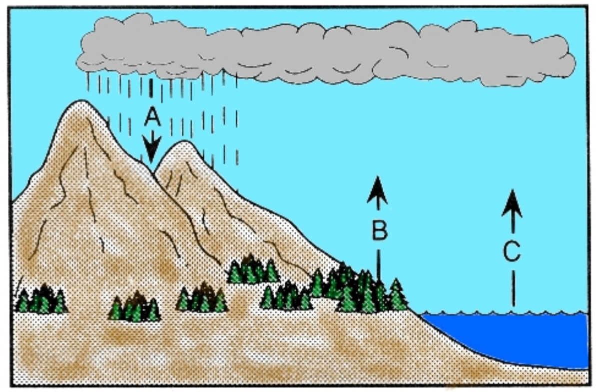
# Water & Climate Review

1) The water cycle:

> Water enters the atmosphere by ***evaporation*** (C in diagram) and also by ***transpiration*** (B in diagram). These words are combined to form ***evapotranspiration***.

> Moist air rises - expands - cools and condenses into clouds. Water returns to earth as ***precipitation*** (A in the diagram).



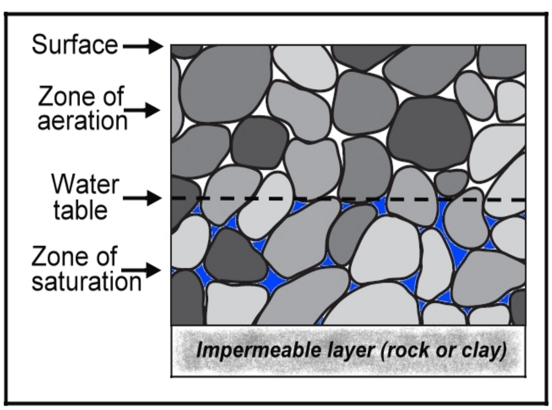

2) What can happen to the water when it returns to earth?

a) It may ***infiltrate*** into the ground and become ***ground water*** if....................

> The ground is ***porous*** and ***permeable***.
> The ***slope*** of the ground is ***not too steep*** (water needs time to infiltrate).
> The precipitation is rain (snow can't infiltrate).
> The ground is ***unsaturated*** (not yet full of water).

b) It may remain on the surface and become ***runoff*** if .................................

> The ground is not porous or if it is ***impermeable***.
> The slope of the ground is steep and the water runs off before it has a chance to infiltrate.
> The ground is frozen or the precipitation is ice or snow.
> The ground is ***saturated*** (all pore spaces between soil particles are already filled with water).
> The rate of precipitation exceeds the rate of infiltration into the ground.




There are usually ***pore spaces*** between soil particles. These spaces may be filled with air (***zone of aeration***) or water (***zone of saturation***).
The interface between these 2 zones is the ***water table***.

The water table rises closer to the surface in wet seasons and falls during dry periods of ***drought***.

The water table falls = ***USAGE***
The water table rises = ***RECHARGE***
The ground is full of water (saturated - water table reaches surface) = ***SURPLUS***
The ground contains no water = ***DEFICIT***

When it rains, water infiltrates into the ground until it hits an impermeable layer of rock or clay. The water fills the pore spaces between the soil particles. This is ground water.

c) ***Runoff*** (water that stays on the surface) finds it's way into streams. The streams join to form rivers. The rivers eventually return the water to the sea. Some evaporates on the way.

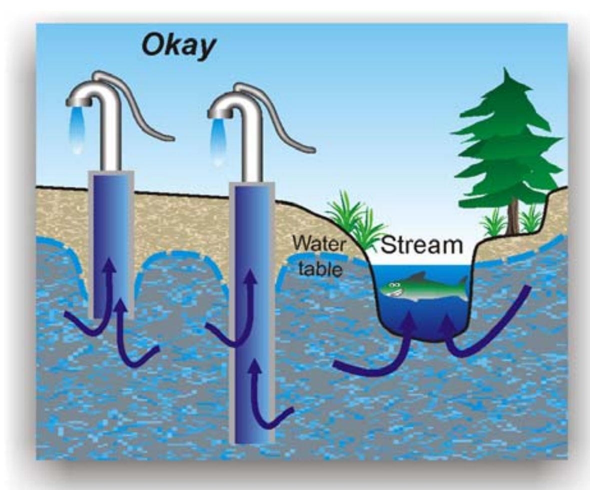
3) How does ground water get out of the ground?

