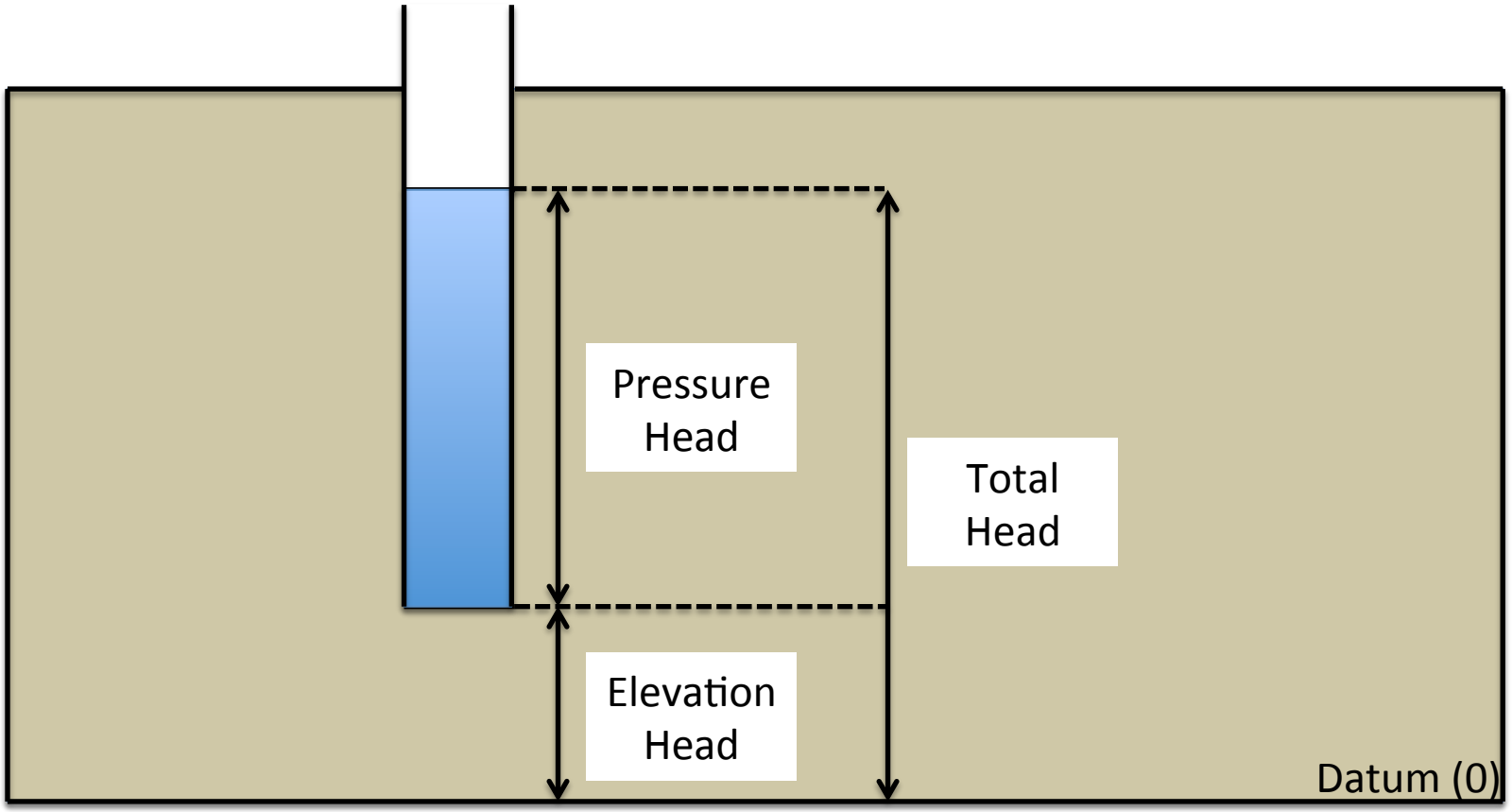
Contaminant Fate and Transport Principles

