# Águas superficiais

## Tempo de empoçamento

TEA018 - Hidrologia Ambiental

Prof. Emílio G. F. Mercuri, Maio de 2023

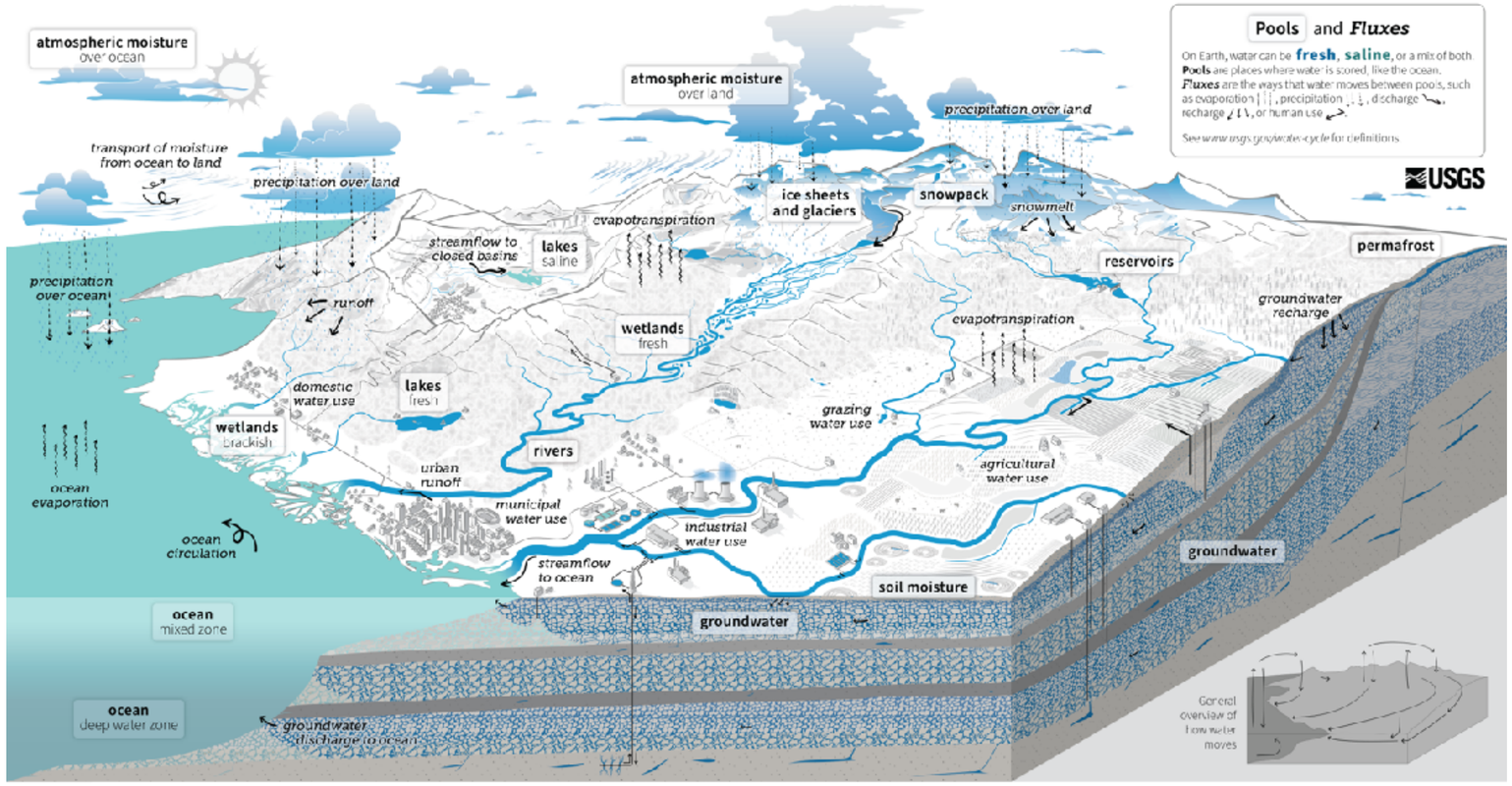
# Agenda

## Tempo de empoçamento e Águas superficiais

- Tipos de escoamento na escala da vertente
- Erosão de solo
- Tempo de empoçamento
- Método de Mein e Larson (1973)
- Exercícios

# Runoff and Streamflow

**Runoff = Escoamento**, ou seja é um termo genérico em hidrologia.




## The Water Cycle

The water cycle describes where water is on Earth and how it moves. Water is stored in the atmosphere, on the land surface, and below the ground. It can be a liquid, a solid, or a gas. Liquid water can be fresh, saline (salty), or a mix (brackish). Water moves between the places it is stored. Water moves at large scales and at very small scales. Water moves naturally and because of human actions. Human water use affects where water is stored, how it moves, and how clean it is.

