Required Readings: Concise Hydrology (Han, D.)

✓Chapter 1: Residence Time

The residence time is the average duration for a water molecule to pass through a water body. It can be derived by dividing the volume of water by the flow rate. Some estimated residence time values are listed in Table 2.

Table 2 Average residence time (Wikipedia, 2009)

Water body	Average residence time
Oceans	2600 to 3200 years
Glaciers	20 to 100 years
Seasonal snow cover	2 to 6 months
Soil moisture	1 to 2 months
Groundwater: shallow	100 to 200 years
Groundwater: deep	10,000 years
Lakes	50 to 100 years
Rivers	2 to 6 months
Atmosphere	days

Required Readings: Concise Hydrology (Han, D.)

✓Chapter 1: Water Balance

A catchment (also called drainage basin, river basin, watershed) is an extent of land where water from rain or snow melt drains downhill into a body of water, such as a river, lake, reservoir, estuary, wetland, sea or ocean. In hydrology, catchment is a logical unit of focus for studying the movement of water within the hydrological cycle, because the majority of water that discharges from the catchment outlet originated as precipitation falling on the catchment.

The water balance equation for a catchment

$$P - R - G - ET = \Delta S \qquad (3)$$

where P - precipitation, R - river runoff, G - groundwater runoff, ET - evapotranspiration, ΔS - storage change in a catchment.

Required Readings: Concise Hydrology (Han, D.)

✓Chapter 1: Example (Residence Time)

Practice 1

The volume of atmospheric water is 12,900 km^3. The evapotranspiration from land is 72,000km^3/year and that from ocean is 505,000km^3/year. Estimate the residence time of water molecules in the atmosphere (in days).

Solution

The residence time can be derived by dividing the volume of water by the flow rate

Total flow rate = 505000+72000=577000 km^3/s

The residence time = 12900/577000 = 0.0224 *year* = 8.2 *days*

Required Readings: Concise Hydrology (Han, D.)

✓Chapter 1: Example (Water Balance)

Practice 2

A reservoir has the following inflows and outflows (in cubic meters) for the first three months of the year. If the storage at the beginning of January is 60m^3, determine the storage at the end of March.

Month	Jan	Feb	Mar
Inflow	4	6	9
Outflow	8	11	5

Solution

The storage change is

$$\Delta S = I - O = (4+6+9)-(8+11+5) = -5m^3$$

The storage is 60-5=55m^3

Required Readings: Fundamentals of Hydrology (Davie, T)

✓Chapter 1: Water Balance Equation

There are numerous ways of representing the water balance equation but equation 1.1 shows it in its most fundamental form.

$$P \pm E \pm \Delta S \pm Q = 0 \qquad (1.1)$$

where P is precipitation; E is evaporation; ΔS is the change in storage and Q is runoff. Runoff is normally given the notation of Q to distinguish it from rainfall which is often given the symbol R and frequently forms the major component of precipitation. The ± terminology in equation 1.1 represents the fact that each term can be either positive or negative depending on which way you view it – for example, precipitation is a gain (positive) to the earth but a loss (negative) to the atmosphere. As most hydrology is concerned with water on or about the earth's surface it is customary to consider the terms as positive when they represent a gain to the earth.

Required Readings: Fundamentals of Hydrology (Davie, T)

✓Chapter 1: Water Balance Equation

$$P - Q - E - \Delta S = 0 \quad (1.2)$$

$$Q = P - E - \Delta S \quad (1.3)$$

In equations 1.2 and 1.3 the change in storage term can be either positive or negative, as water can be released from storage (negative) or absorbed into storage (positive).

Required Readings: Fundamentals of Hydrology (Davie, T)

✓Chapter 1: Water Balance Equation

Precipitation in the water balance equation represents the main input of water to a surface (e.g. a catchment). As explained on p. 10, precipitation is a flux of both rainfall and snowfall. Evaporation as a flux includes that from open water bodies (lakes, ponds, rivers), the soil surface and vegetation (including both interception and transpiration from plants). The storage term includes soil moisture, deep groundwater, water in lakes, glaciers, seasonal snow cover. The runoff flux is also explained on p. 10. In essence it is the movement of liquid water above and below the surface of the earth.

Required Readings: Fundamentals of Hydrology (Davie, T)

✓Chapter 1: Classes of Precipitation

Table 2.1 Types of precipitation

Class	*Definition*
Drizzle	A subset of fine rain with droplets between 0.1 and 0.5 mm, but close together
Rain	Liquid water droplets with diameter between 0.5 and 0.7 mm, but smaller if widely scattered
Freezing rain or drizzle	Rain or drizzle, the drops of which freeze on impact with a solid surface. Also called sleet in the USA
Sleet	Partly melted snowflakes, or rain and snow falling together (UK). Fairly transparent grains or pellets of ice (USA)
Ice crystals, ice prisms, snow and snowflakes	Snow can fall as single branched hexagonal or star-like ice crystals, or in the case of ice prisms, as unbranched ice crystals in the form of hexagonal needles, columns or plates. The nature of the crystal depends on the temperature at which it forms and the corresponding amount of water vapour. More often snow falls as agglomerated snowflakes.
Snow grains	Very small, white, opaque grains of ice, flat or elongated, with diameter generally <1 mm. Also called granular snow
Snow pellets	White, opaque grains of spherical or conical ice (2–5 mm). Also called granular snow, or graupel
Ice pellets	Transparent or translucent pellets of ice, spherical or irregular with diameter <5 mm
Hail	Balls or pieces of ice usually between 5 and 125 mm in diameter, commonly showing alternating concentric layers of clear and opaque ice in cross-section

Source: Adapted from Shuttleworth (2012) and Sumner (1988)