A to Z
Water Movement in Soils

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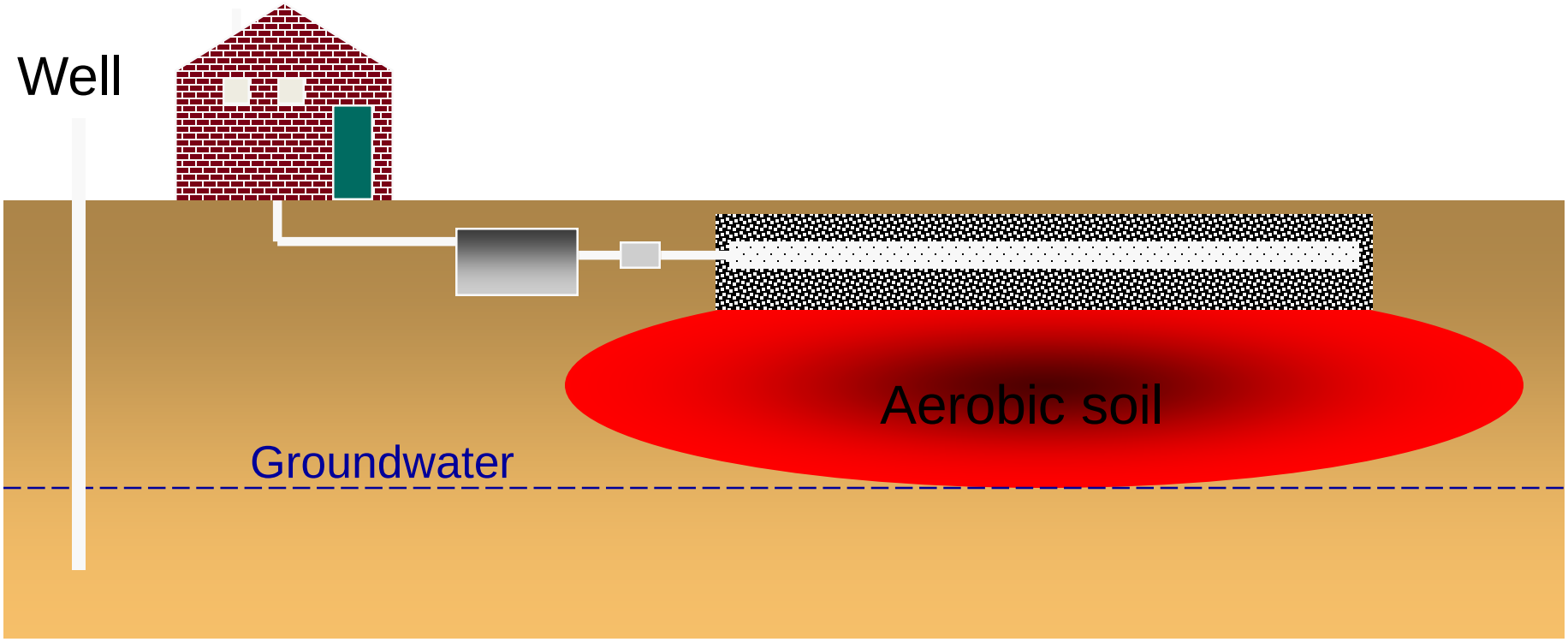
2019 Northeast Onsite Wastewater Short Course

April 3, 2019

Ideal Soil for Dispersal and Treatment of Wastewater

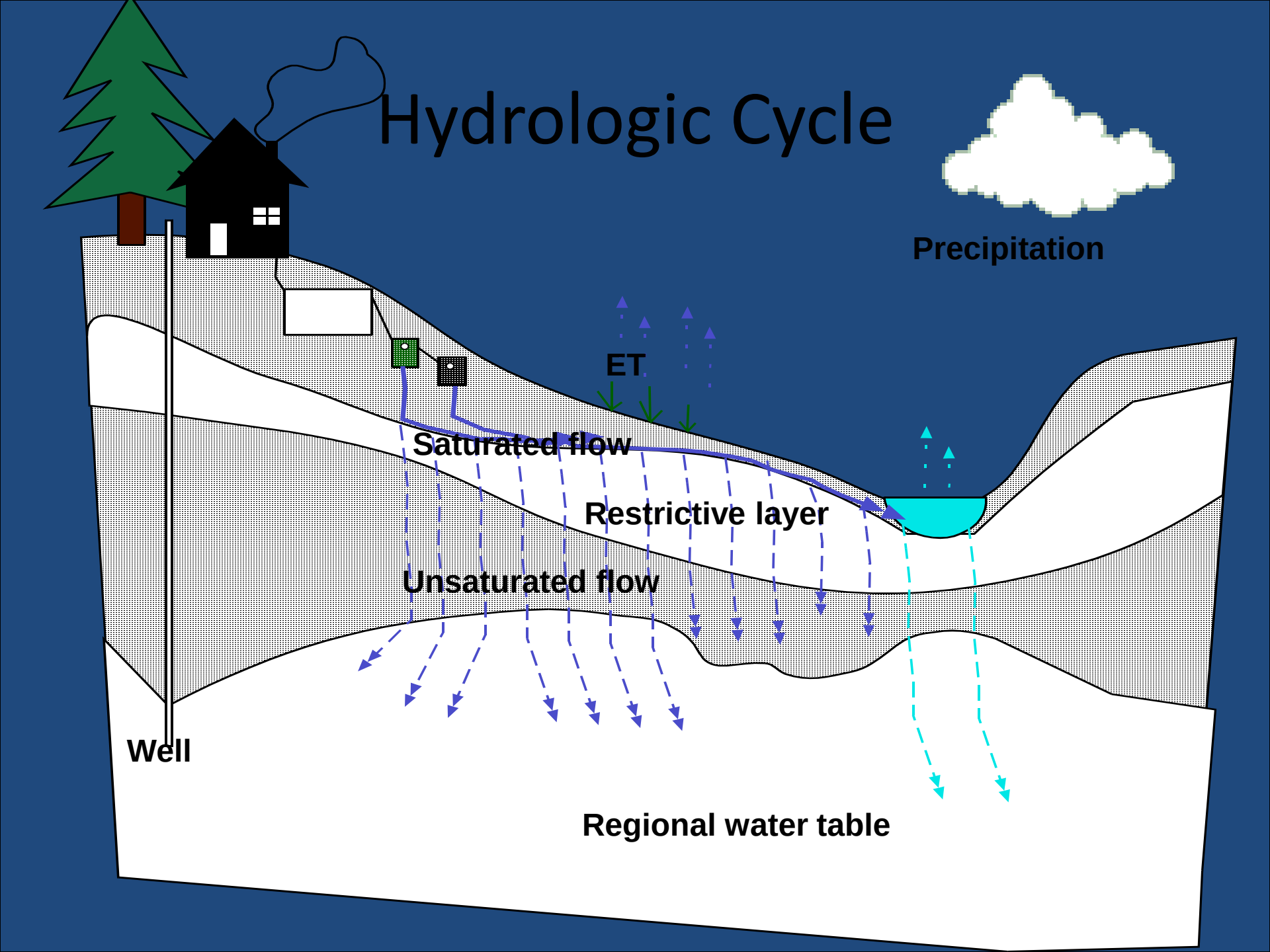
- Deep
- Permeable
- Well Drained (Well Aerated)
- Loamy
- Ample Area

Aerobic zone

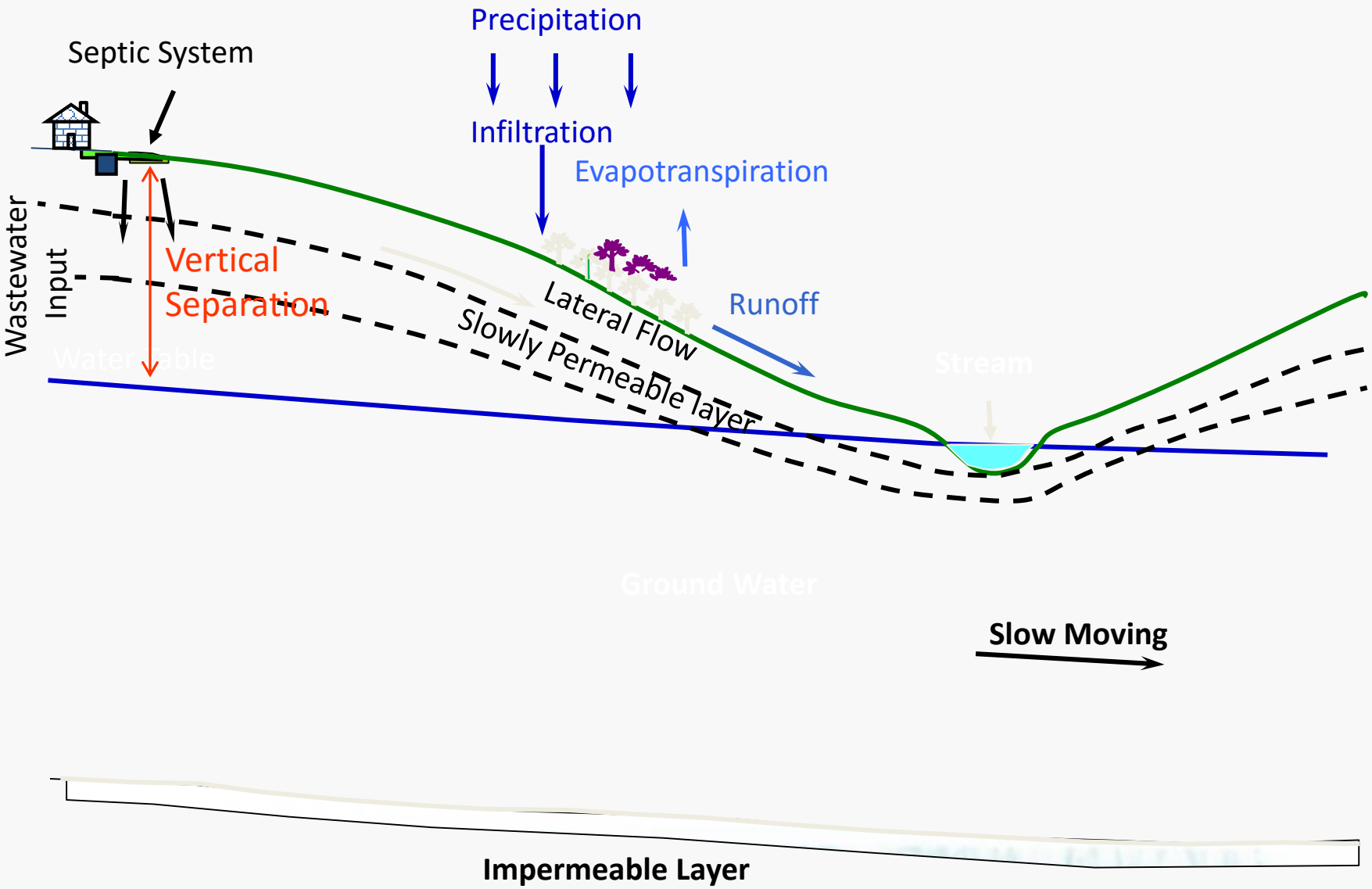


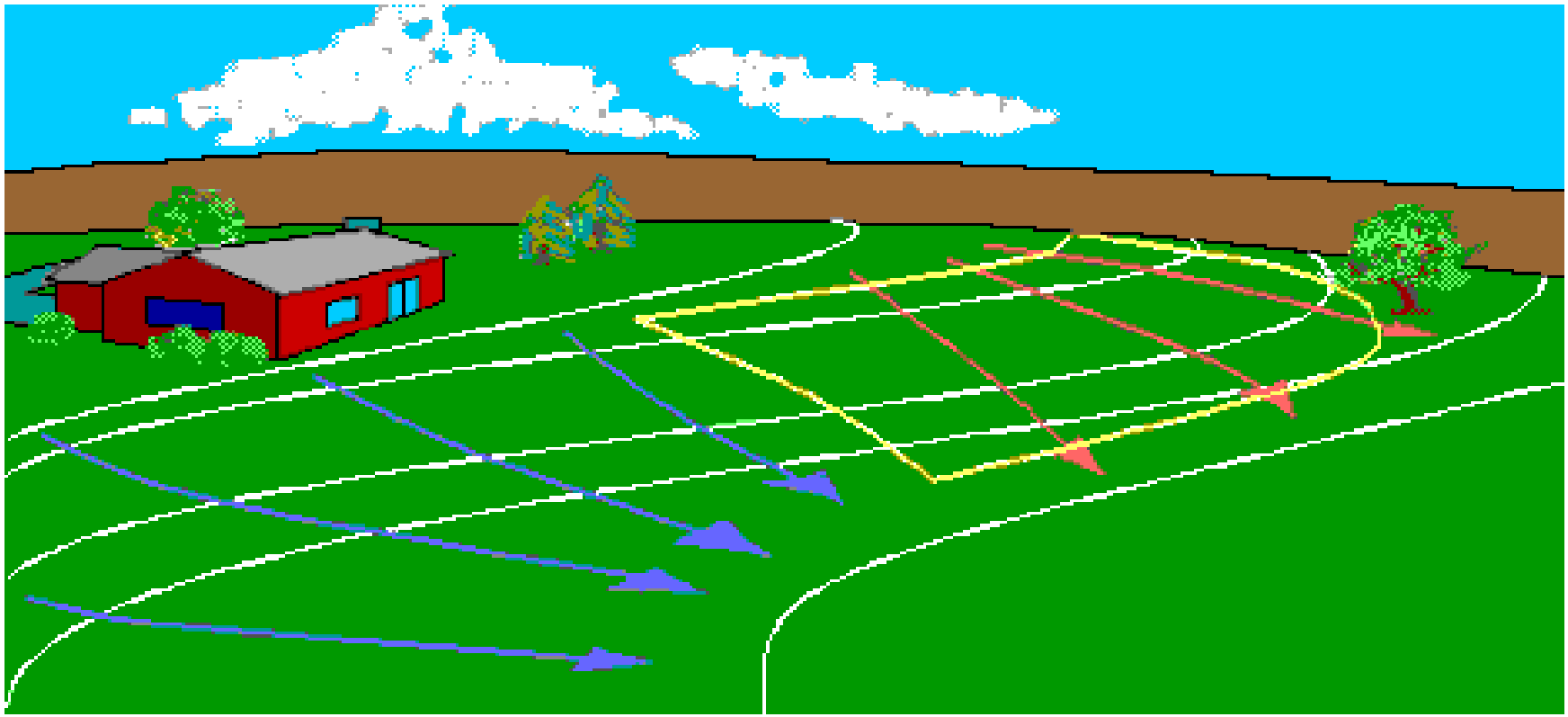
Many Soils Possess Drainage Restrictions

