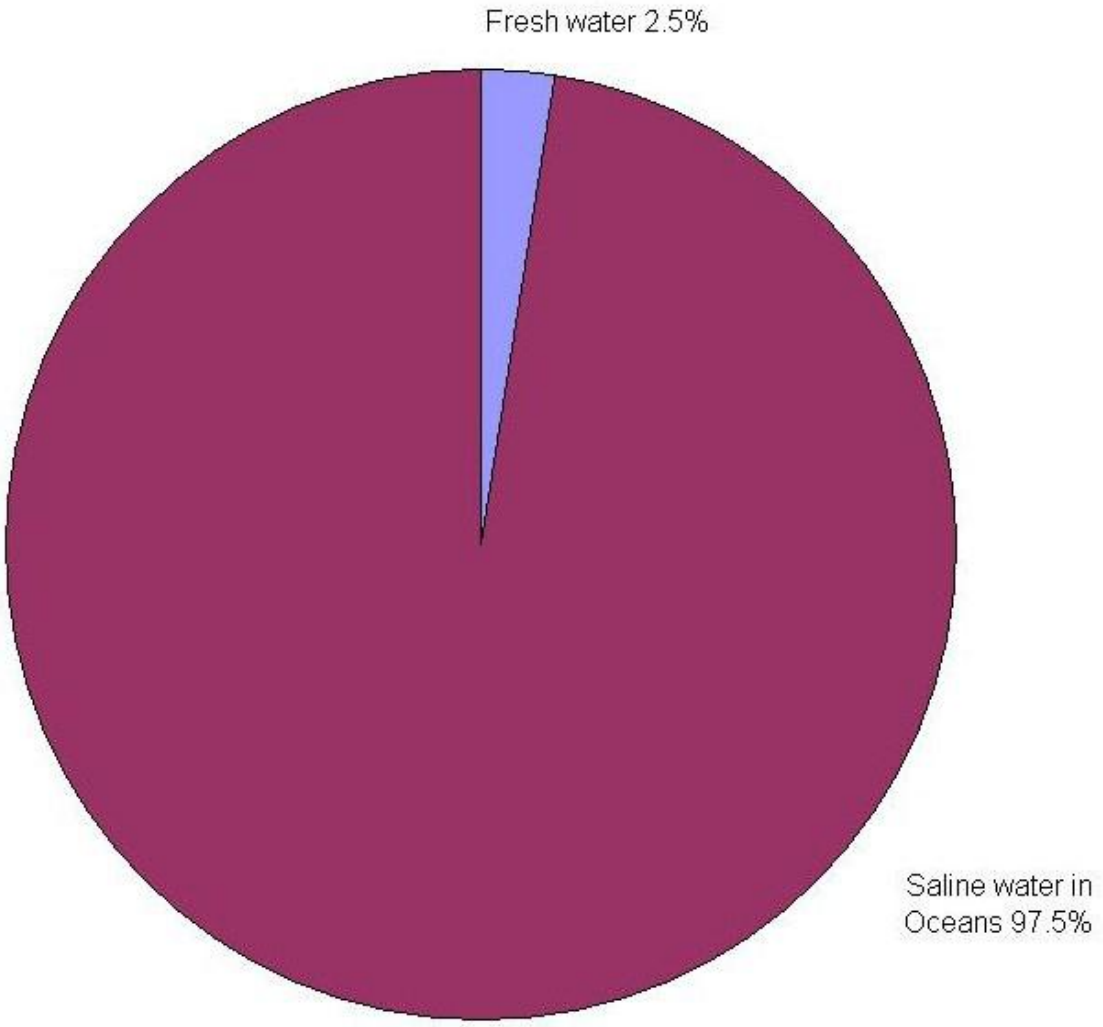


**Figure 2.** Total global water content

The oceans are the largest reservoirs of water, but since it is saline it is not readily usable for requirements of human survival. The freshwater content is just a fraction of the total water available (Figure 3). Again, the fresh water distribution is highly uneven, with most of the water locked in frozen polar ice caps.

