

WATER CYCLE AND WATER BUDGET

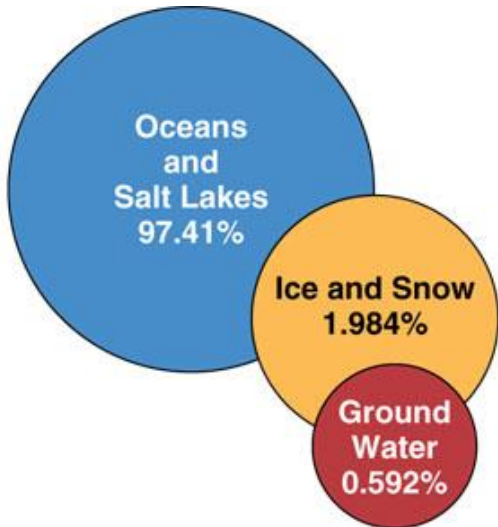
EESC 3600

Brooklyn College of CUNY

Fall 2021



Where is the most freshwater? Where is the most liquid freshwater?



- Lakes and rivers, 0.0071%
- Soils, wetlands, and biota, 0.0059%
- Atmospheric water, 0.001%

100 liters (26 gallons)



Total water
100%

2.59 liters (0.7 gallon)



Freshwater
2.59%

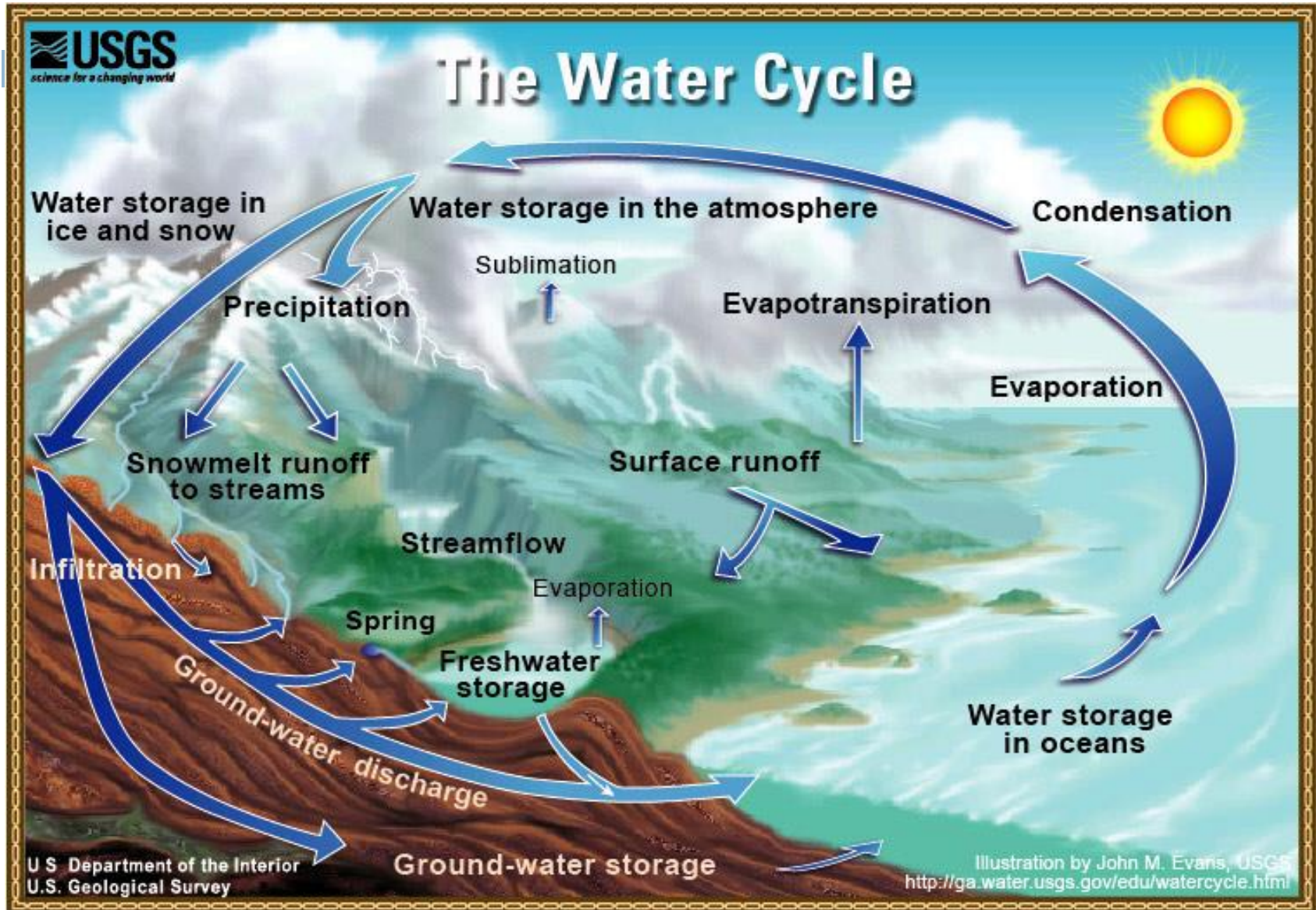


0.003 liter
(1/2 teaspoon)