- Redoximophic Features
- Mottles
- Landscape Position
- Location within the Watershed


Hydrologic Cycle
Precipitation
ET
Saturated flow
Restrictive layer
Unsaturated flow
Well
Regional water table

Hydrologic Cycle





- The best location for an absorption field on the site is where flow will diverge (note the red flow lines). Areas where water naturally converges (note blue flow lines) should be avoided.

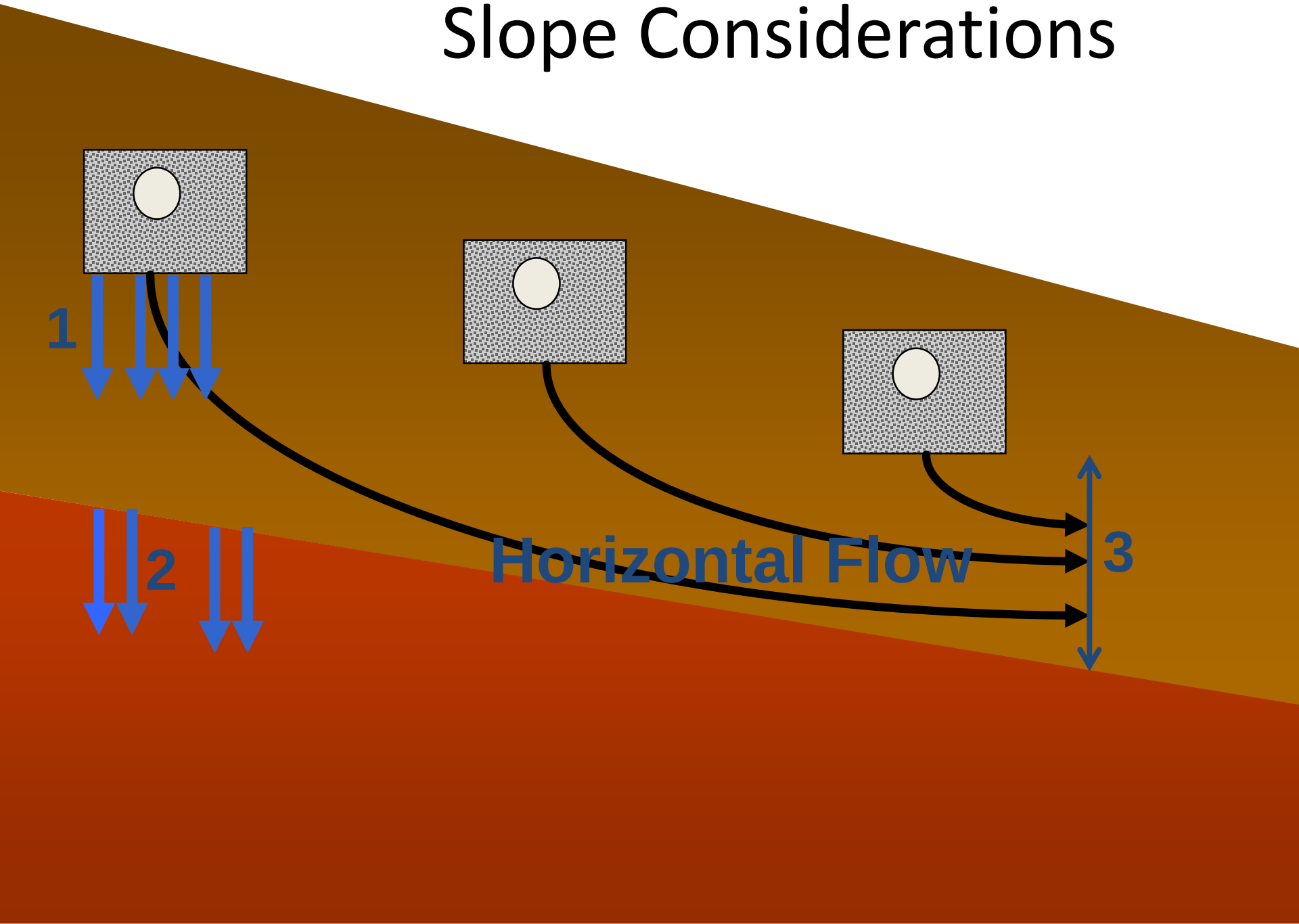
Water Tables

- Apparent: Ground Water Table
- Perched: Laying on top of (“perched”) a horizon or zone which is not saturated. With the lack of vertical movement, there may be a significant lateral flow vertor.

Apparent Water Table

Perched Water Table

Slope Considerations



To Better Understand Management of Water One Must Understand how Water Moves in Soils

- Saturated Flow: All pores are filled with water; gravity moves much of the water
- Unsaturated Flow: Movement by capillarity or matric potential; the attraction of water to soil surfaces and pore walls.
- In unsaturated flow that material with the greatest surface area has the largest affinity to water.

In Other Words:

- Sands and Gravels do NOT attract or pull water when surrounded or embedded within soil materials!
- Sands and Gravels do NOT suck

In other words, gravel at the bottom of a vented flower pot will NOT drain the pot!

Therefore, gravel around a drain tile below soil fill will NOT drain the soil!

Unsaturated vs. Saturated flow

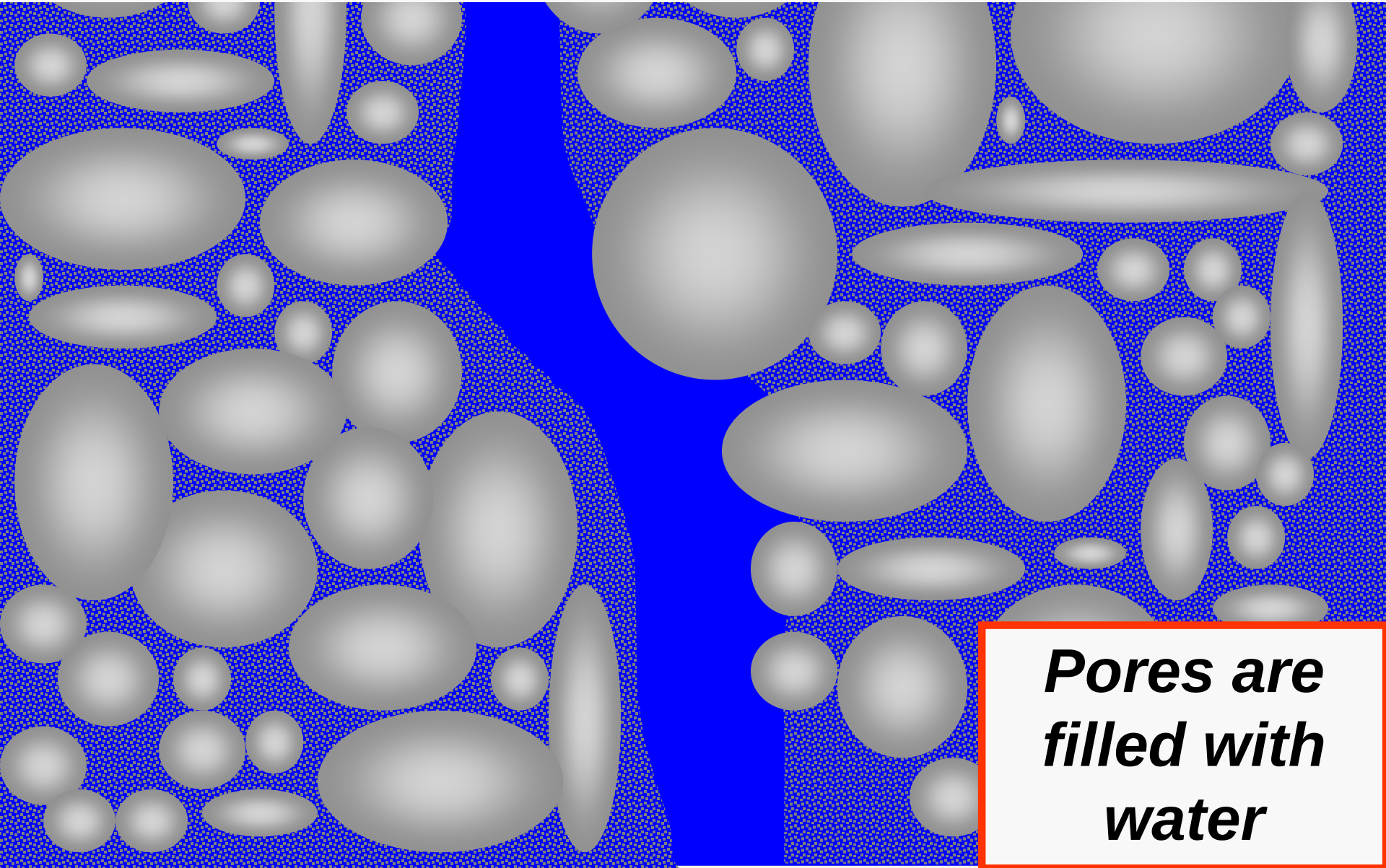
Unsaturated

- Pores: Air available
- Slower:
  Next to particles: in small pores
- Aerobic

Saturated

- Pores: Volume filled with water
- Faster:
  In large pores
- Non aerobic

Saturated Conditions



What is Saturation

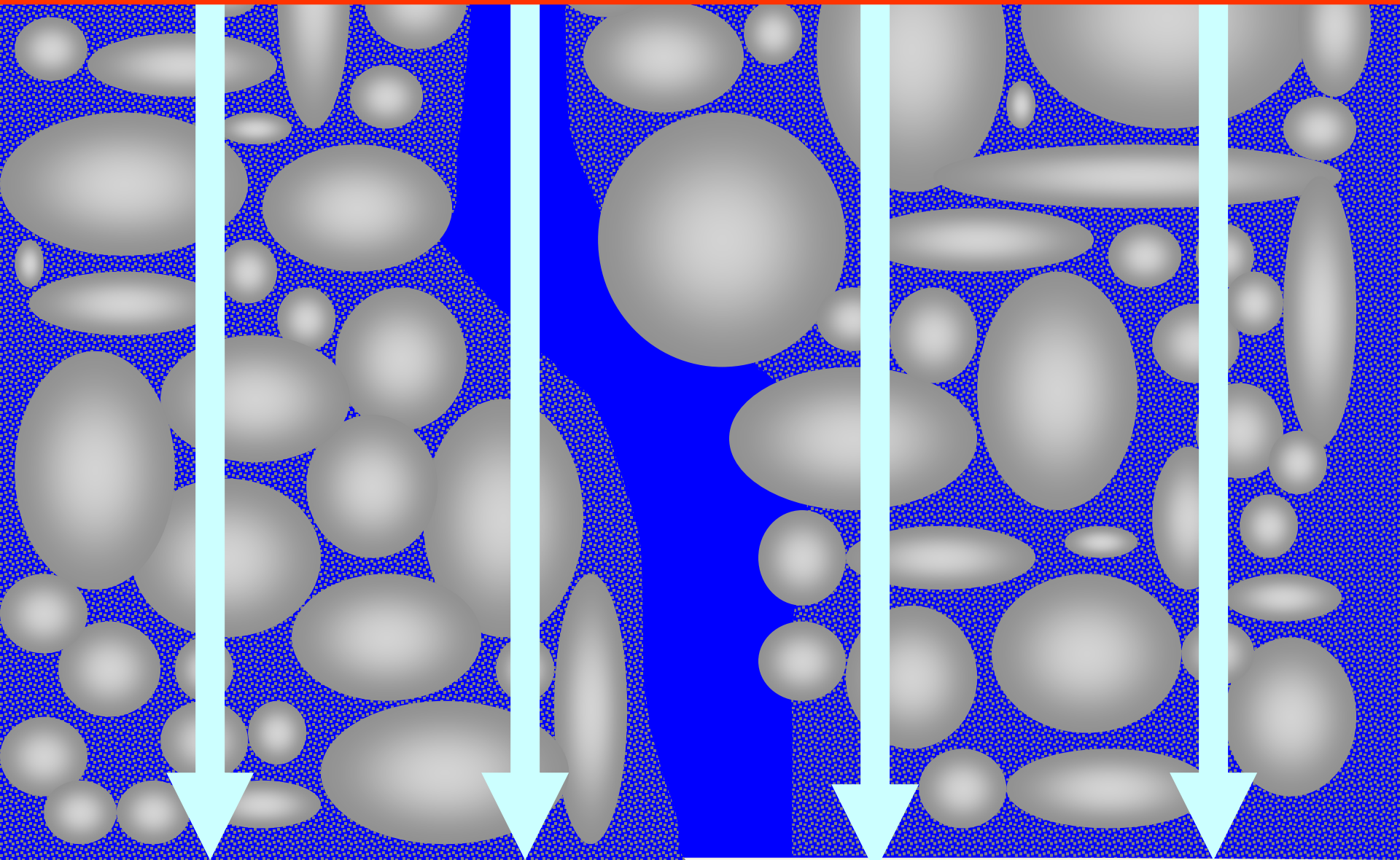
- A horizon is saturated when the soil water pressure is zero or positive