The hydrologic cycle consists of four key components
1. Precipitation
2. Runoff
3. Storage
4. Evapotranspiration

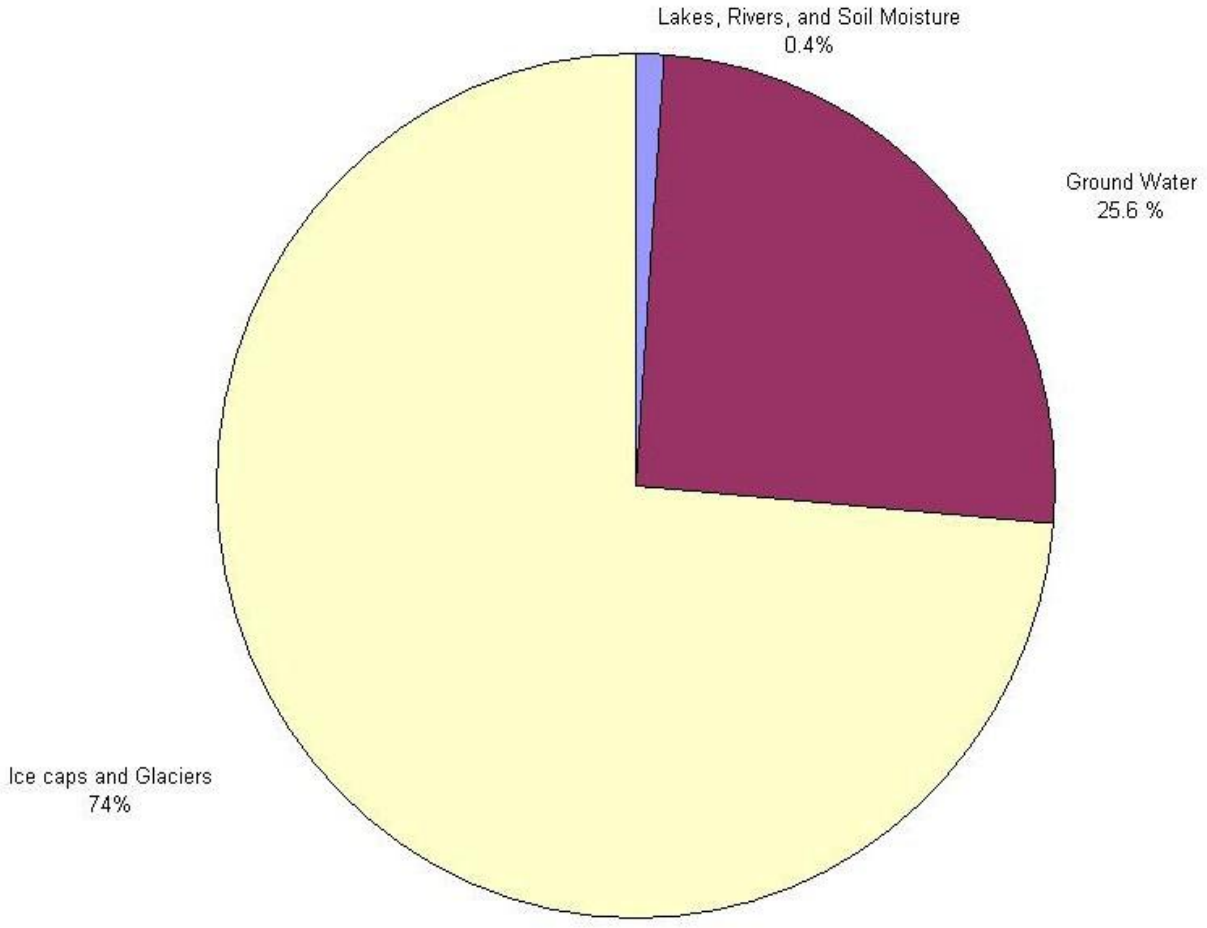


**Figure 3.** Global fresh water distribution

## 1- Precipitation

Precipitation occurs when atmospheric moisture becomes too great to remain suspended in clouds. It denotes all forms of water that reach the earth from the atmosphere, the usual forms being rainfall, snowfall, hail, frost and dew. Once it reaches the earth's surface, precipitation can become surface water runoff, surface water storage, glacial ice, water for plants, groundwater, or may evaporate and return immediately to the atmosphere. Ocean evaporation is the greatest source (about 90%) of precipitation.

Rainfall is the predominant form of precipitation and its distribution over the world and within a country. The former is shown in Figure 4, which is taken from the site http://cics.umd.edu/~yin/GPCP/main.html of the Global Precipitation Climatology Project (GPCP) is an element of the Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research program (WCRP).