**Pools** store water. 96% of all water is stored in **oceans** and is saline. On land, saline water is stored in **saline lakes**. Fresh water is stored in liquid form in **freshwater lakes**, artificial **reservoirs**, **rivers**, and **wetlands**. Water is stored in solid, frozen form in **ice sheets** and **glaciers**, and in **snowpack** at high elevations or near the Earth's poles. Water vapor is a gas and is stored as **atmospheric moisture** over the ocean and land. In the soil, frozen water is stored as **permafrost** and liquid water is stored as **soil moisture.** Deeper below ground, liquid water is stored as **groundwater** in aquifers, within cracks and pores in the rock.

**Fluxes** move water between pools. As it moves, water can change form between liquid, solid, and gas. **Circulation** mixes water in the oceans and transports water vapor in the atmosphere. Water moves between the atmosphere and the surface through **evaporation**, **evapotranspiration**, and **precipitation**. Water moves across the surface through **snowmelt**, **runoff**, and **streamflow**. Water moves into the ground through infiltration and **groundwater recharge**. Underground, groundwater flows within aquifers. It can return to the surface through natural **groundwater discharge** into rivers, the ocean, and from **springs**.

We alter the water cycle. We redirect rivers. We build dams to store water. We drain water from wetlands for development. We use water from rivers, lakes, reservoirs, and groundwater aquifers. We use that water to supply our **homes** and **communities.** We use it for **agricultural** irrigation and **grazing** livestock. We use it in **industrial** activities like thermoelectric power generation, mining, and aquaculture. The amount of water that is available depends on how much water is in each pool (water quantity). It also depends on when and how fast water moves (water timing), how much water we use (water use), and how clean the water is (water quality).