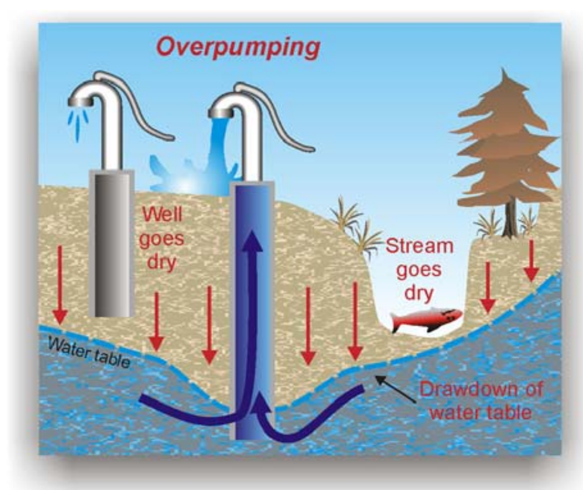
a) ***Capillarity*** is the tendency of water to rise up through very tiny pore spaces. Small soil particles (silt) = small pore spaces = greater capillarity. Water rises to the surface where it evaporates.

**Capillarity**

When you watch water rising up in a paper towel or napkin that has been dipped in water, you are watching capillarity.

b) It may be pulled from the ground by plants and enter the air by ***transpiration***.
c) It may flow underground until it enters a stream or lake.
d) It may be pumped from the ground by people (***usage***).




If too much water is pumped, the water table falls and the well may run dry (right).

Notice that the well must be drilled to ***below the water table*** to get water. Also notice (in left illustration) that the surface of the stream ***is at the water table***. This is also true of lakes. The surface of a lake or pond is at the water table.

In dry periods streams may continue to flow because ground water enters the stream through it's banks. Again, during dry periods stream may be fed by ground water.

4) How can runoff be controlled and infiltration increased?

We want to return water to the soil (*recharge*). This can be accomplished by……

a) Creating '*sumps*' or '*catch basins*' which are man-made depressions where runoff collects and has time to slowly infiltrate back into the soil.

b) Plant vegetation, especially grass and trees. Roots open the soil allowing more and faster infiltration. Plants also slow the movement of surface water giving it more time to infiltrate.

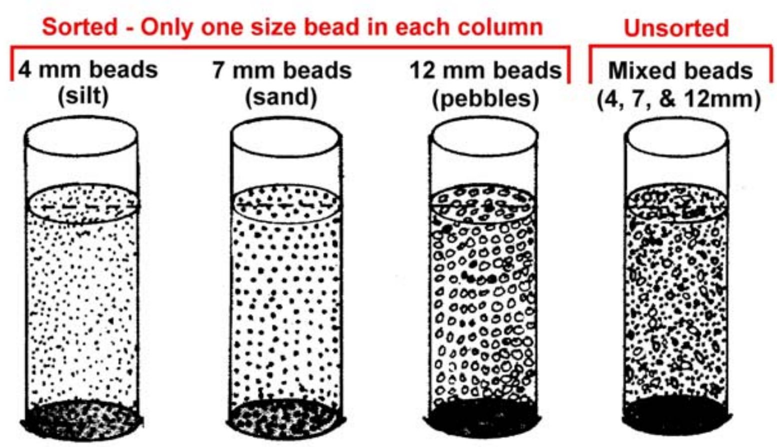
c) Avoid paving or building on areas where ground water recharge occurs. Blacktop and concrete are impermeable and prevent infiltration.

d) Flatten or terrace steep slopes. This slows runoff.

