Background Information for Lab 2: MATLAB Programming
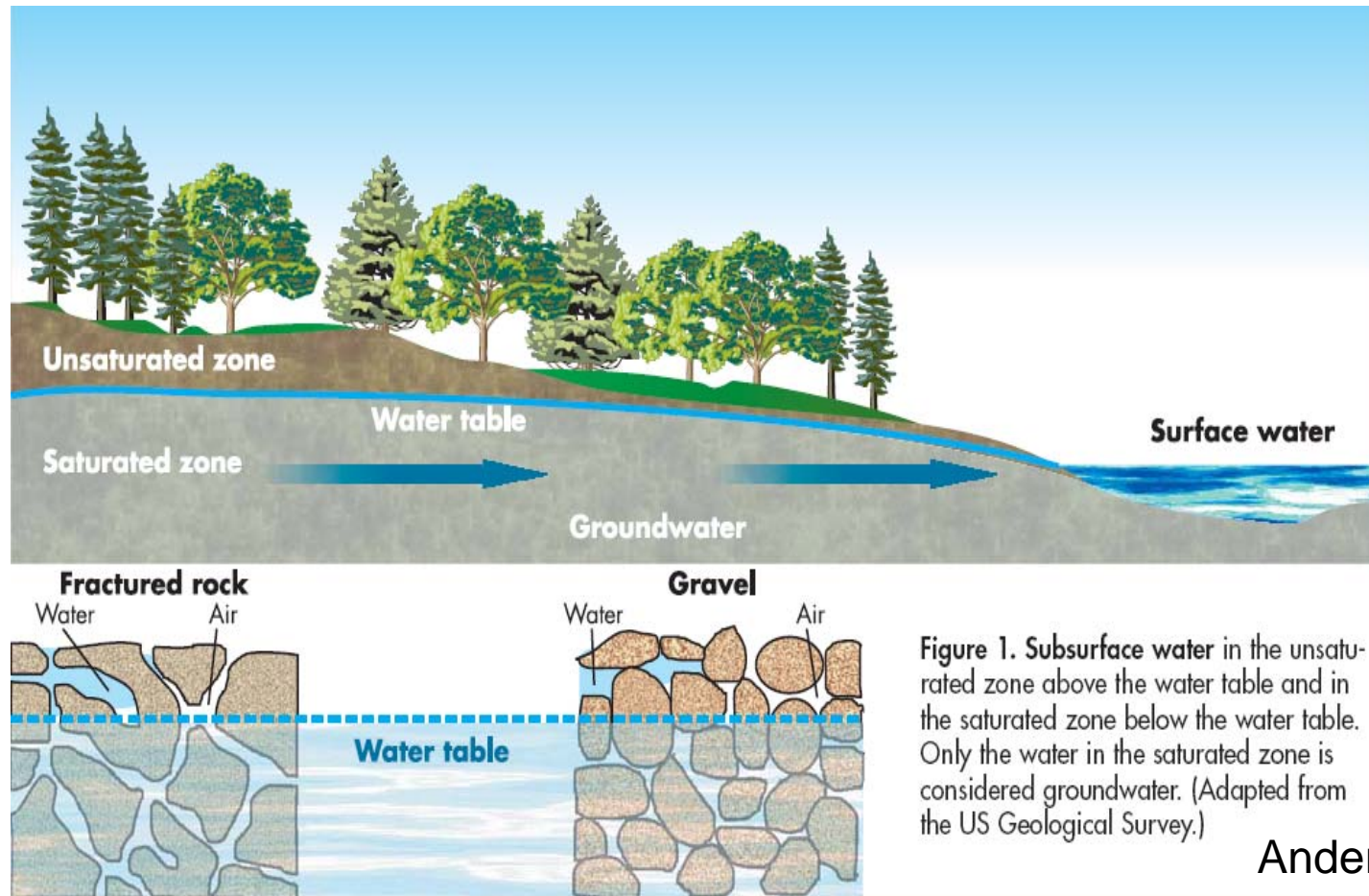
Instructor: Dr. Ming Ye

How to mathematically describe water movement in subsurface?