In layman's terms

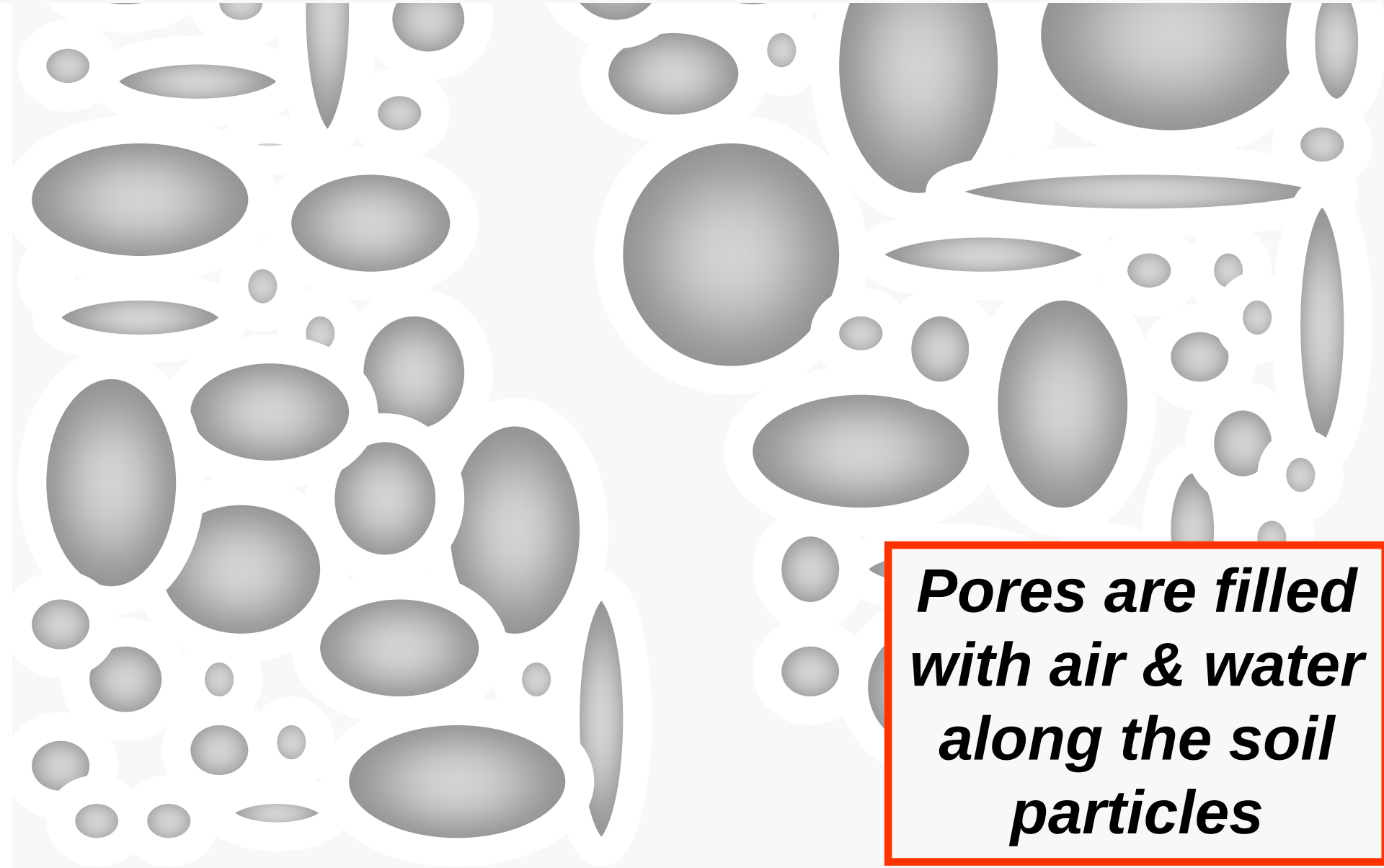
- Water flows from the soil into a hole

Auger hole in soil is filled with air just after digging

Free water is not under a suction, and flows in response to gravity.



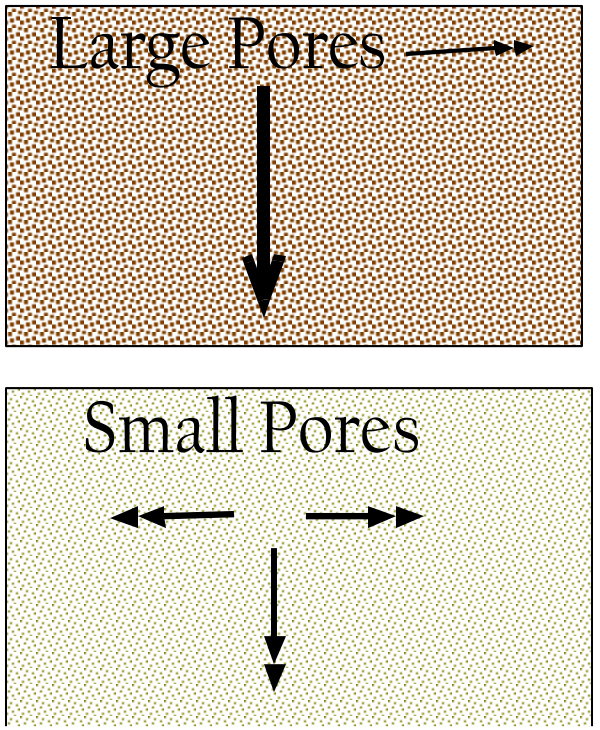
Unsaturated Conditions



Pores are filled with air & water along the soil particles

Pore size & unsaturated flow

- Large pores water will moved predominantly by gravity
- Small pores water will move in all directions better & further



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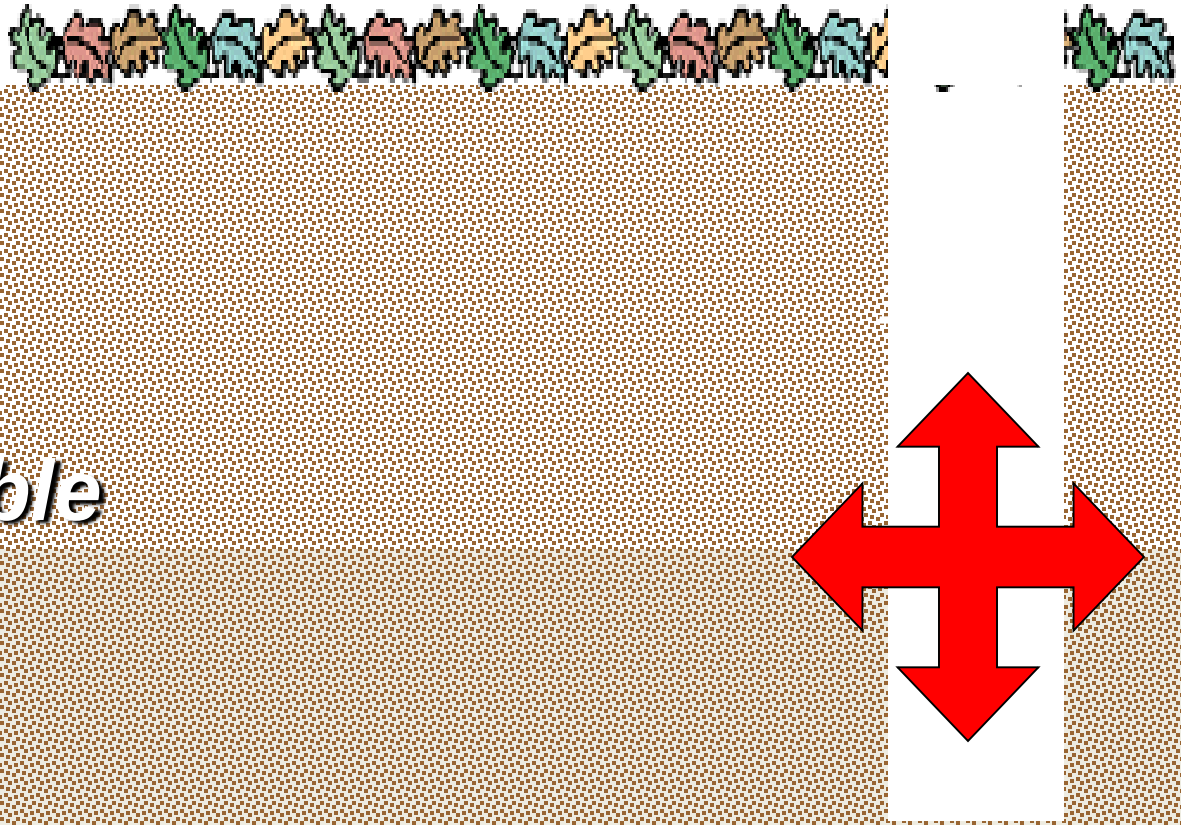