The terracing of this hillside in Peru was done by the Inca civilization between 600 and 800 years ago. Each terrace holds water flowing down from the terrace above greatly slowing the rate of runoff and giving the water more time to infiltrate. Notice that vegetation is planted on each terrace to help keep the soil porous.

5) How do the properties of different kinds of soils affect groundwater?

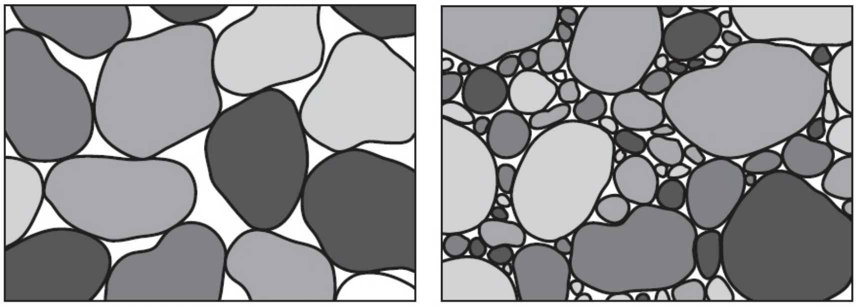
# PROPERTIES OF SOILS




| | 4 mm beads (silt) | 7 mm beads (sand) | 12 mm beads (pebbles) | Mixed beads (4, 7, & 12mm) |
|---|---|---|---|---|
| **Porosity** (water required to fill) | Same | Same | Same | Least |
| | (sorted columns all have about 43% empty space) | | | |
| **Permeability** | Least | | Most | *Least** |
| **Time needed for infiltration** | Most | | Least | *Most** |
| **Capillarity** | Most | | Least | |
| **Rate of infiltration** | Slowest | | Fastest | *Slowest** |
| **Surface area / Water required to wet / Water retained** | Most | | Least | *Most** |

*** Alternative Choice: Rarely if ever will you be asked to choose between 4mm and mixed beads.***

a) *Porosity*: The amount of pore space between particles.
As long as soils are *sorted*, porosity remains the same (about 43%)
If soil particle sizes are mixed, porosity decreases! That's because in unsorted soil the small particles pack in between the larger ones.



Sorted Unsorted

b) Permeability: The ease with which water flows through a soil. Bigger particles have bigger spaces between them. These large spaces allow water to 'permeate' at a fast rate.
Most permeable: Sorted soils with large particles (gravel - pebbles)
Least permeable: Sorted soils with small particles (clay) or mixed particles.

*Impermeable*: Rock with no pore spaces between particles:

c) *Capillarity*: Smallest particles = greatest capillarity.
Largest particles = least capillarity.

d) *Rate of infiltration*:
Largest particles = fastest rate of infiltration (least runoff)
Smallest particles = slowest rate of infiltration (most runoff)

e) *Time required for infiltration*:
Large particles = fastest rate = least time required
Smallest particles = slowest rate = most time required

f) *Water needed to wet the surface* (aka water retained)

*IMPORTANT FACT: Smaller particles have much more surface area than large particles!*
*The greater the surface area, the more water is needed to wet it.*
Since small particles have much more surface area than large particles, more water is needed to wet soils made of small particles. This water sticks to the particle surfaces and is *retained* in the soil.