Figure 1. Subsurface water in the unsaturated zone above the water table and in the saturated zone below the water table. Only the water in the saturated zone is considered groundwater. (Adapted from the US Geological Survey.)
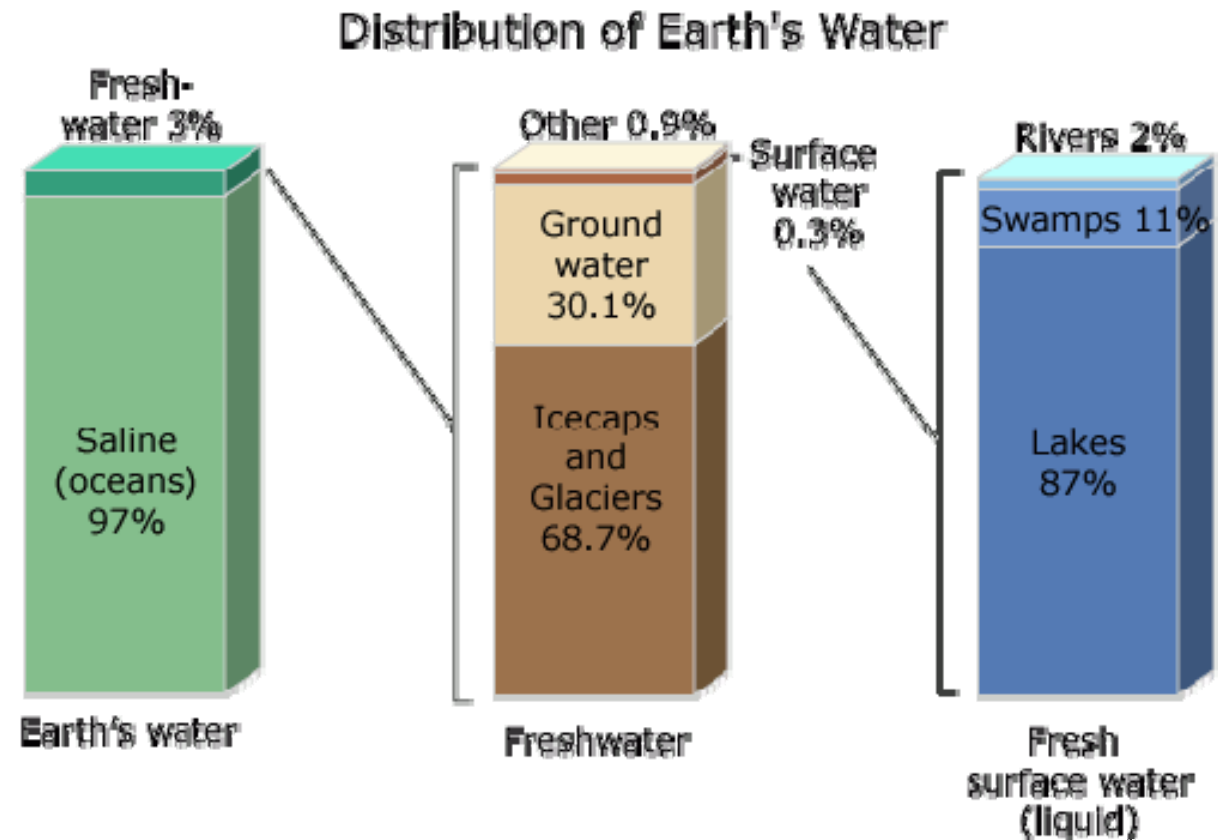
Anderson, 2007

Groundwater: water in the saturated region of the subsurface
Vadose zone water (soil moisture): water in the unsaturated region of the subsurface

The Earth's Water Supply

In U.S., 75% of public water systems rely on groundwater

Distribution of Earth's Water

Fresh-water 3%

Saline (oceans) 97%

Earth's water

Other 0.9%

Ground water 30.1%

Icecaps and Glaciers 68.7%

Freshwater

Surface water 0.3%

Rivers 2%

Swamps 11%

Lakes 87%

Fresh surface water (liquid)

http://ga.water.usgs.gov/edu/earthwherewater.html

In Florida, ~93% population rely on groundwater.