Readily
available
freshwater
0.003%

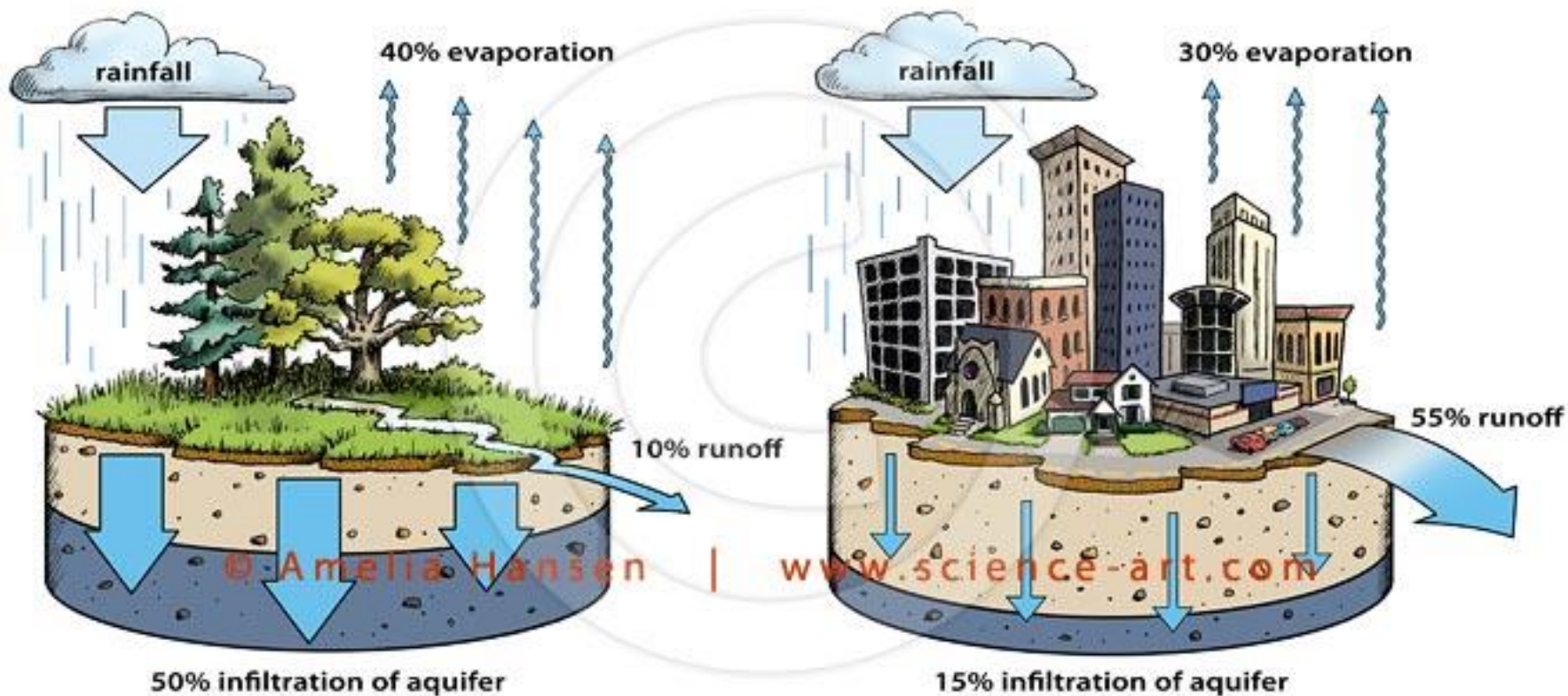
The Natural Water Cycle



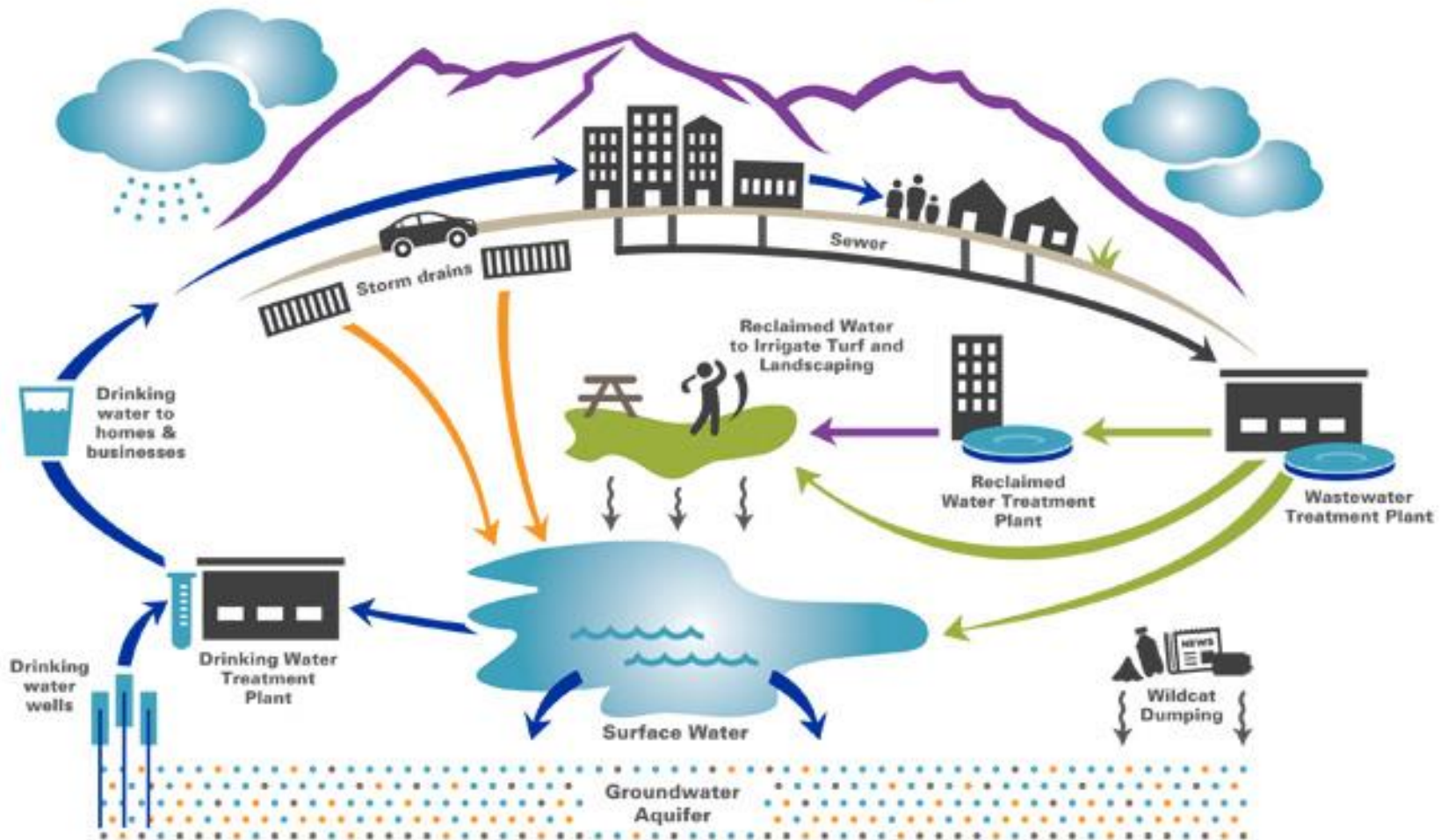
Water Cycle on a Global Scale

- Ocean has more evaporation than precipitation
- Land had more precipitation than evaporation
- Overall balanced by surface and groundwater runoff