6) What is *climate*: The average weather for a region over a long period of time.
Climate includes: Temperature, precipitation, humidity, winds, and insolation.
Climate is affected by:

a) Latitude:
> Close to the equator = hot/humid (rain forests)
> Mid latitudes (NY State) = moderate insolation & humidity (seasons)
> 30° N or 30° S = hot and dry (deserts)
> High latitudes (near poles) = Cold & dry

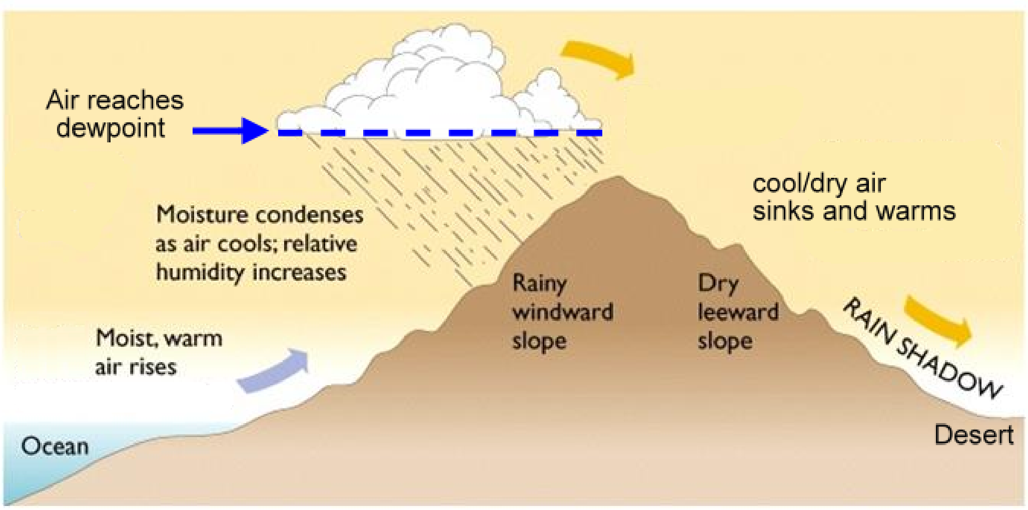
b) Elevation:
> High elevations are just like high latitudes = Cold & dry

c) Proximity to a large body of water (being near the coast or a large lake)
> Coastal areas do not have extremes of climate.
They have cooler summers and warmer winters.
> Inland areas are more extreme: Hot summers/Cold winters.

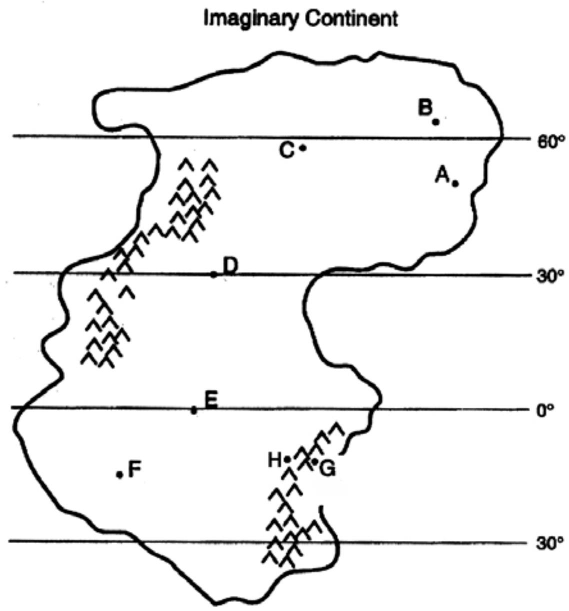
d) Ocean currents:
> Warm currents make the climate more mild.
> Cold currents make the climate colder.
> See page 4 of the reference tables.

e) Mountain ranges (orographic effect).
> Windward side of mountain:
Air rises - expands - cools - reaches dewpoint - rain
> Leeward side of mountain:
Air sinks - is compressed - warms, but is dry = deserts.

## Effects of Mountains on Climate




Note: When looking at a diagram it may be necessary to check the wind belt map on page 14 of your reference tables to determine which is the windward and which is the leeward side.




Location....................

E) On equator. Not near water. Probably hot with some moisture.
D) 30° N, not near water.Probably desert.
A) Similar to NY State. Temperate climate.
G) In prevailing SE windbelt and therefore on the windward side of a mountain range near a coast. Only about 12° from the equator. Probably has a very warm,wet climate.
H) Further inland and on the leeward side of the mountain range. Probably hot and dry

7) How are climates classified?