EXPLANATION

Floridan aquifer system—
Gray where extent
is buried

The Floridan aquifer system is one of the most productive aquifers in the world. This aquifer system underlies an area of about 100,000 square miles, and it provides water for several large cities, including Savannah and Brunswick in Georgia and Jacksonville, Tallahassee, Orlando, and St. Petersburg in Florida.
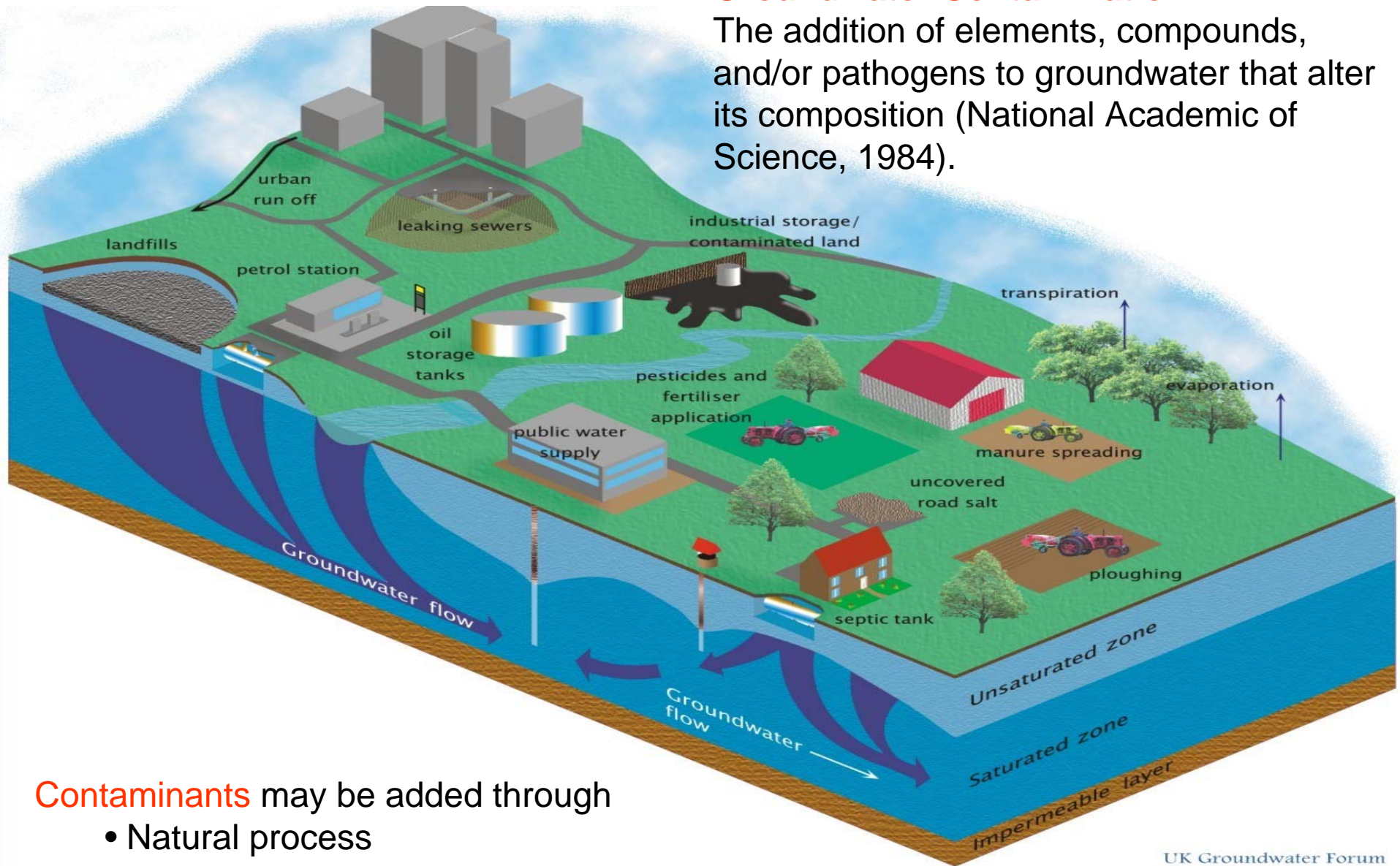
Source: Fernald, E.A., and E.D. Purdum, 1998. *Water Resources Atlas of Florida*. Institute of Science and Public Affairs, FSU
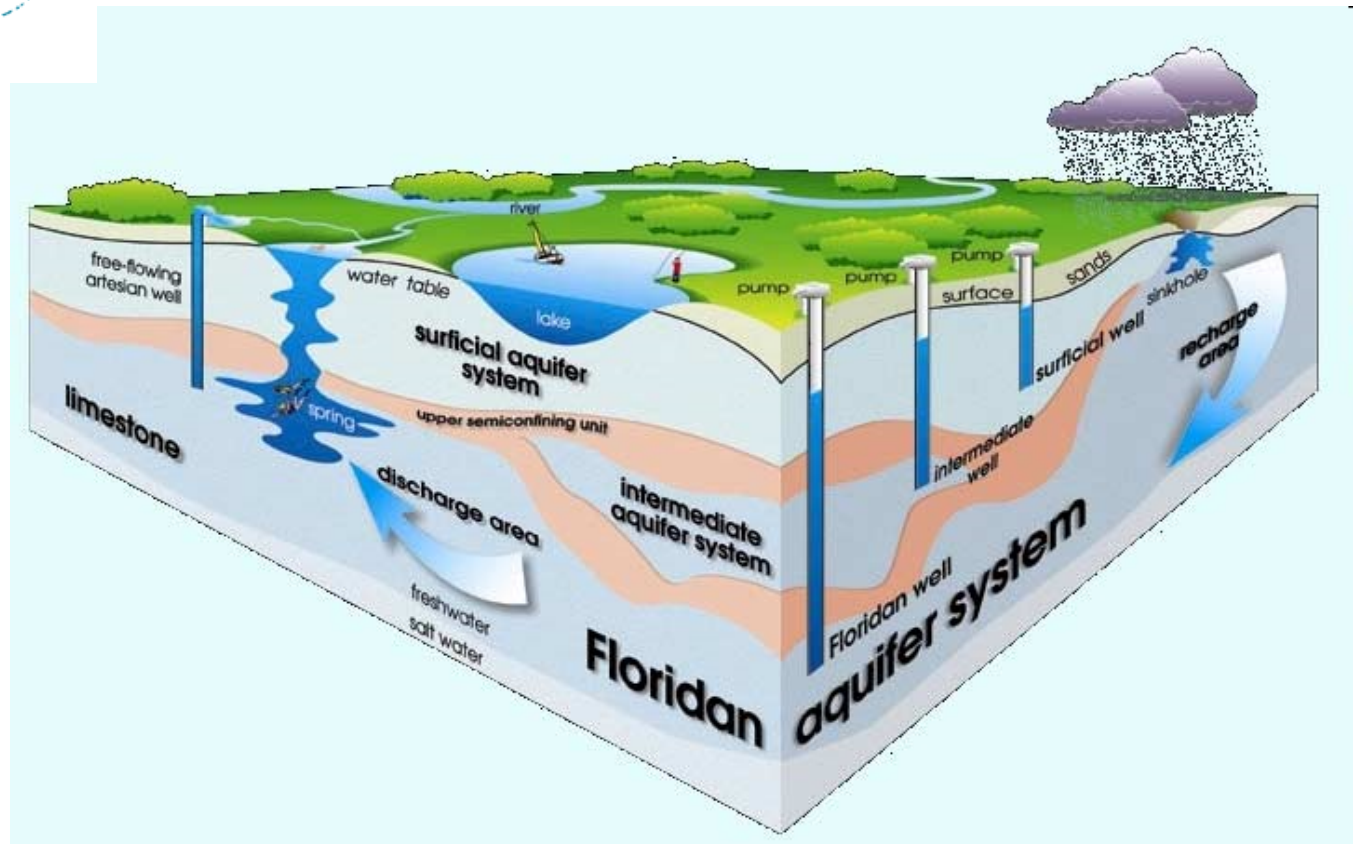
Groundwater Contamination:
The addition of elements, compounds, and/or pathogens to groundwater that alter its composition (National Academic of Science, 1984).