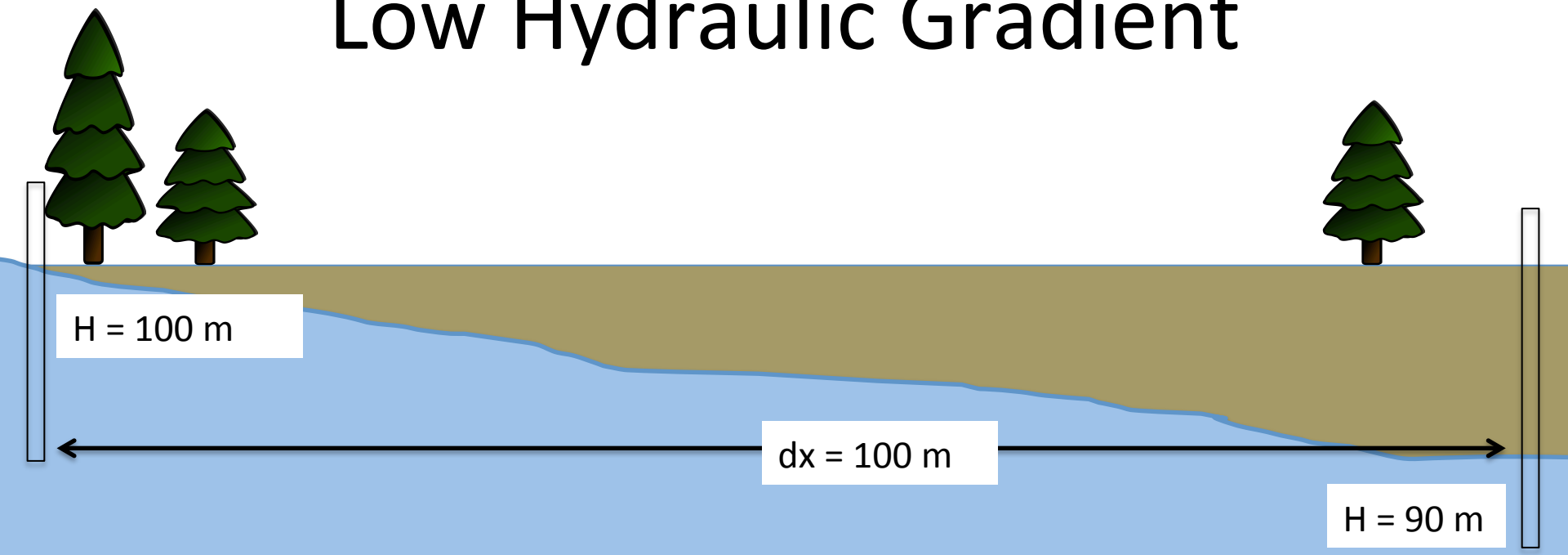
Phase 1A Attachment 10B Site Photographs