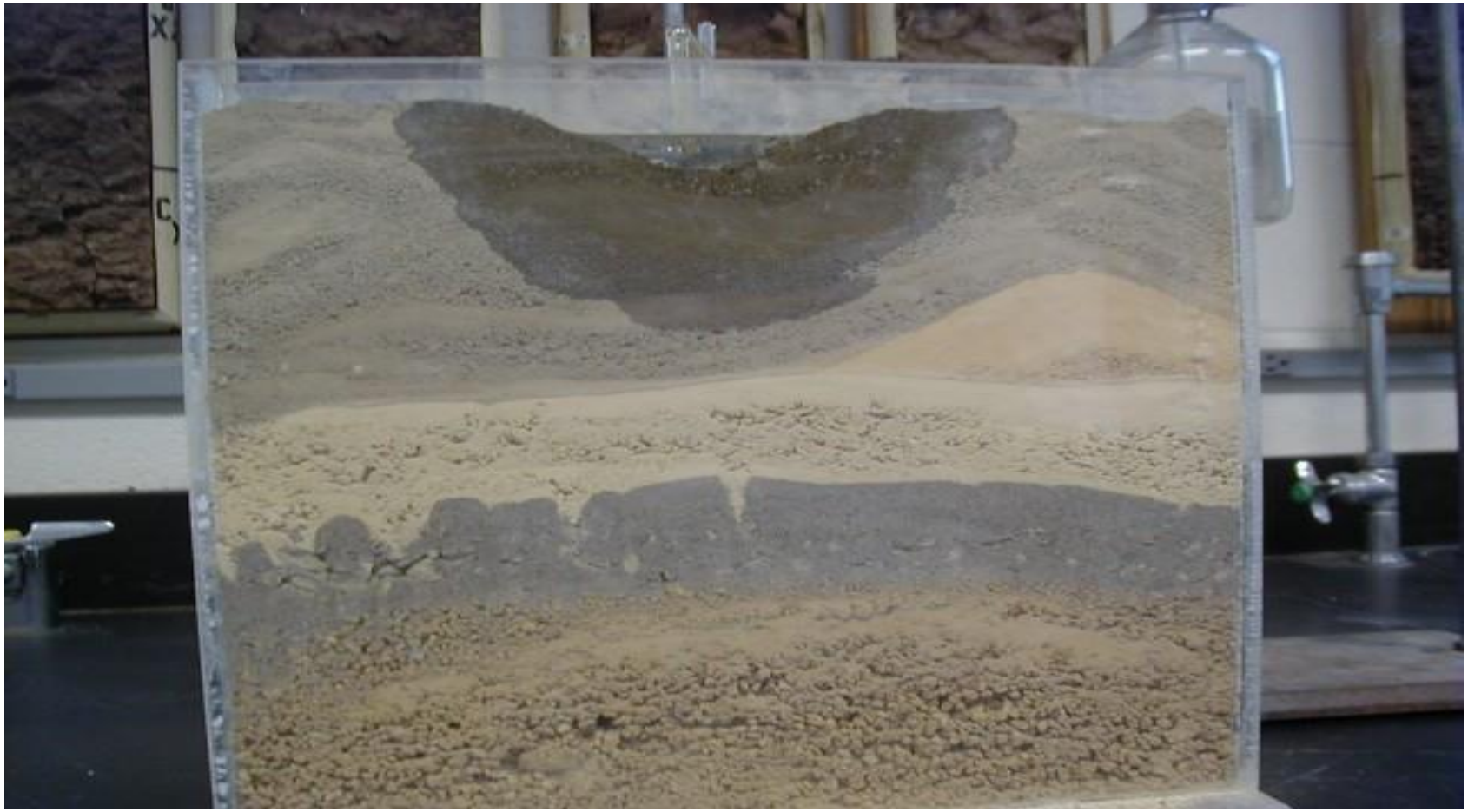
Water table

Water Movement in Soil Movie

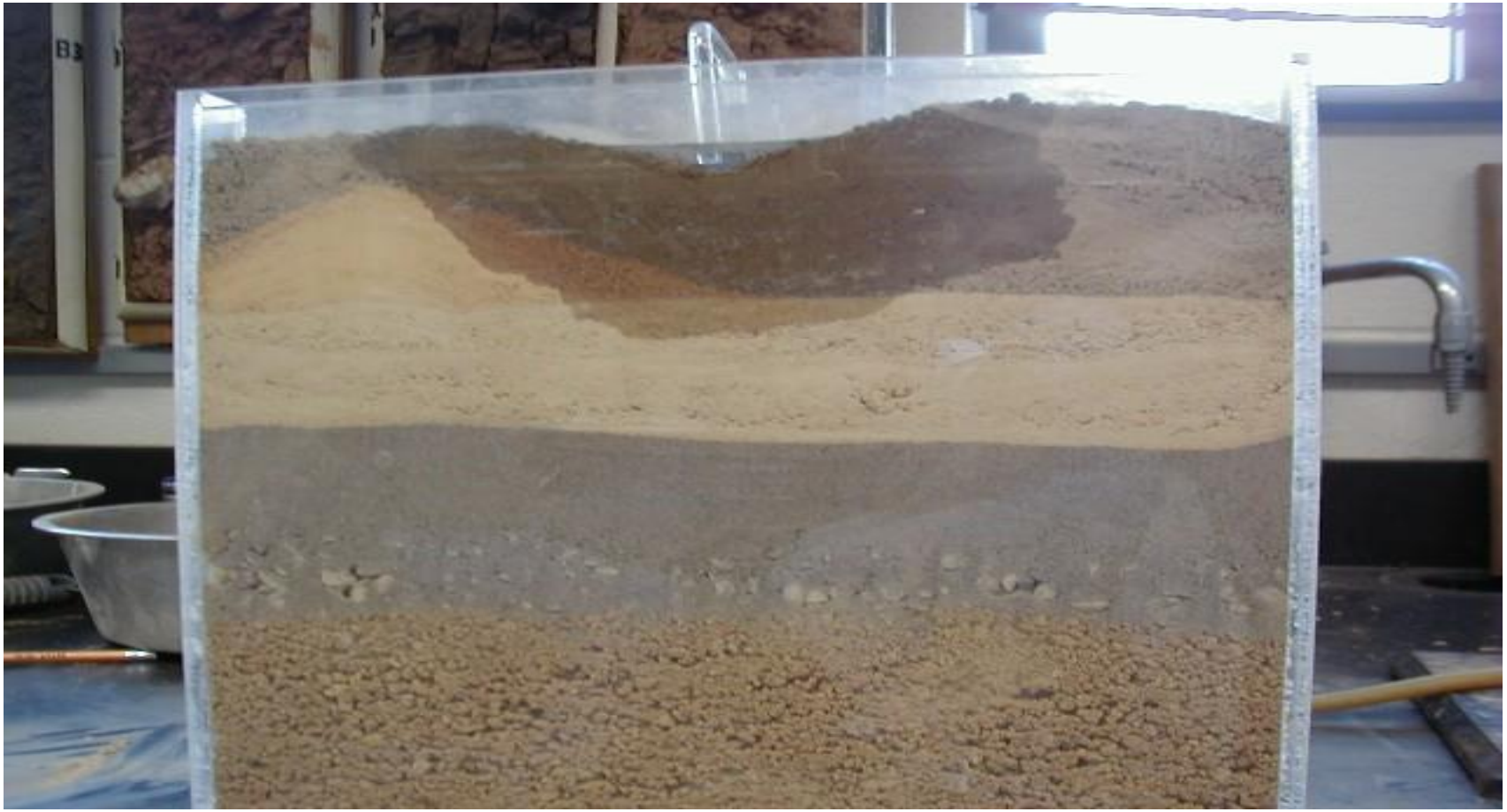
- Loamy A Horizon
- Loamy B Horizon
- Coarse Sand B Horizon
- Loamy B Horizon