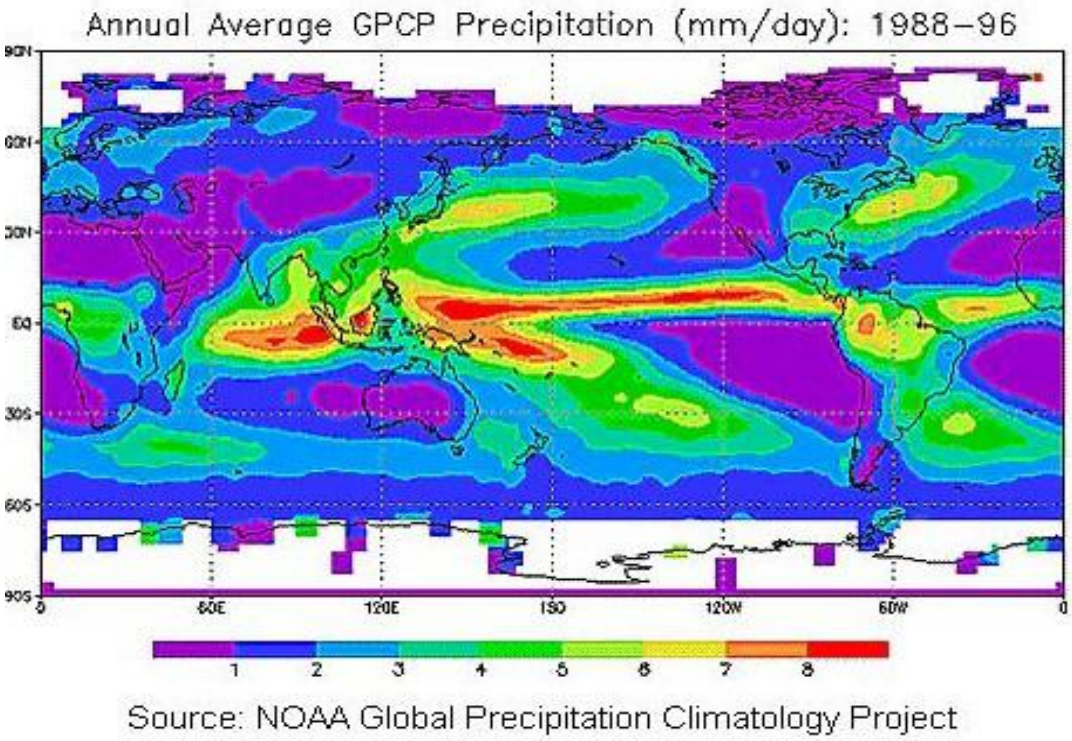


**Figure 4.** A typical distribution of global precipitation (Courtesy: Global Precipitation Climatology Project)

## 2- Runoff

Runoff is the water that flows across the land surface after a storm event. As rain falls over land, part of that gets infiltrated the surface as overland flow. As the flow bears down, it notches out rills and gullies which combine to form channels. These combine further to form streams and rivers. The geographical area which contributes to the flow of a river is called a river or a watershed.

## 3- Storage

Portion of the precipitation falling on land surface which does not flow out as runoff gets stored as either as surface water bodies like Lakes, Reservoirs and Wetlands or as sub-surface water body, usually called Ground water.

Ground water storage is the water infiltrating through the soil cover of a land surface and traveling further to reach the huge body of water underground. As mentioned earlier, the amount of ground water storage is much greater than that of lakes and rivers. However, it is not possible to extract the entire groundwater by practicable means. It is interesting to note that the groundwater also is in a state of continuous movement – flowing from regions of higher potential to lower. The rate of movement, however, is exceptionally small compared to the surface water movement. The following definitions may be useful:

***Lakes:*** Large, naturally occurring inland body of water

***Reservoirs:*** Artificial or natural inland body of water used to store water to meet various demands.

***Wet Lands:*** Natural or artificial areas of shallow water or saturated soils that contain or could support water–loving plants.

## 4- Evapotranspiration

Evapotranspiration is actually the combination of two terms – evaporation and transpiration. The first of these, that is, evaporation is the process of liquid converting into vapour, through wind action and solar radiation and

returning to the atmosphere. Evaporation is the cause of loss of water from open bodies of water, such as lakes, rivers, the oceans and the land surface. It is interesting to note that ocean evaporation provides approximately 90 percent of the earth's precipitation. However, living near an ocean does not necessarily imply more Transpiration is the process by which water molecules leaves the body of a living plant and escapes to the atmosphere. The water is drawn up by the plant root system and part of that is lost through the tissues of plant leaf (through the stomata). In areas of abundant rainfall, transpiration is fairly constant with variations occurring primarily in the length of each plants growing season. However, transpiration in dry areas varies greatly with the root depth. Evapotranspiration, therefore, includes all evaporation from water and land surfaces, as well as transpiration from plants.