Groundwater Basics

Hydraulic head = pressure head + elevation head

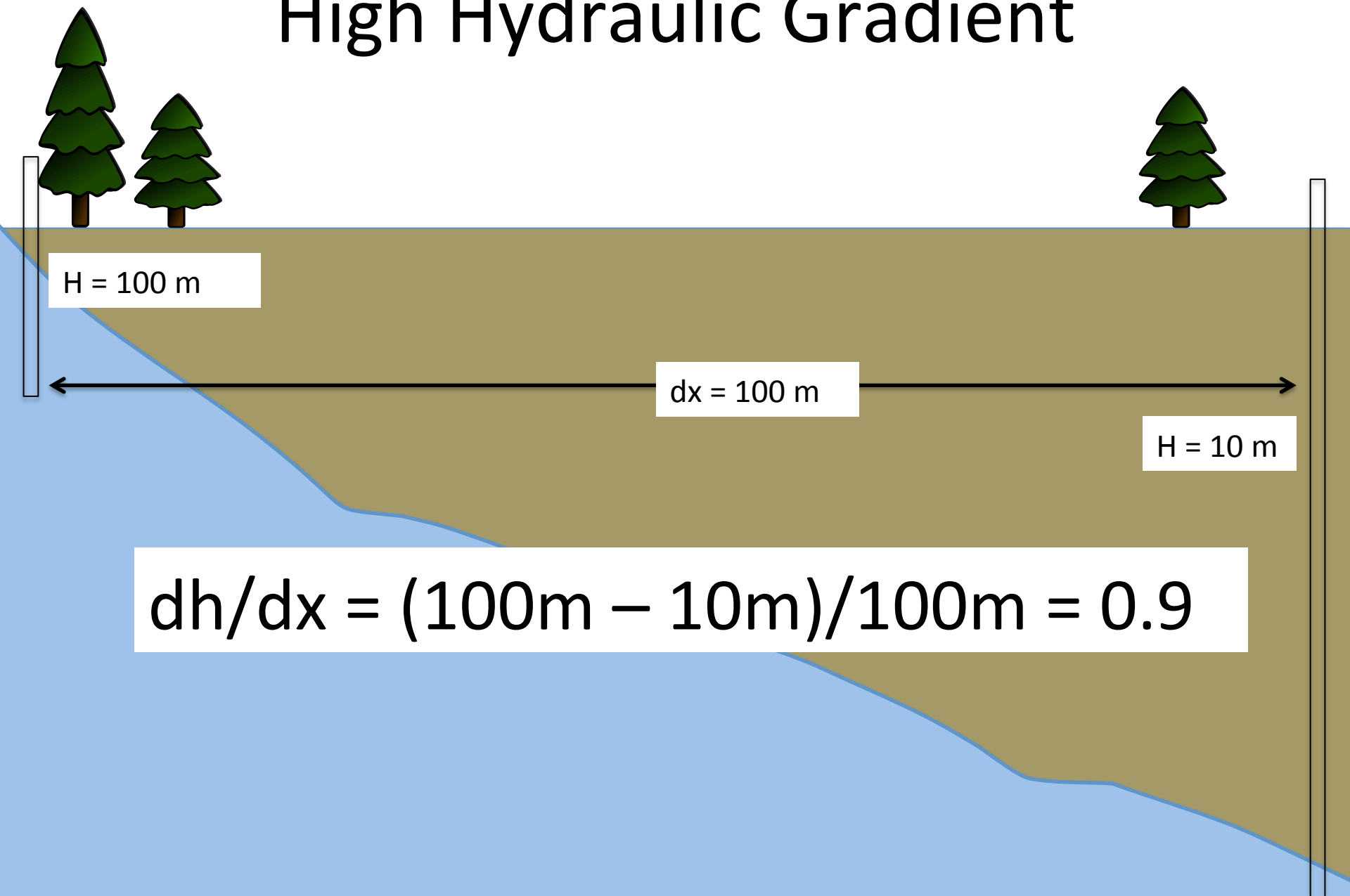


Low Hydraulic Gradient



$$dh/dx = (100m - 90m)/100m = 0.1$$

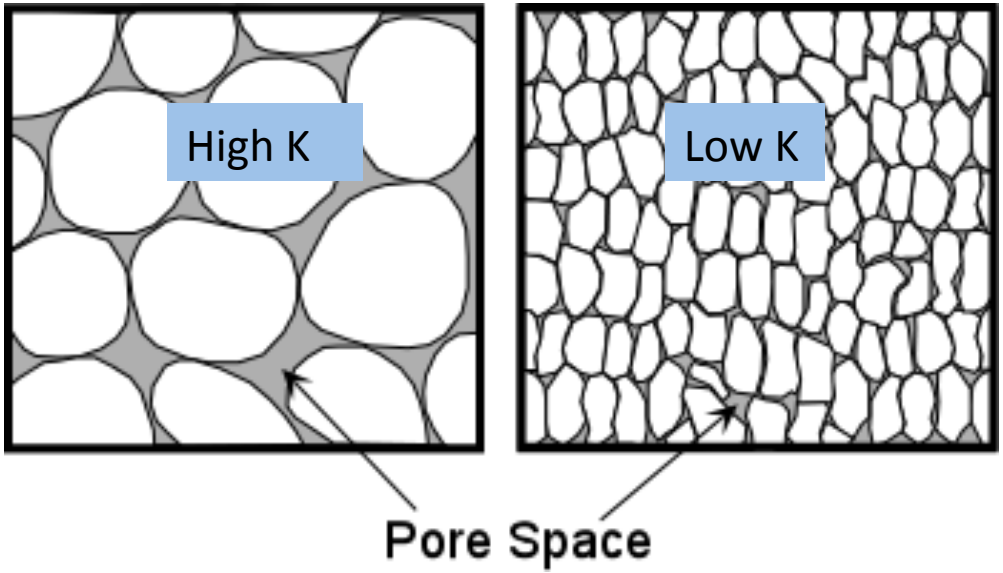
High Hydraulic Gradient



$$dh/dx = (100m - 10m)/100m = 0.9$$

What controls flow?

- Darcy's Law: Q = -KA*dh/dx
- Flow is set by:
  - hydraulic gradient (dh/dx)
  - hydraulic conductivity K (ease of flow)



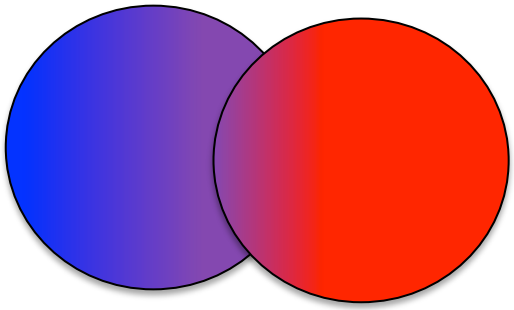
Other properties control flow

Types of bonds

- Swapping and sharing of electrons (e-) allows atoms to form compounds and molecules