Climates are classified according to a ***P/Ep ratio*** (divide one by the other).

P = total annual precipitation (usually in millimeters).

Ep = ***potential evapotranspiration***

Ep is the amount of water that ***could*** enter the air by evaporation and transpiration.
Ep depends on one thing only: TEMPERATURE. So learn this: ***Ep = Temperature.***
Warm climate = more Ep. Cold climate = less Ep.

Table 1

**Water Budget Data**

| Month | J | F | M | A | M | J | J | A | S | O | N | D | Yearly Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation ($P$) | 72 | 68 | 81 | 75 | 74 | 87 | 84 | 82 | 72 | 76 | 63 | 72 | |
| Potential Evapo-transpiration ($E_p$) | 0 | 0 | 3 | 34 | 83 | 115 | 134 | 122 | 84 | 46 | 15 | 0 | |

Table 2

**Climate Classification**

| Climate Type | Total Yearly $P/E_p$ Ratio |
|---|---|
| Humid | greater than 1.2 |
| Subhumid | 0.8 to 1.2 |
| Semiarid | 0.4 to 0.8 |
| Arid | less than 0.4 |

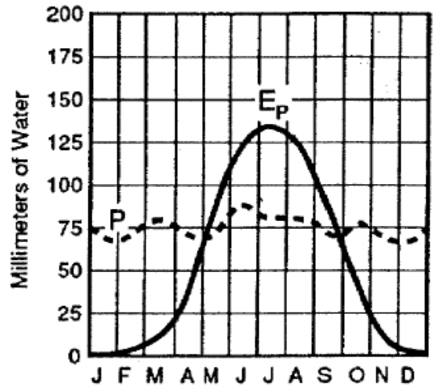
**1) Use a calculator to get the total yearly P.**

**2) Get the total yearly Ep.**

**3) Divide P by Ep to get the P/Ep ratio.**

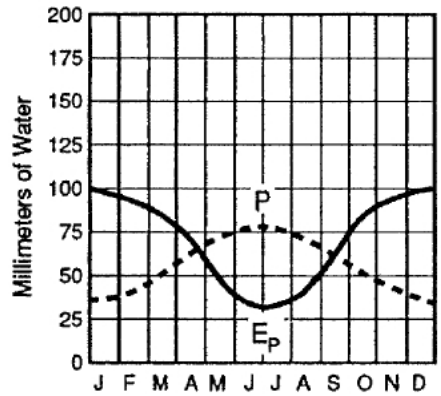
**4) Use the ratio and table 2 to classify the climate**

Sometimes water budgets are graphs. They look look this:

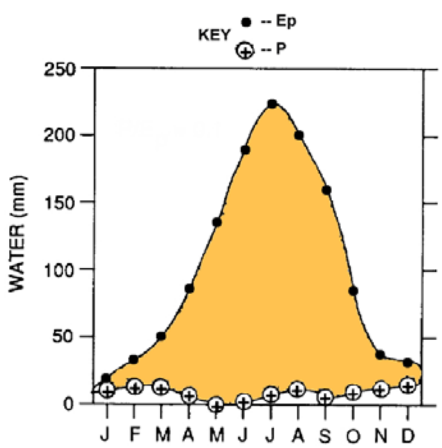



Things to understand:
1) This water budget is for a location in the northern hemisphere. Notice that Ep peaks in June, July, and August. Since Ep depends on temperature it must mean that June, July and August are the hottest months. That means it must be in the northern hemisphere.

2) Getting total precipitation is easy. Each month got just about 75 mm so 75 X 12 (months) = 900.




This is a water budget for a location in the southern hemisphere. The highest Ep (temperature) occurs in December, January, and February.




This is a water budget for a very ***arid*** (dry) climate.
In every month there is more Ep than P meaning that every drop of rain that falls evaporates and none goes into the ground. It is likely that there is no ground water in this location.