Initial Wetting Front

Further Movement of the Wetting Front

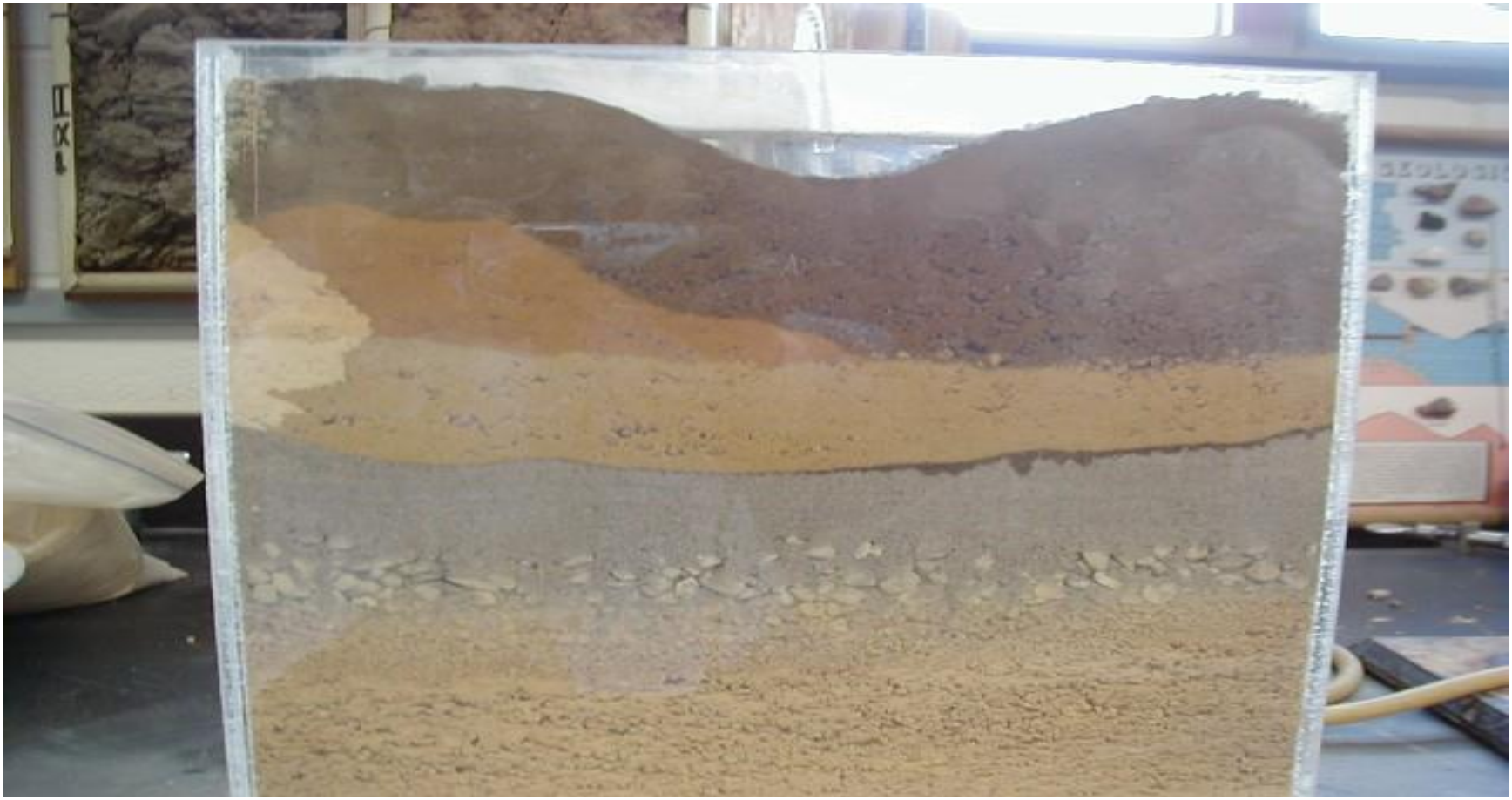


Initial Wetting Front



Wetting Front Hits Course Sand

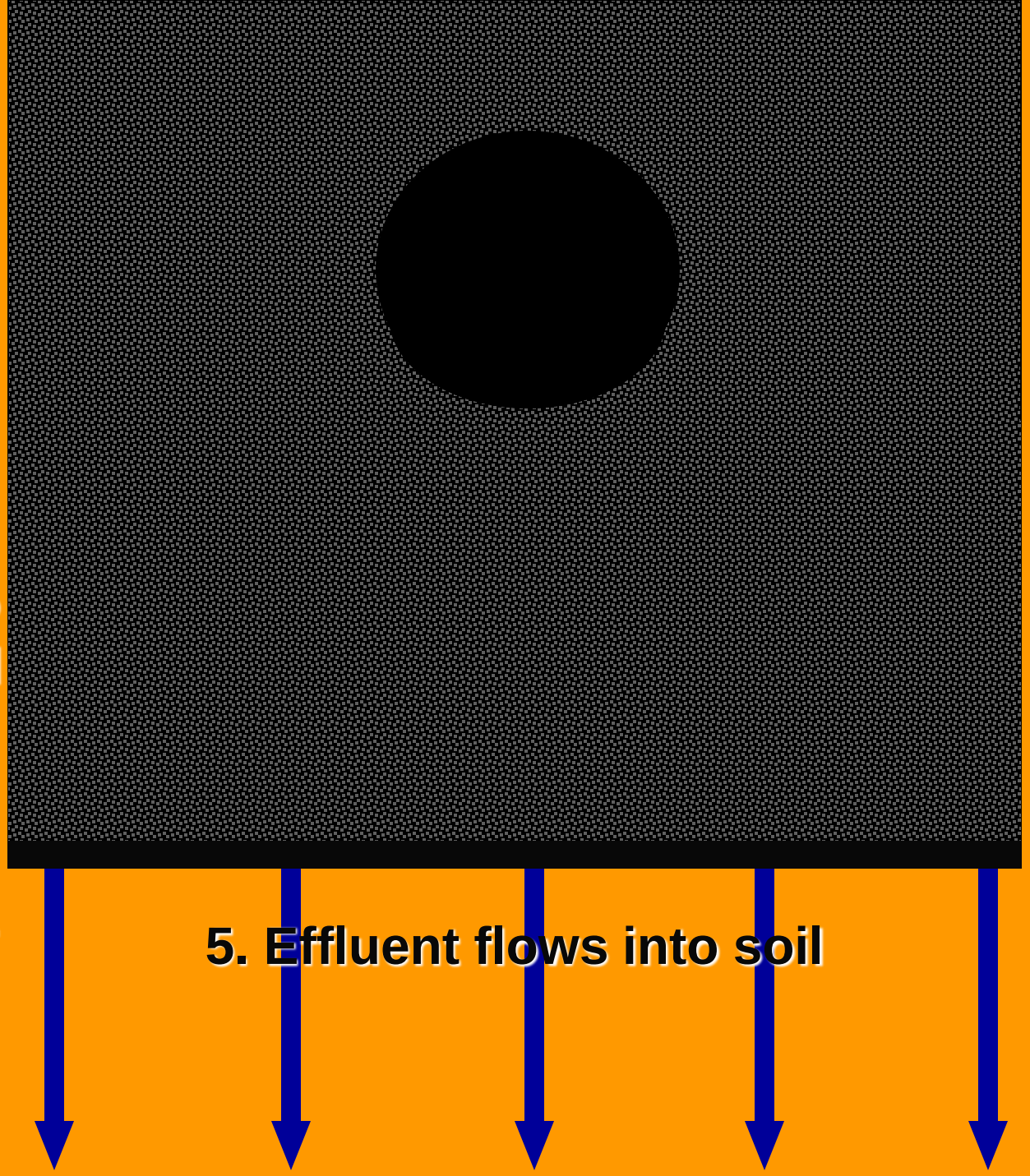
Wetting Front Stacks Up Above Boundary



Water Breaks Course Sand Boundary

Trench Flow Examples

1. Effluent flows into pipe

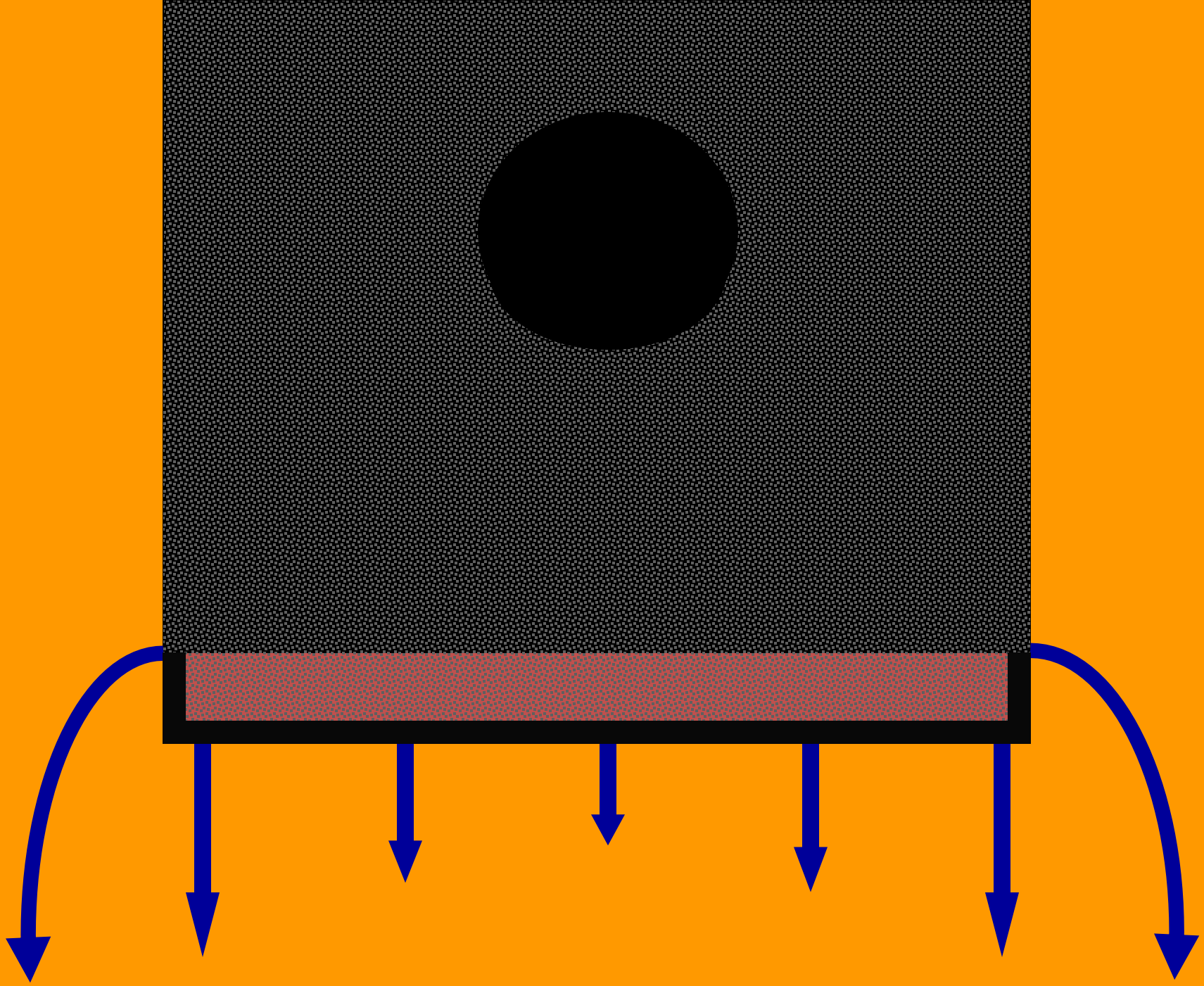


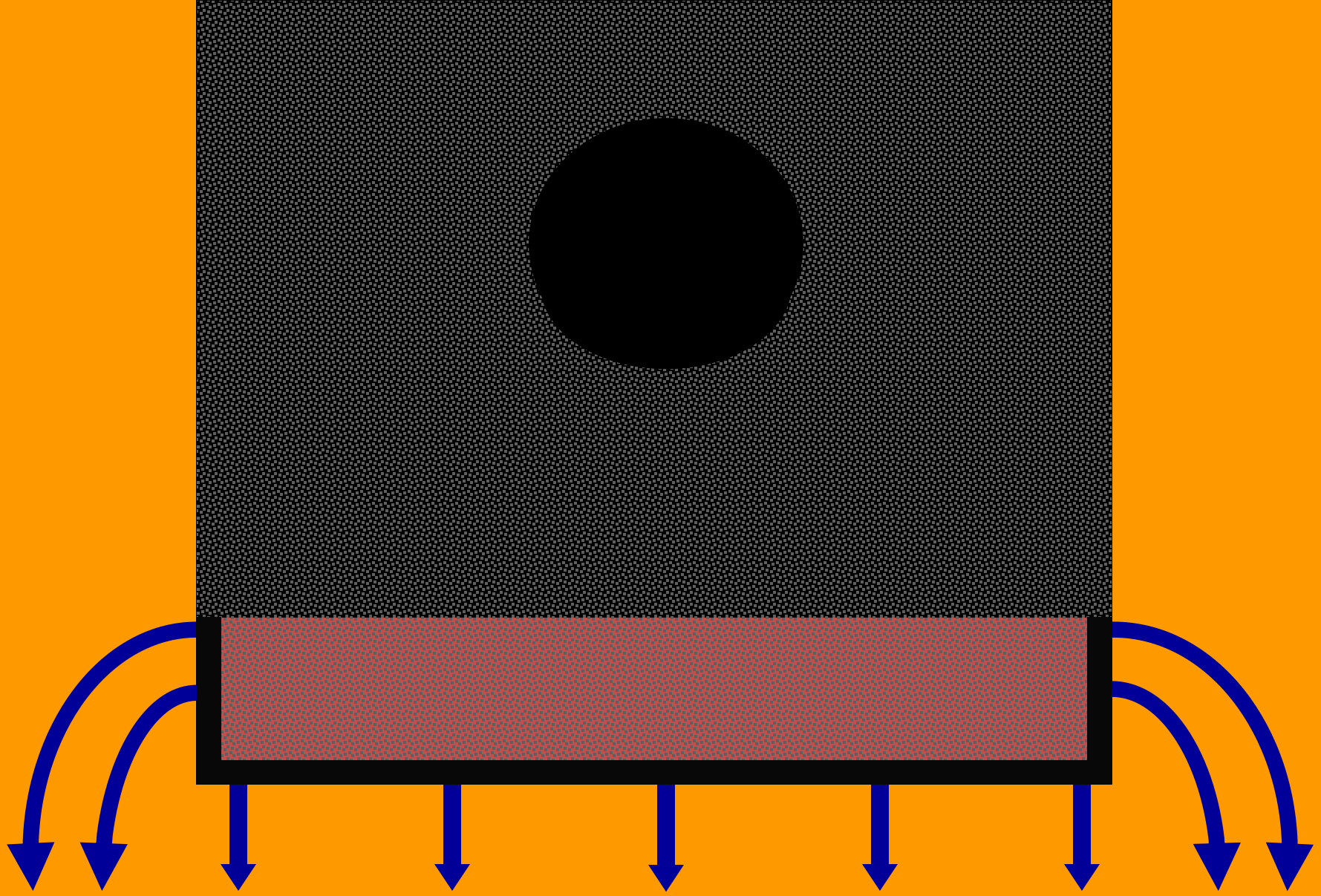
2. Effluent flows out of pipe and into gravel

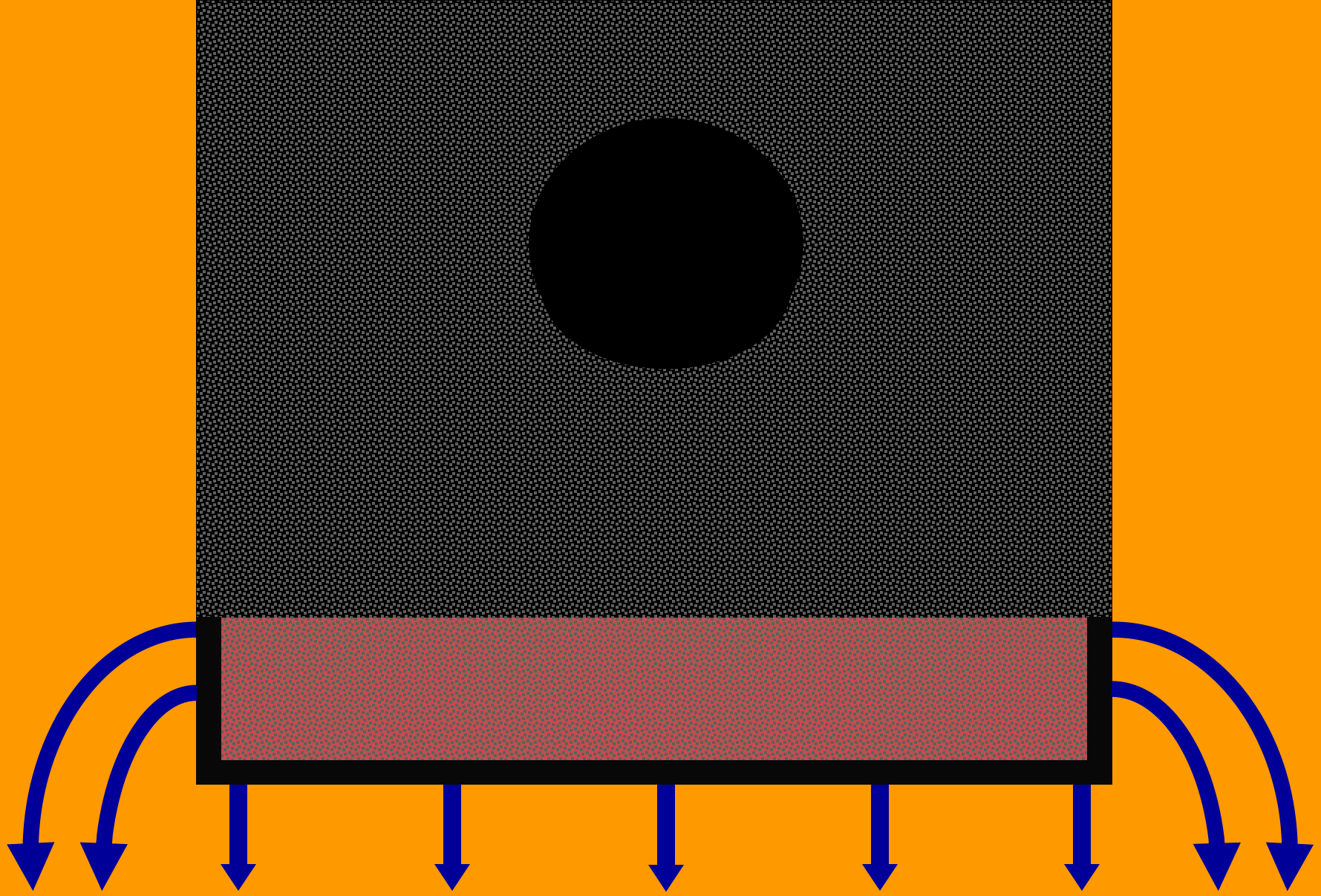
3. Effluent begins to pond and flows across soil interface.