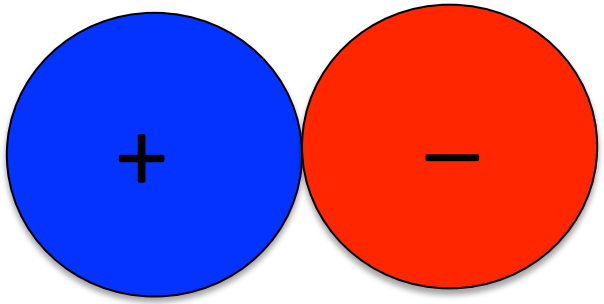
<u>Covalent</u>

- share e-



<u>Ionic</u>

- opposite charges



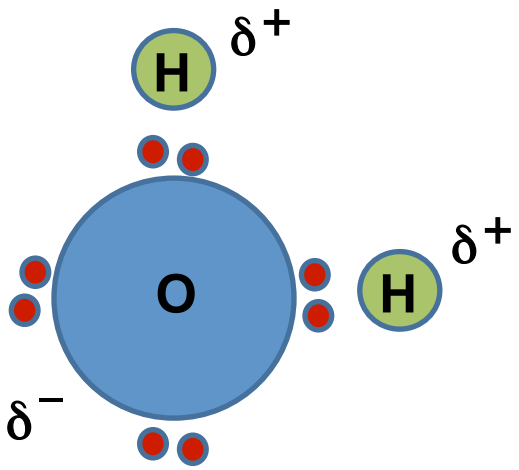
Other properties control flow

Polar vs nonpolar

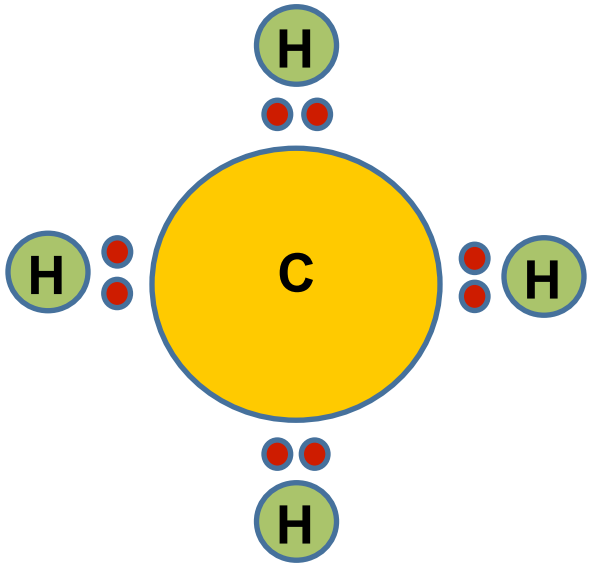
- Covalent bonds (e- are shared) can be either polar or nonpolar

Polar: one atom "hogs" the e-

Nonpolar: equal sharing of e-



Polar

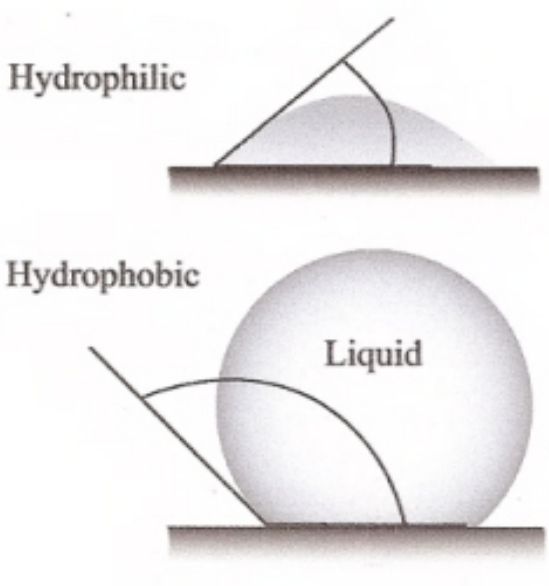


Nonpolar

Other properties control flow

Hydrophilic: “water loving” polar, form ionic bonds with water molecules

Hydrophobic: “water fearing” nonpolar, repel water molecules



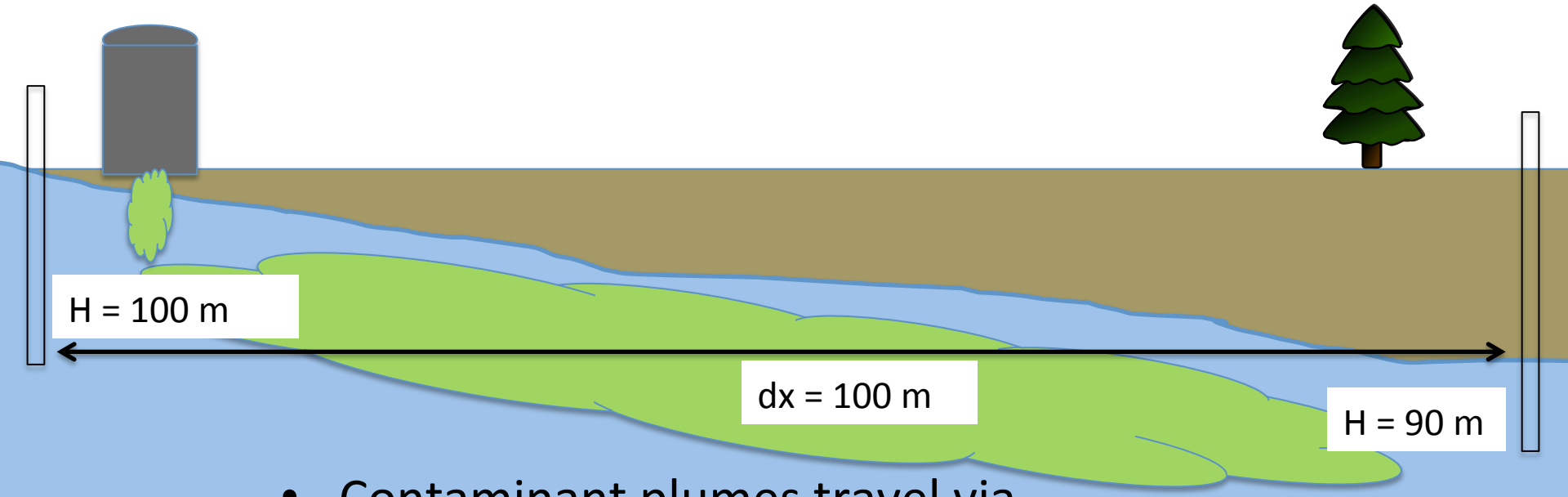
Juice in water

Oil in water

How does this affect transport?