Natural vs. Urban Water Cycle



Urban Water Cycle



What are the drivers of a water cycle?

- Solar energy
- Gravity
- Osmosis
- Capillary force

The Hydrologic Equation

- Also called Water Inventory Equation, or the continuity equation, or the Conservation equation
- Conservation of mass
- **Changes in Storage = Inflow – outflow**
- Mass or volume
- Often depth of water is used (if area is the same or doesn't change)

Examples of Inputs

- Precipitation
- Surface water inflow (runoff and overland flow)
- Groundwater inflow
- Artificial import

Examples of Output

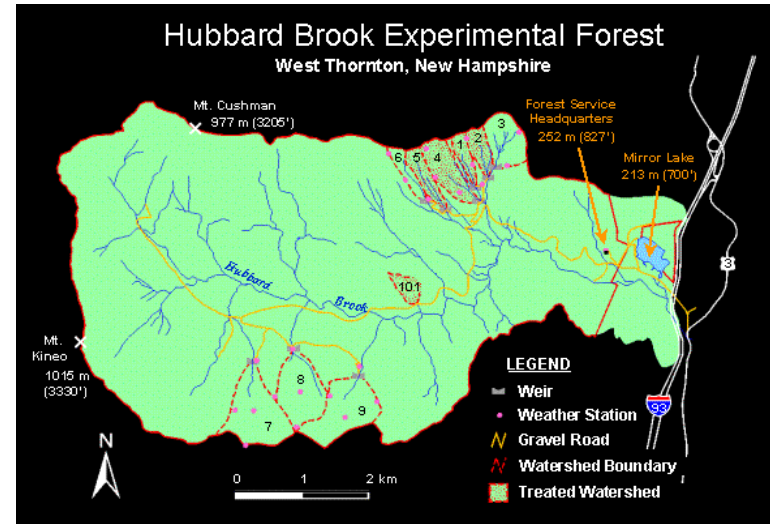
- **Transpiration**
- **Evaporation**
- **Surface water runoff**
- **Groundwater outflow**
- **Artificial output**

Changes

- Volume in surface water
- Volume in groundwater
- Soil moisture
- Ice and snow accumulation
- Depression storage
- Intercepted water in plant surfaces

Water Budget

- Systems can be large or small, depending what you're focusing on;
- Time period: annual, monthly, daily ...



Water Budget of a Puddle



Water Budget for Prospect Park Lake



Water Budget for a NYC Bioswale



Residence Time

$$T_R = \frac{\textit{Volume}}{\textit{Rate of Input}}$$



- Ocean: 4100 years
- Atmosphere: 9 days
- Jamaica Bay: ~20 days
- Surface water: days to years
- Groundwater: weeks to decades

Runoff Ratio

Runoff ratio is the runoff for each watershed divided by the precipitation for that watershed. It is the proportion of rainfall that does not infiltrate and is not taken up by evapotranspiration, and thus ends up as runoff. Also called Runoff Coefficient.

$$C = \frac{\textit{Runoff}}{\textit{Precipitation}}$$

Classroom Exercise

A watershed area of 10,000 square miles received 2-in of rain over a 24-hr period. The average runoff ratio of the area is 0.3 (representing a relatively developed, urbanized area). If all the runoff ends up in a lake that is 50 m in diameter (assuming the shape is round) and 30 m deep on average. The current water level is at 13 m.

1. Will there be a flood?
2. What assumptions do you have to make to calculate this?
3. What if the runoff ratio is 0.6 (representing a less developed area)?