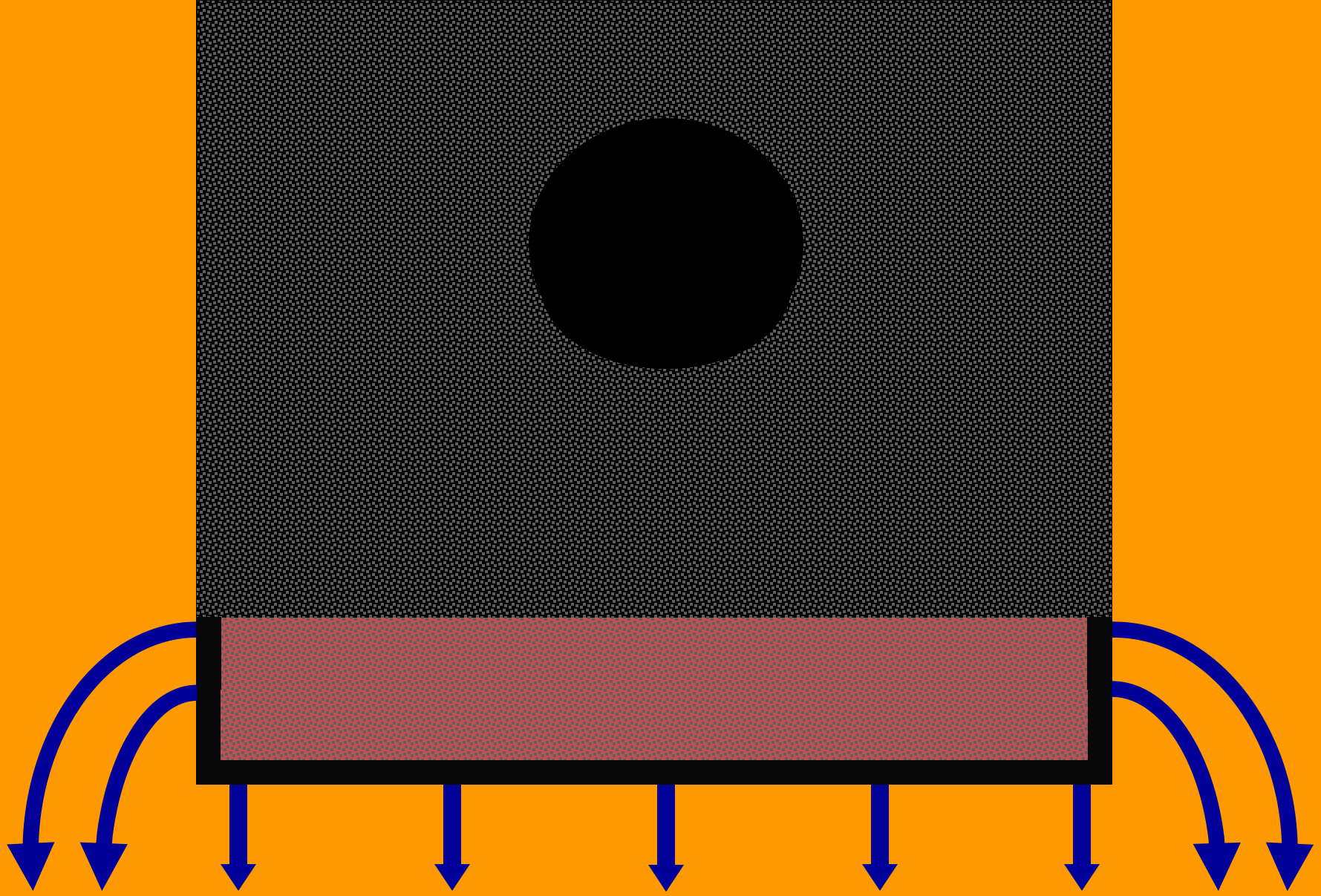
4. Biomat begins to form

5. Effluent flows into soil









NOT TO SCALE

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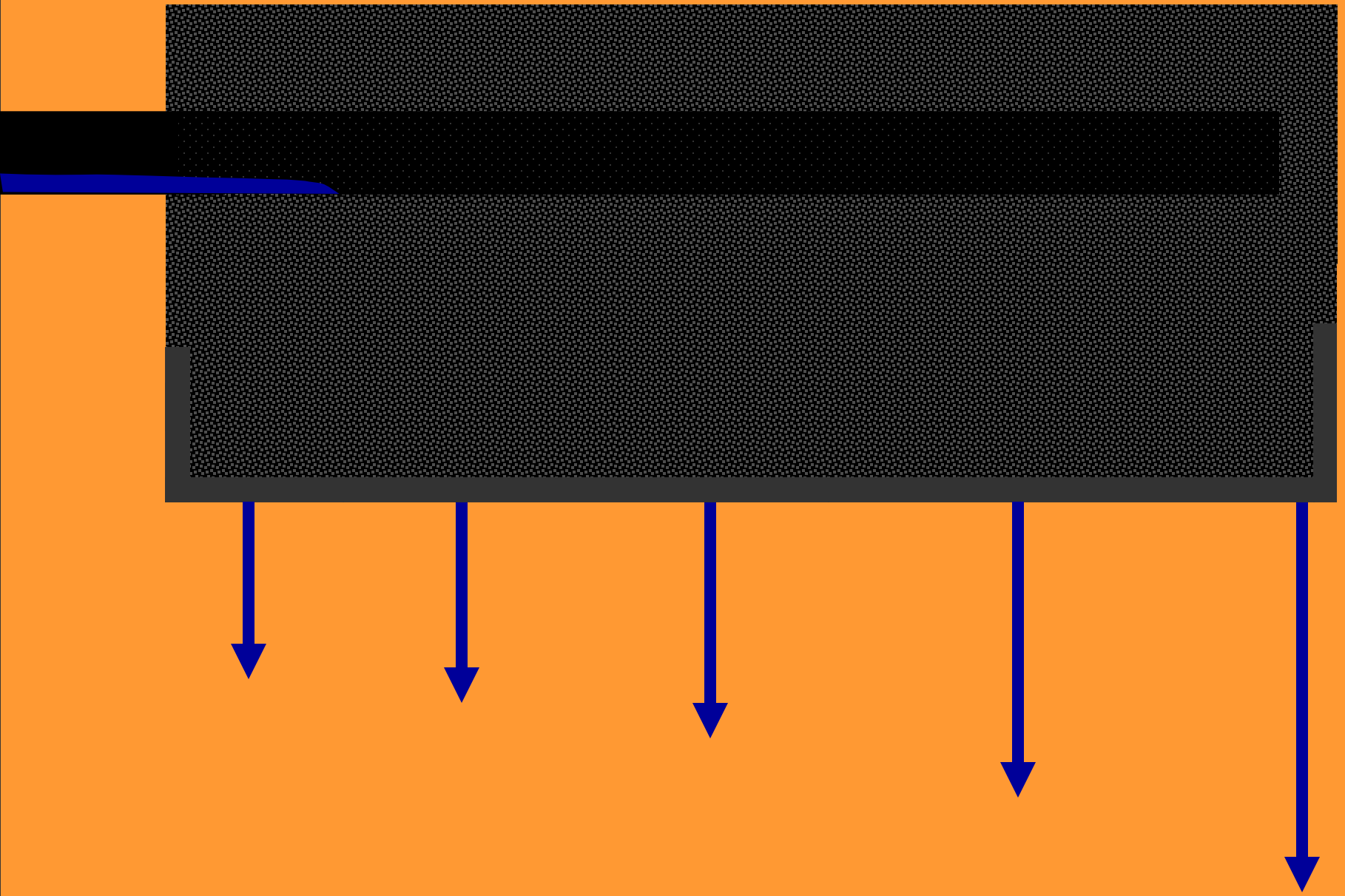

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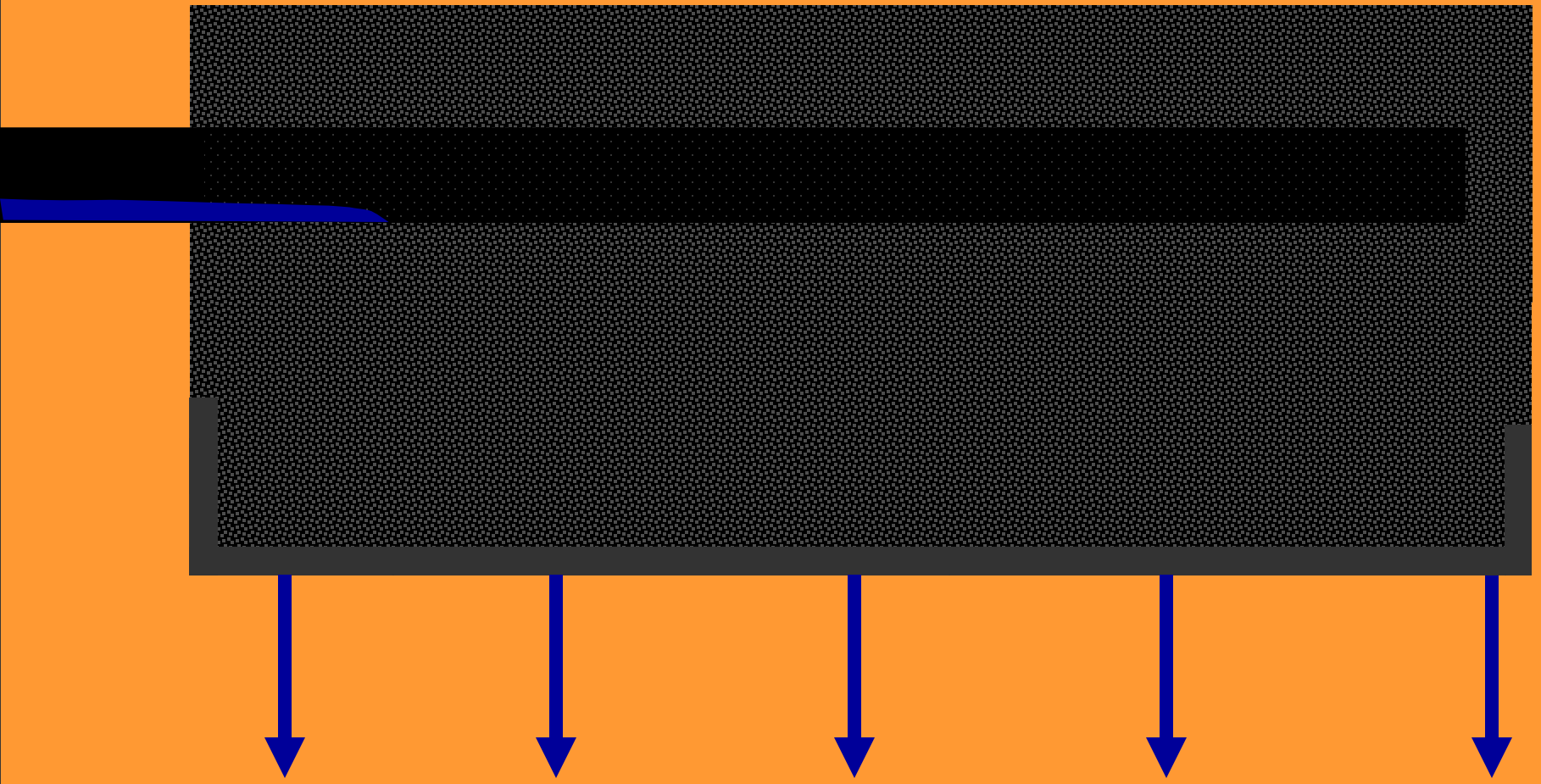

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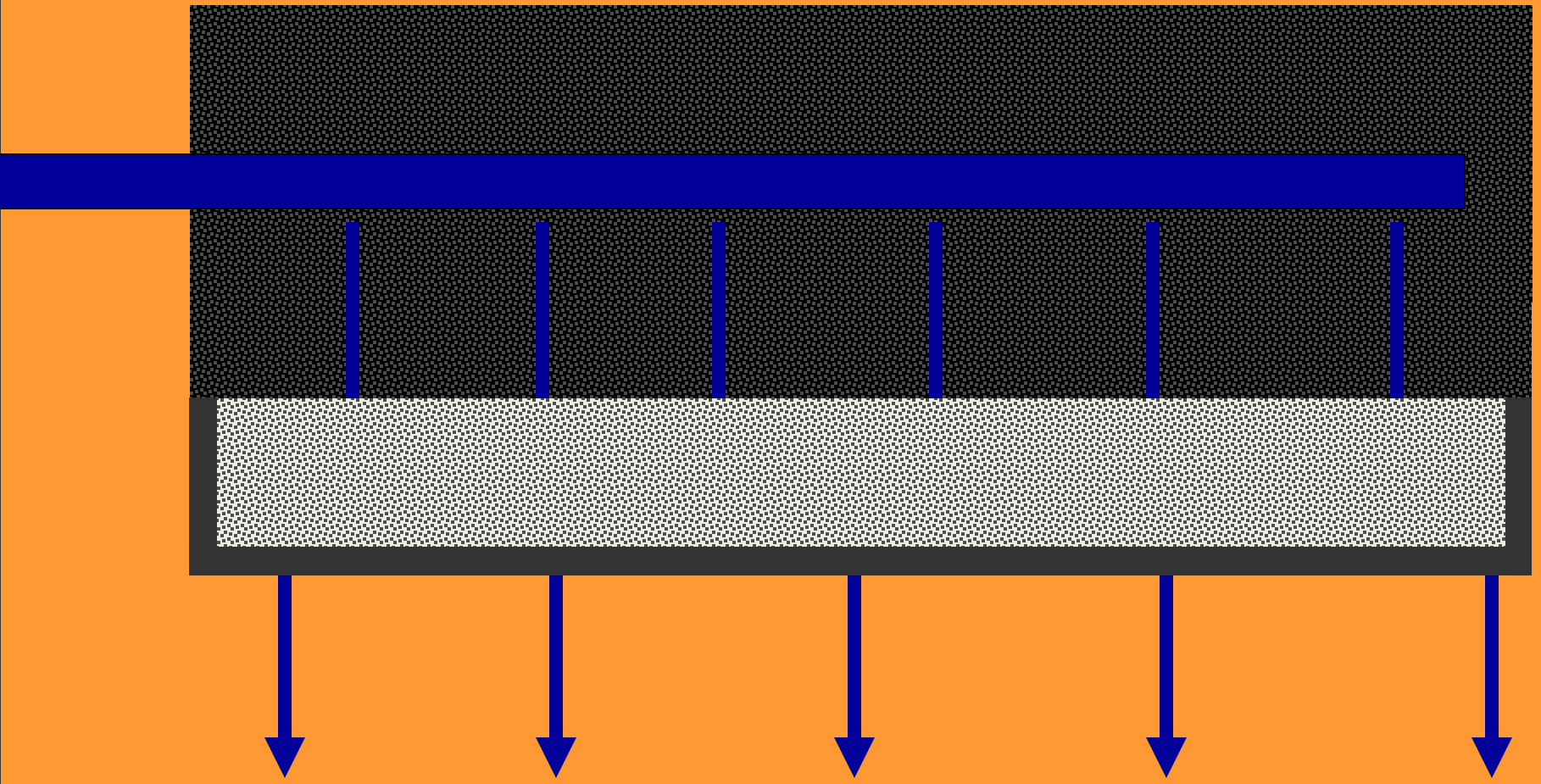