Contaminants may be added through
- Natural process
- Man's waster-disposal practices
- Direct result of human activities but unrelated to waste-disposal practices

Labels in figure: urban run off, landfills, leaking sewers, petrol station, oil storage tanks, industrial storage/contaminated land, transpiration, evaporation, pesticides and fertiliser application, manure spreading, public water supply, uncovered road salt, ploughing, septic tank, Groundwater flow, Groundwater flow, Unsaturated zone, Saturated zone, impermeable layer, UK Groundwater Forum
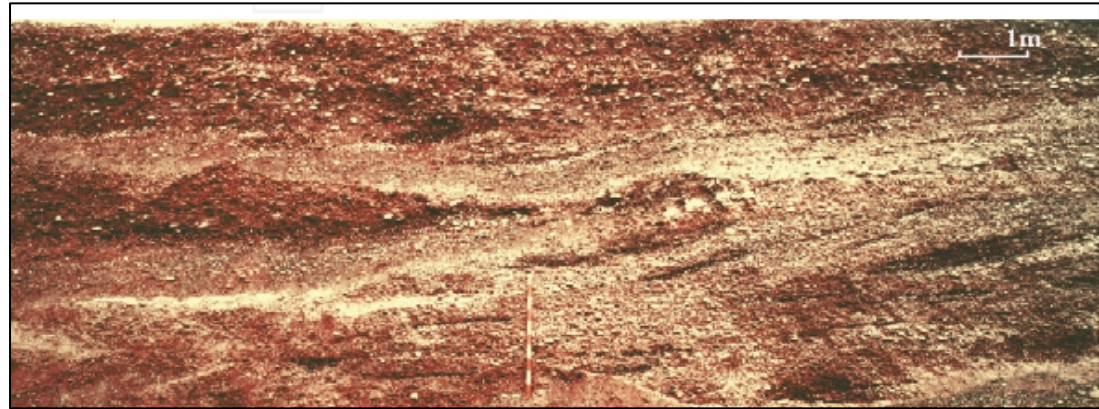
Groundwater Contamination