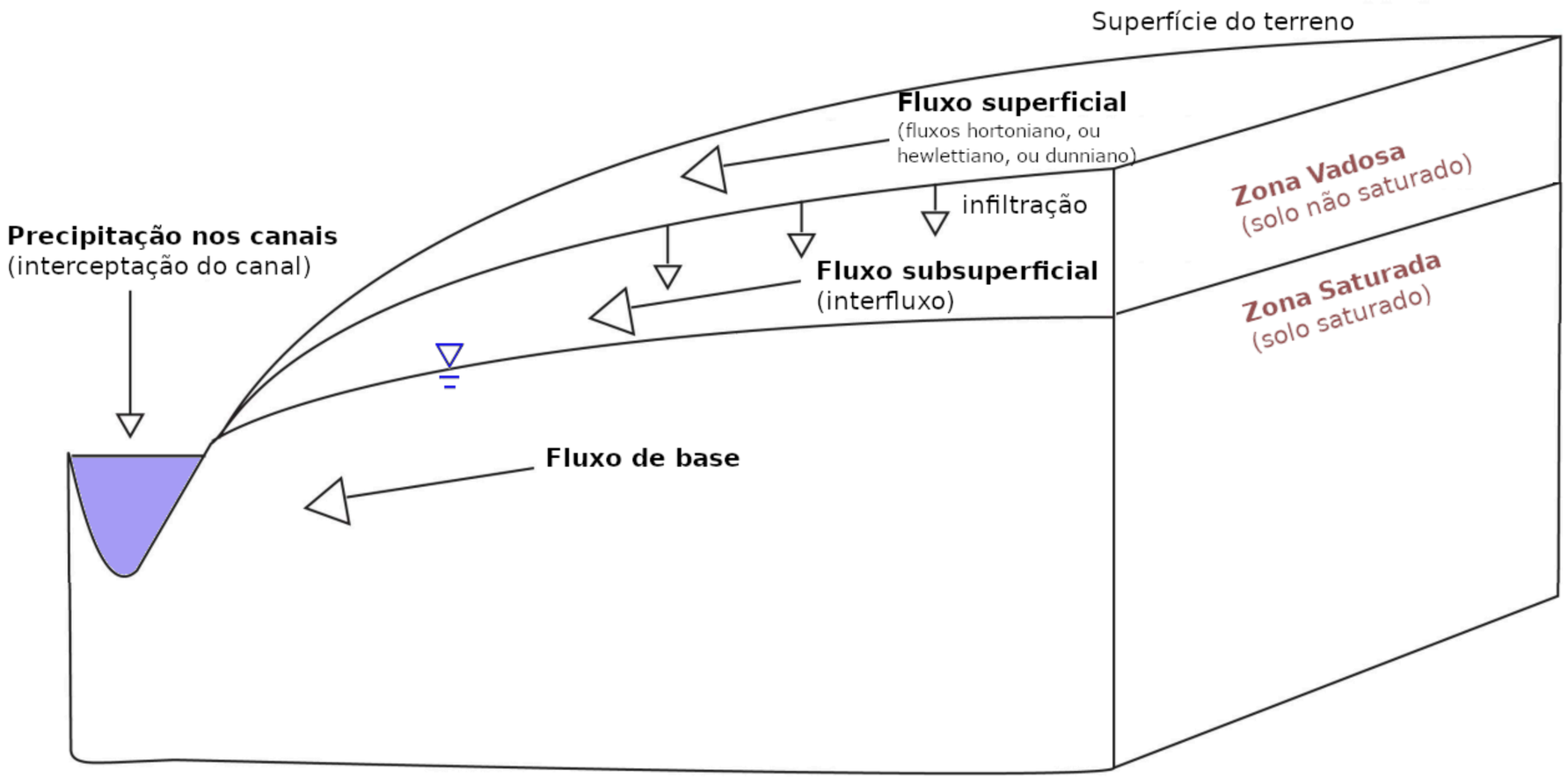
We affect **water quality.** In agricultural and urban areas, irrigation and precipitation wash fertilizers and pesticides into rivers and groundwater. Power plants and factories return heated and contaminated water to rivers. Runoff carries chemicals, sediment, and sewage into rivers and lakes. Downstream from these sources, contaminated water can cause harmful algal blooms, spread diseases, and harm habitats. **Climate change** is affecting the water cycle. It is affecting water quality, quantity, timing, and use. It is causing ocean acidification, sea level rise, and more extreme weather. By understanding these impacts, we can work toward using water sustainably.

**Runoff** is the flow of water across the earth, and is a major component in the hydrological cycle. Runoff that flows over land before reaching a watercourse is referred to as *surface runoff* or *overland flow*. Once in a watercourse, runoff is referred to as *streamflow*, *channel runoff*, or *river runoff*. *Urban runoff* is surface runoff created by urbanization.

# Águas superficiais

## Tipos de escoamento na escala da vertente

- Entrada de água nos canais ou rios:



# Fluxo superficial

## Tipos de fluxo superficial

Vários conceitos têm sido usados para descrever a geração de escoamento.

- **Horton (1933)** estabeleceu que o escoamento ocorre quando a intensidade da precipitação excede a taxa de infiltração de água no solo.

- **Hewlett e Hibbert (1967)** aprimoraram essa ideia ao incluir a umidade do solo como uma variável, pois o fluxo Hortoniano não leva em consideração o teor de água do solo antes da precipitação. Essa nova compreensão do escoamento é conhecida como fluxo Hewlettiano.

- **Dunne (1978)** refinou o conceito de geração de fluxo Hewlettiano, estabelecendo assim o fluxo de superfície Dunniano, que é gerado devido à saturação do solo superficial. Isso geralmente ocorre em áreas próximas a córregos, que evoluem com o tempo.

Fluxo Hortoniano

Saturação da superfície,
que pode levar ao fluxo Dunniano.