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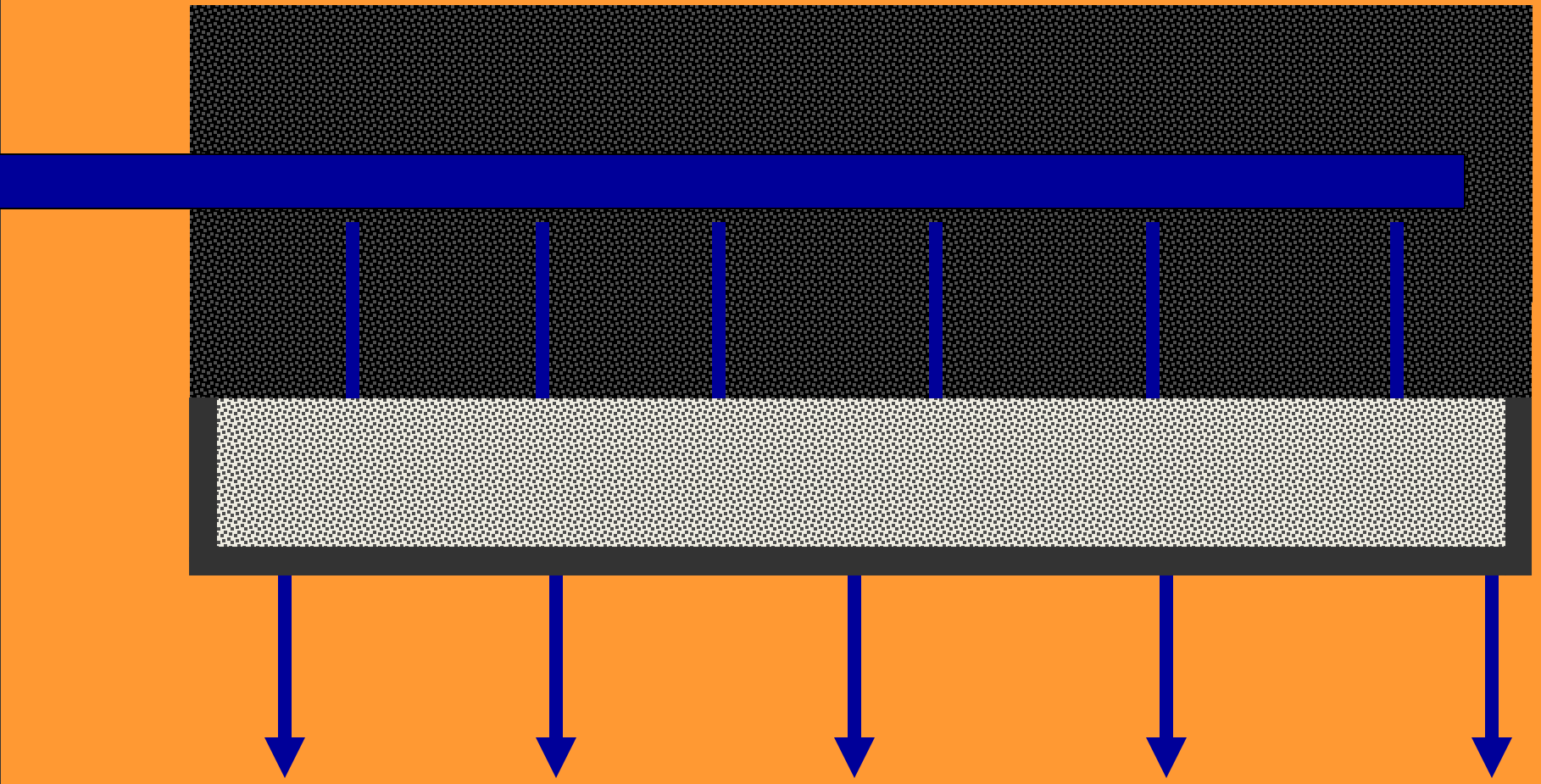


NOT TO SCALE

Drip Distribution

Conical Distribution Pattern under Unsaturated Flow

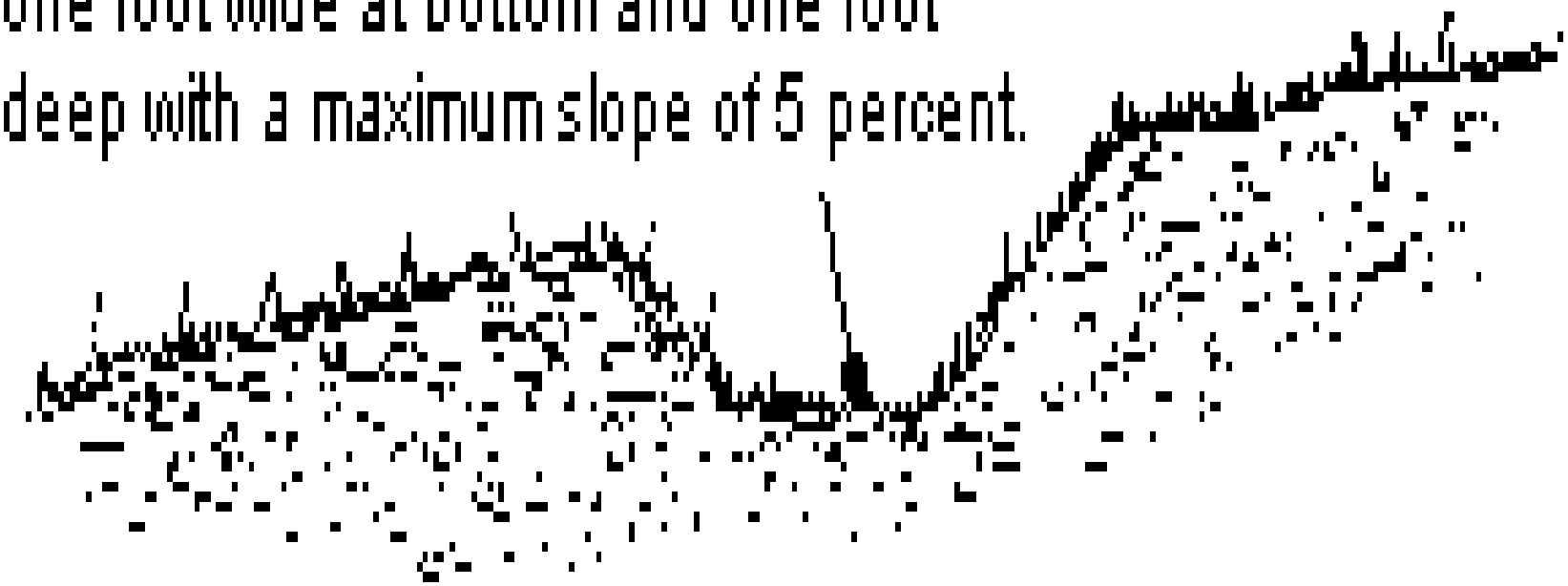
Surface Water Management

Use of Swales, Berms, Surface Diversions, Terraces, etc.


Poor storm water management

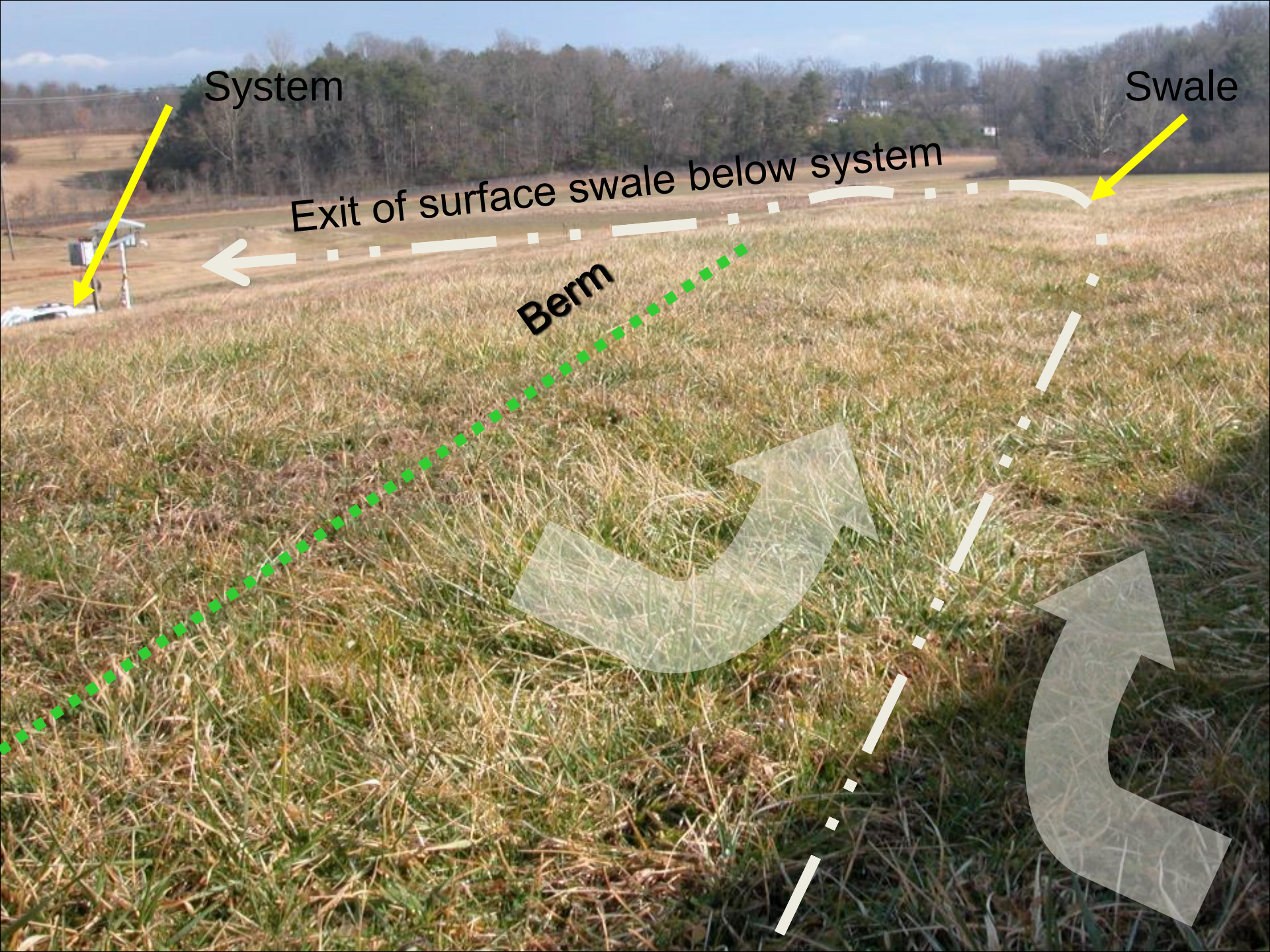
Swale for Surface Water Management

Grass-lined swale should be a minimum one foot wide at bottom and one foot deep with a maximum slope of 5 percent.



Diversion berms and swales

- Required?
- Present and effective?