- It occurs underground, out of sight.
- Contaminants generally travel unnoticed in the subsurface until being found in a water-supply well.
- Weeks, months, or even years may elapse before a problem is discovered.
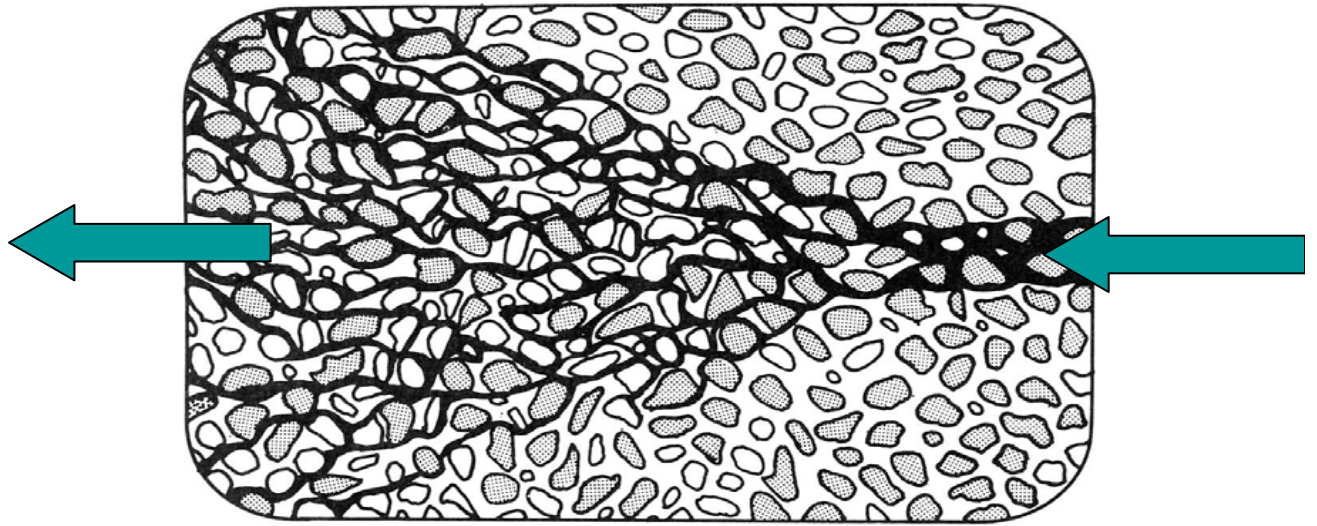- It will last for a long time, if no remediation actions are taken.
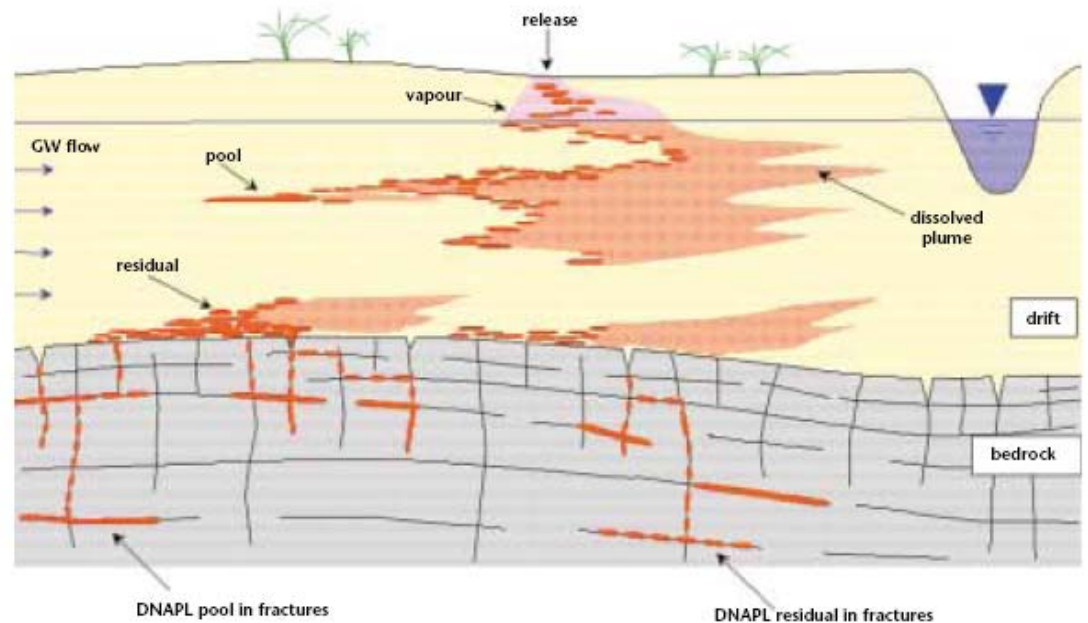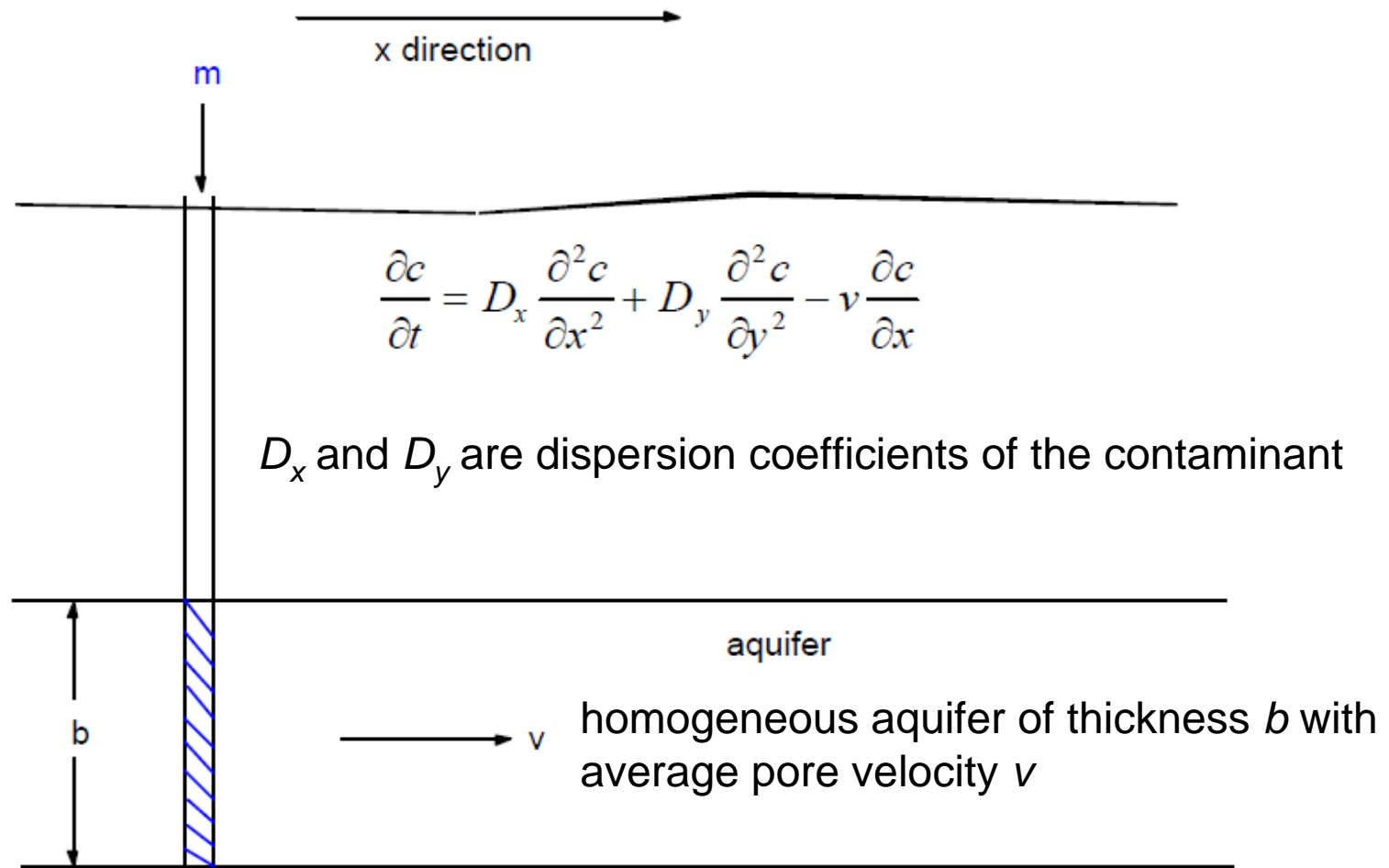
Lab 2

A groundwater transport problem

Geological medium

Microscopic scale dispersion

A mass *m* of non-reactive contaminant is assumed to be injected instantaneously into an extensive aquifer of thickness *b*

x direction

m

$$\frac{\partial c}{\partial t} = D_x \frac{\partial^2 c}{\partial x^2} + D_y \frac{\partial^2 c}{\partial y^2} - v \frac{\partial c}{\partial x}$$

D_x and D_y are dispersion coefficients of the contaminant

aquifer

b

v

homogeneous aquifer of thickness *b* with average pore velocity *v*

Making a Function m. File

Analytical solution:

$$c(x, y, t) = \frac{m/b}{4\pi t \sqrt{D_x D_y}} \exp\left(-\frac{(x-vt)^2}{4D_x t} - \frac{y^2}{4D_y t} \right)$$

This solution is sometimes referred to as a "Gaussian puff" because the cloud spreads out in the form of a Gaussian distribution.

- Independent variables: x, y, and t
- State variables: c (concentration)
- Model parameters: m, D_x, D_y, v, b
- Objective:

  Write a .m file that solves concentration for any values of m, D_x, D_y, v, and b