# How soil offers hope for the climate crisis

**A importância do solo e fatores que influenciam na sua erosão.**

**How soil offers hope for the climate crisis**

The Guardian

https://www.youtube.com/watch?v=BSHR4sUZpcw&ab_channel=TheGuardian

- 6 inches = 15,24 cm
- ploughing = arar o solo

# Tempo de empoçamento

**Artigo de motivação:**
**Evaluation of surface ponding and runoff generation in a seasonally frozen drained agricultural field**
Journal of Hydrology 2020

Do *abstract* do artigo:

- Surface runoff is often poorly quantified in hydrologic studies of subsurface drained fields, as it is a relatively minor component of the water balance and difficult to measure in large fields.
- However, conservation practices that seek to mitigate pollutant transport through subsurface drainage may increase surface runoff, and therefore it needs to be better understood.
- The goal of this study was to determine the frequency and extent of occurrence of surface ponding and runoff, and to understand their generation processes in a seasonally frozen, subsurface drained agricultural field in eastern Indiana.
- Results from both simulations and observations indicated that all of the ponding events in this location were generated by saturation excess rather than infiltration excess processes.

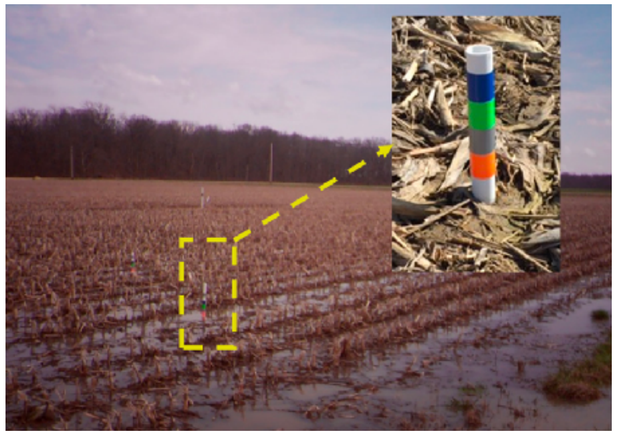
# Tempo de empoçamento

**Artigo de motivação:**
**Evaluation of surface ponding and runoff generation in a seasonally frozen drained agricultural field**
Saadat, et al. 2020
Journal of Hydrology

## Categorias de empoçamento
## (photo ponding classification)

Surface ponding categories and descriptions.

| Category | Description |
|---|---|
| 0 | No ponding |
| 1 | Minor ponding, water visible but not connected |
| 2 | Moderate ponding, water connected up to height of furrows |
| 3 | Major ponding, water connected across furrows |
| 4 | Extreme ponding continues to the edge of the field, water connected across the field |



Category 1


Category 2


Category 3


Category 4


**Fig. 5.** Photo ponding classification.

# Tempo de empoçamento

## Definição

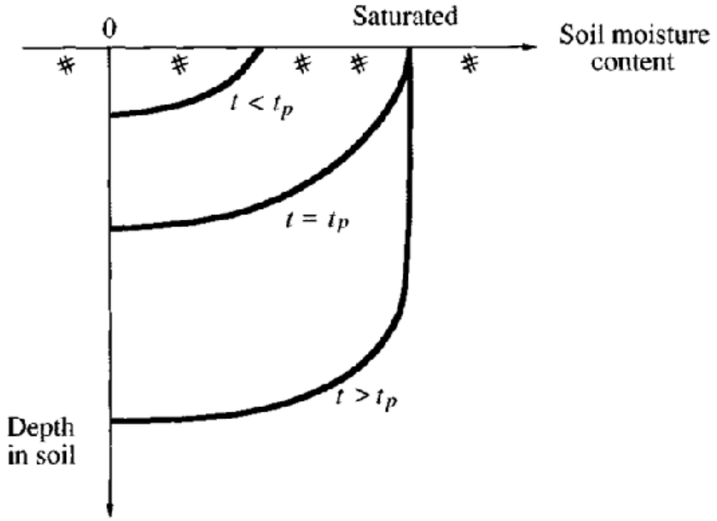
Empoçamento ocorre se:

- **Taxa de precipitação (i) > capacidade de infiltração (C.I.) do solo**

**Tempo de empoçamento:** $t_p$ (do inglês ponding time)

"é o tempo entre o início da precipitação e a formação de poças d'água na superfície"

Se a precipitação ocorre em solo seco:




$(t < t_p) \rightarrow i < C.I. \rightarrow$ (só ocorre infiltração)

**superfície insaturada**

$(t = t_p) \rightarrow i = C.I. \rightarrow$ (início do empoçamento)

**superfície saturada**

$(t > t_p) \rightarrow i > C.I. \rightarrow$ zona saturada se extende p/ profundidade maior

**Escoamento superficial pode ocorrer**

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