- Hydrophilic: “water loving” will more readily move with groundwater
  - transported longer distances
  - e.g. high concentrations of HCl in water
- Hydrophobic: “water fearing” will more readily stay in sediment
  - Stay in system longer
  - e.g. Dioxins and HCBs concentrations in the soil
    - HCB soil: 190-2100 ppm (Western Ditch and Main Ditch)
    - HCB groundwater: 0.41-3.0 ppb (monitoring wells)

Plume Transport



- Contaminant plumes travel via
  - Advection
  - Dispersion
  - Diffusion

Advection

- Movement of the contaminant by the flow of the fluid

- Driving force is the hydraulic gradient

Head = 10 m

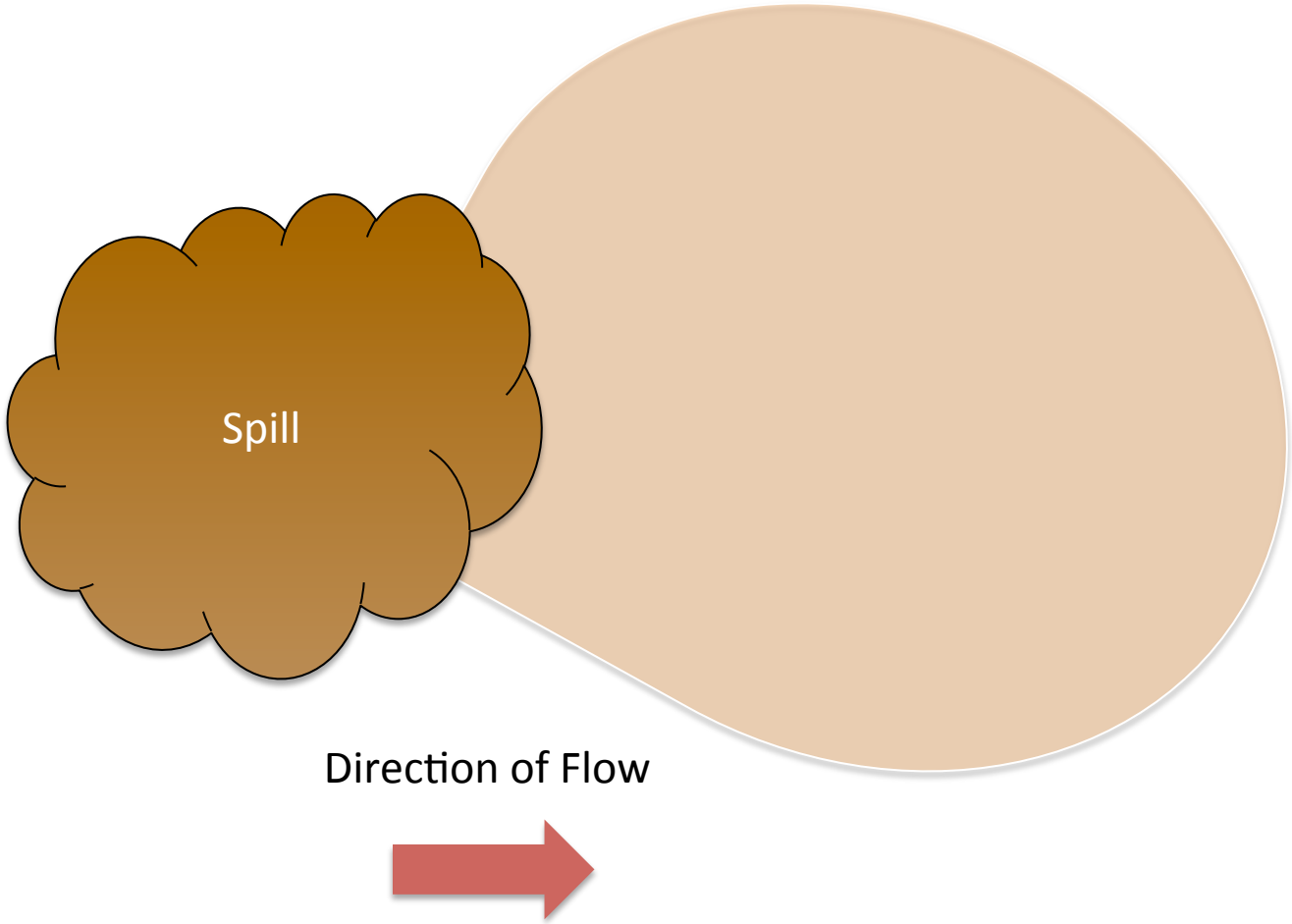
Head = 0 m

Direction of Flow

Just Advection:

Advection controls the LENGTH of the plume

In Reality:



Dispersion controls the WIDTH of the plume

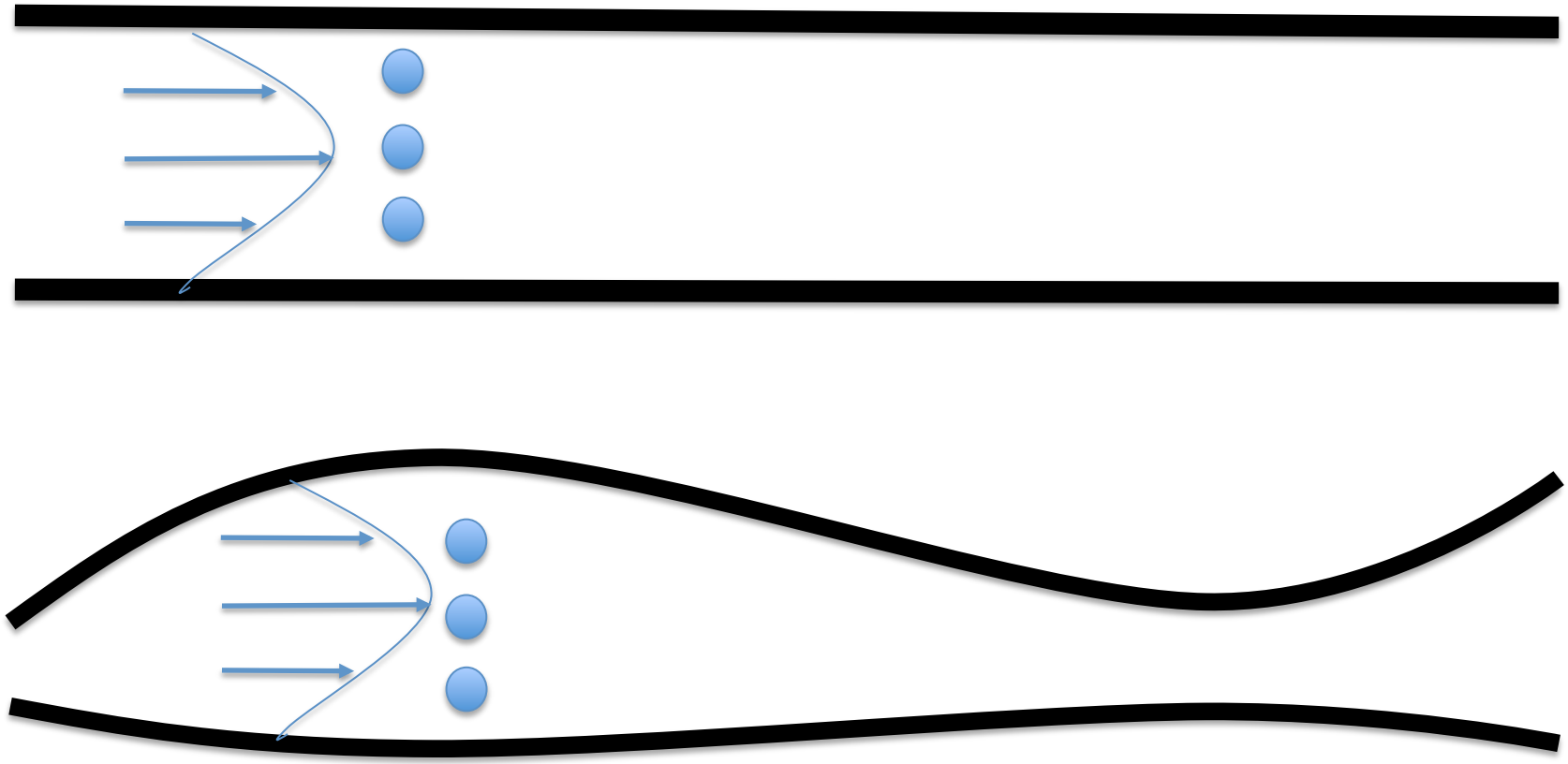
Dispersion

Actually a combination of two processes:

- Mechanical Dispersion
  - Variation in the speed of contaminant

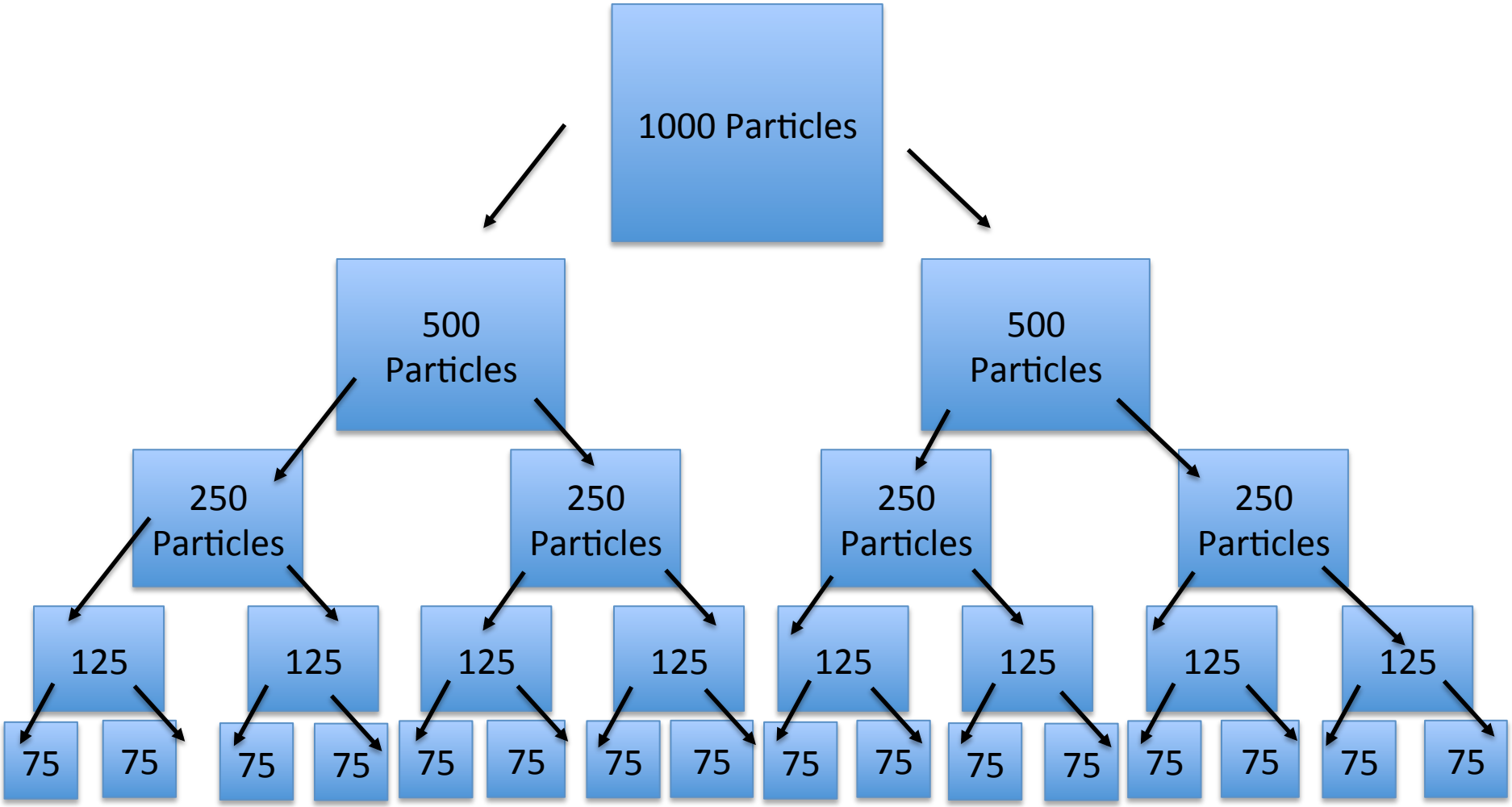
- Diffusion
  - Random motion

Mechanical Dispersion

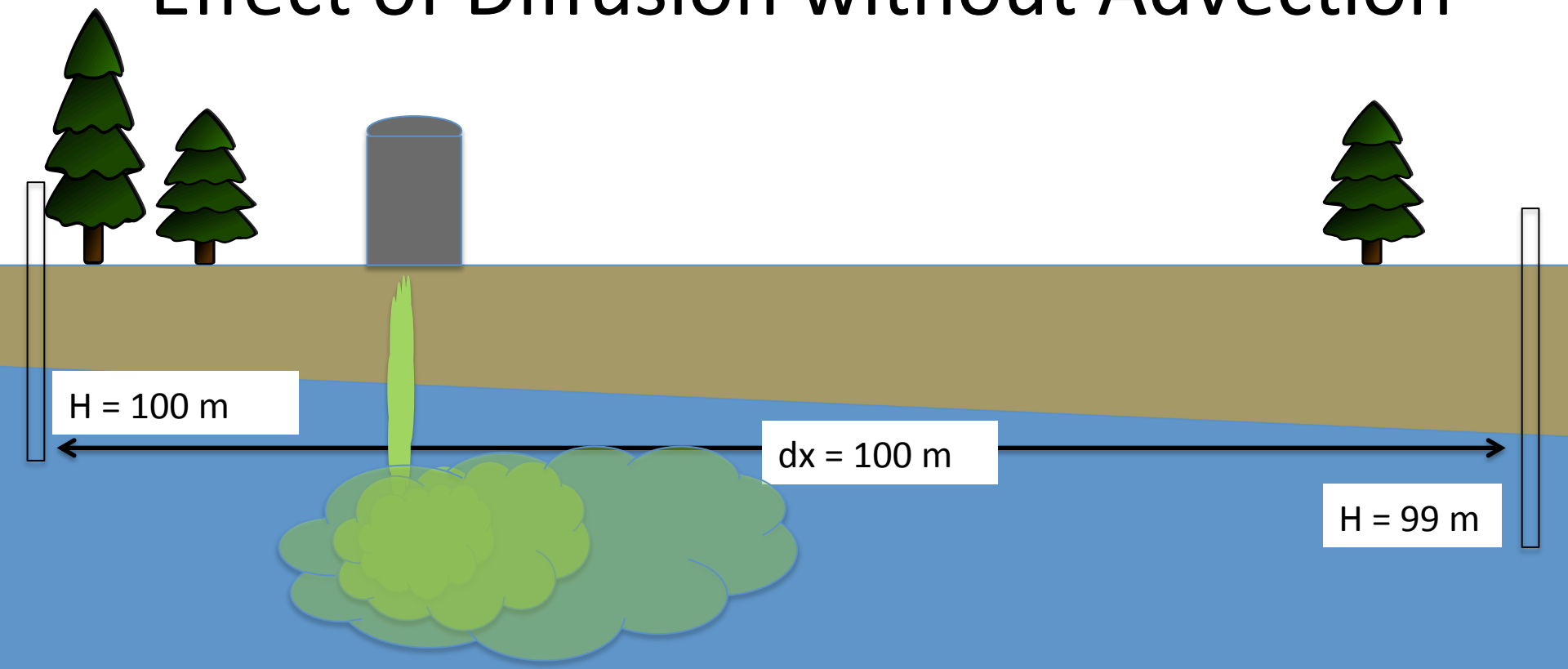


Diffusion

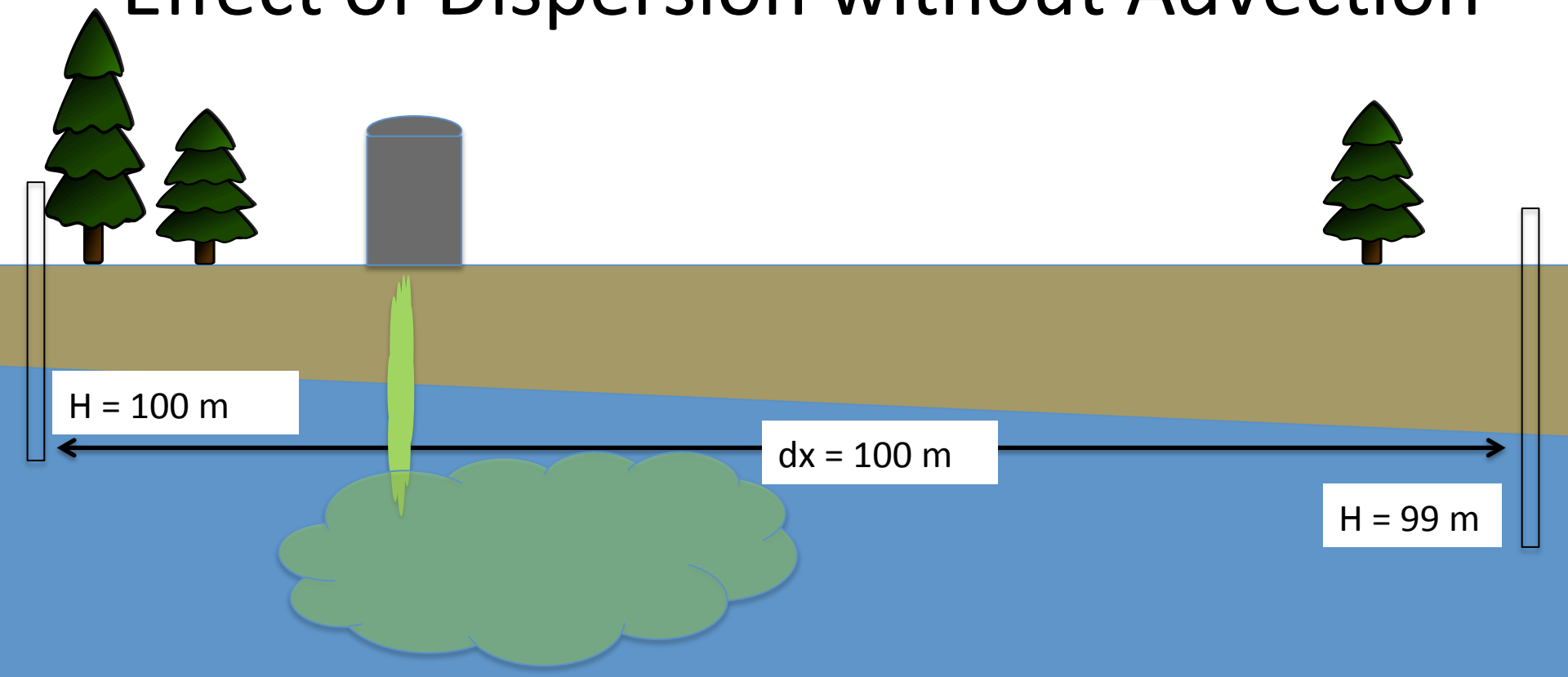
: the movement of contaminants from areas with high concentration to low concentration via random motion



Effect of Diffusion without Advection



Effect of Dispersion without Advection



Darcy's Law

$$Q/A = -K\, dh/dx$$

Fick's Law

$$J = -\theta De\, dC/dx$$