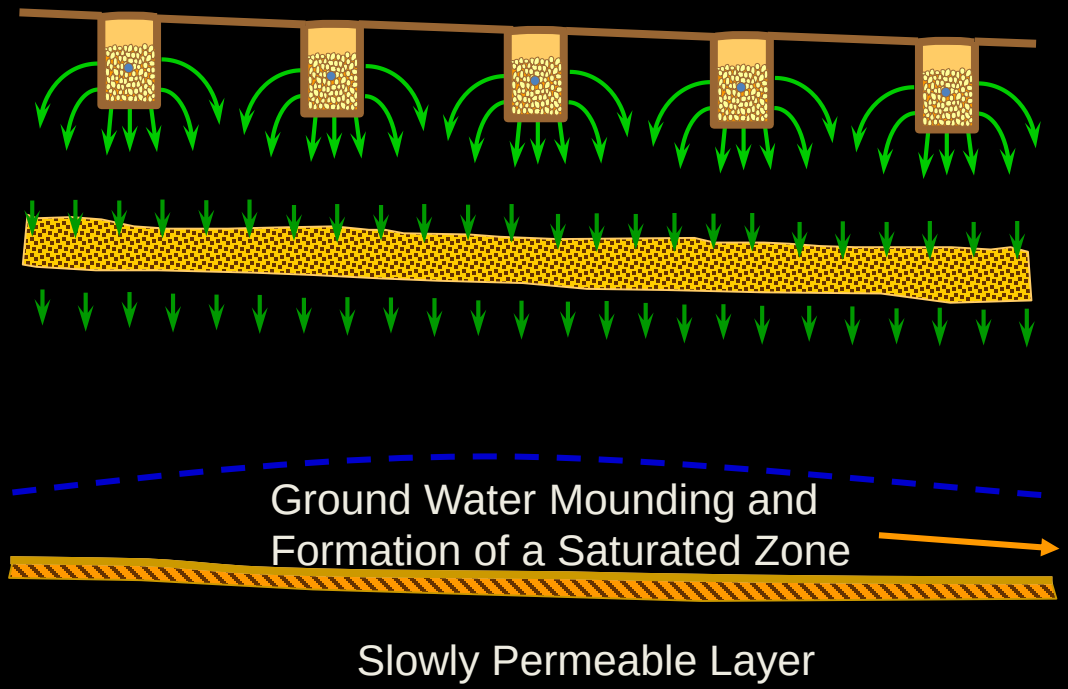

System
Swale
Exit of surface swale below system
Berm

HYDROLOGY OF A SEPTIC SYSTEM

Infiltration from Trenches

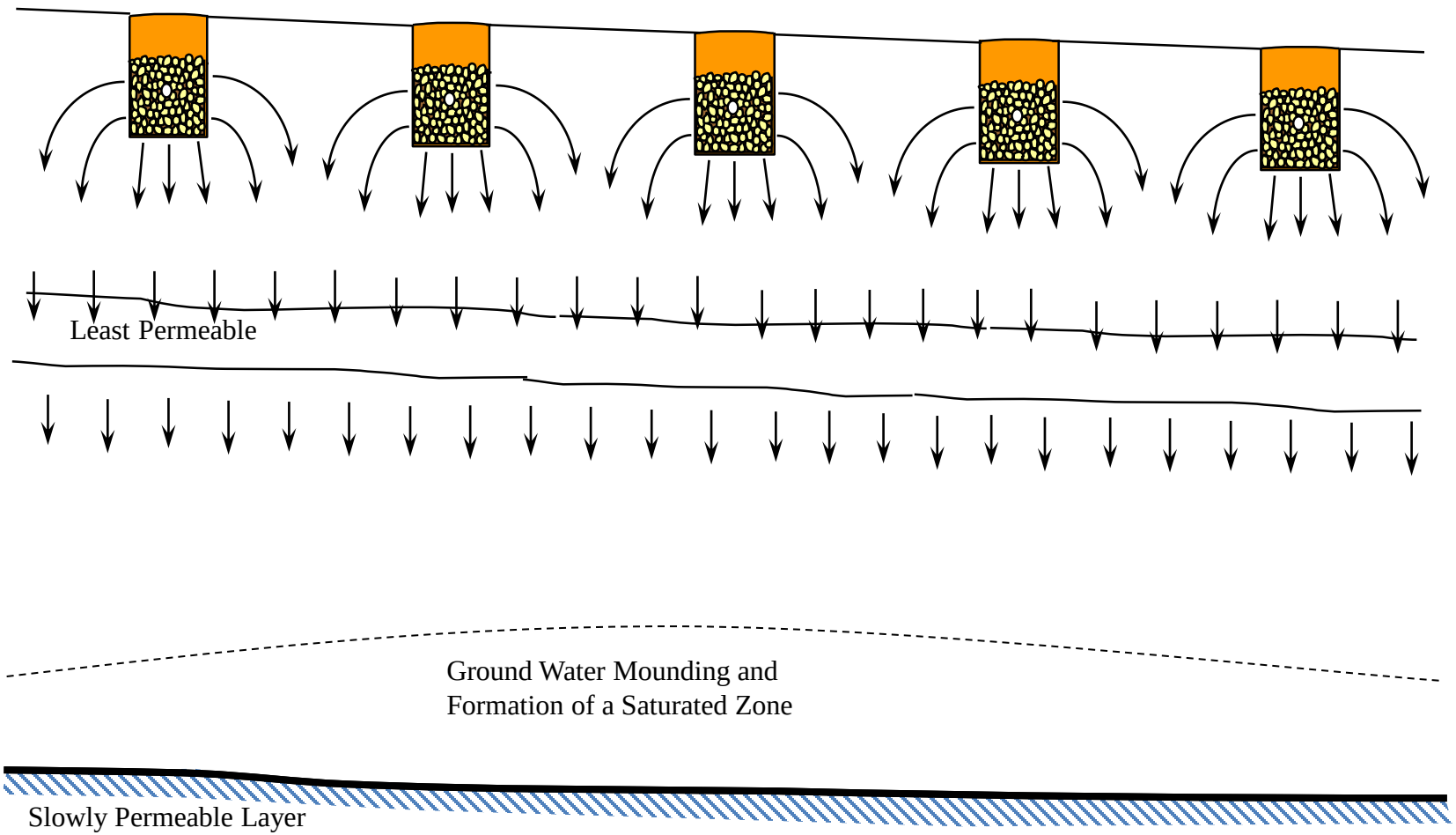
Vertical Movement through the Unsaturated Zone

Lateral Movement in the Saturated Zone



How does slope influence the hydrology of a septic system?

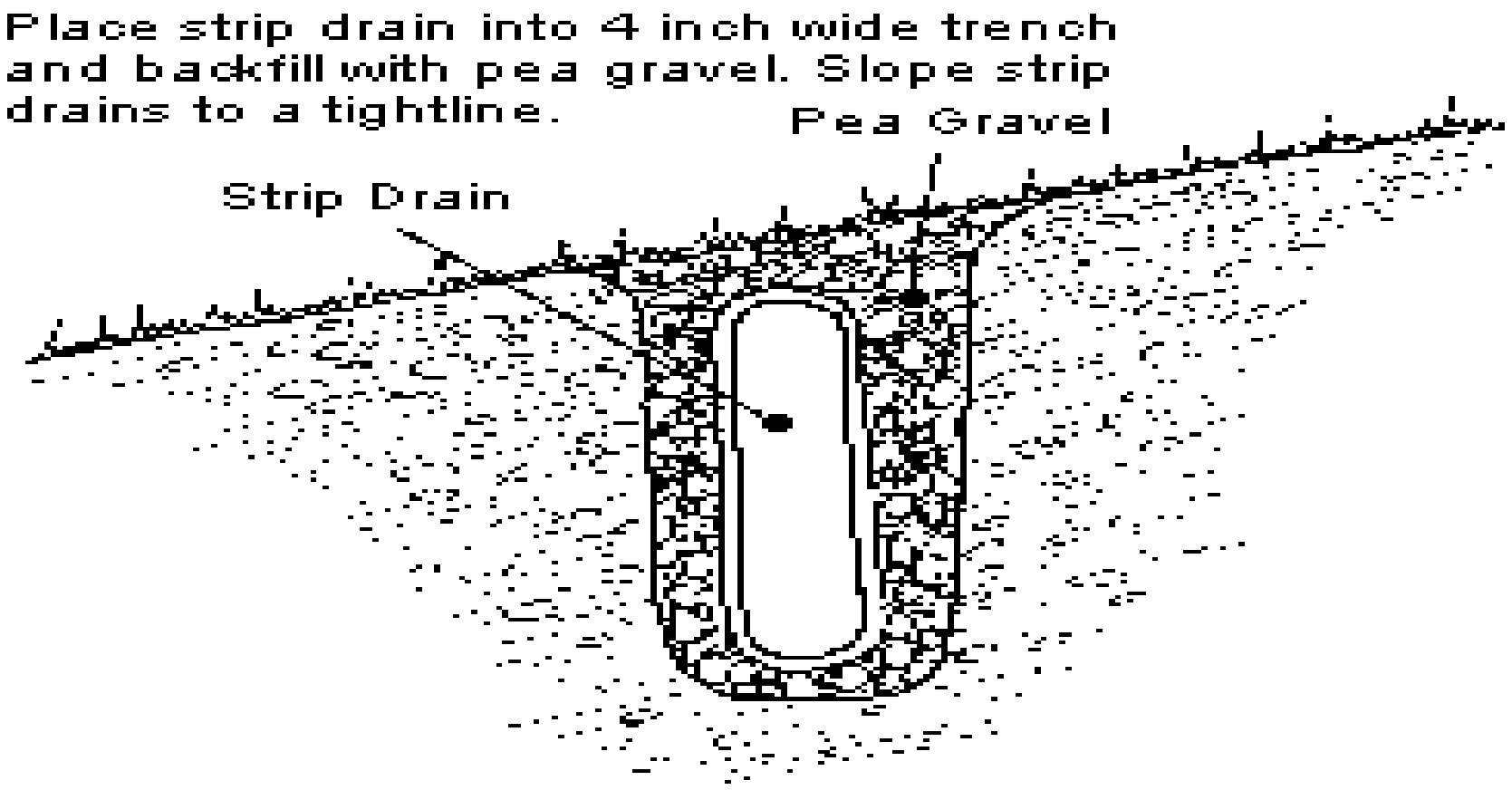
Flow pattern in sub-surface trench



Capillary Fringe

- Unsaturated zone above the water table
- Water held in this zone by tension (matric potential, adhesive and cohesive forces)
- This zone is generally not important to us, and is difficult to measure

Strip Drain: Note Gravel Completely to the Surface!!!



Based on the Principles of Water Movement under Saturated and Unsaturated Conditions: A Curtain Drain Should:

- Be dug into the restrictive layer to serve as a trough.
- Must be diverted around the soil treatment field
- Must have an outlet in which the water does not intrude on the soil treatment field.
- Have trench filled with coarse aggregate material or other suitable material to the SOIL SURFACE!

Remember:

- Sands and Gravels do NOT attract or pull water when surrounded or embedded within soil materials!
- Sands and Gravels do NOT suck

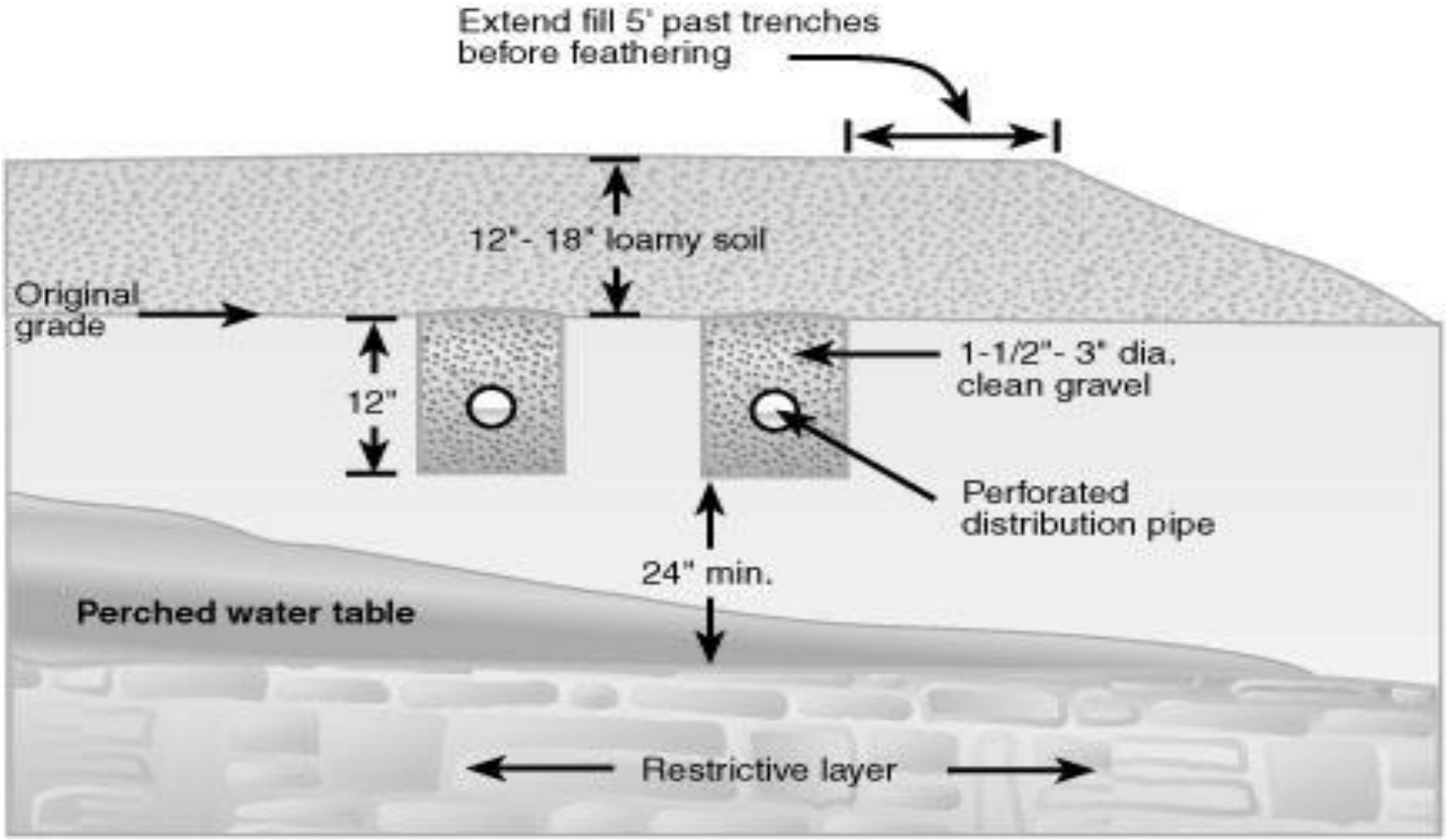
In other words, gravel at the bottom of a vented flower pot will NOT drain the pot!

Therefore, gravel around a drain tile below soil fill will NOT drain the soil!

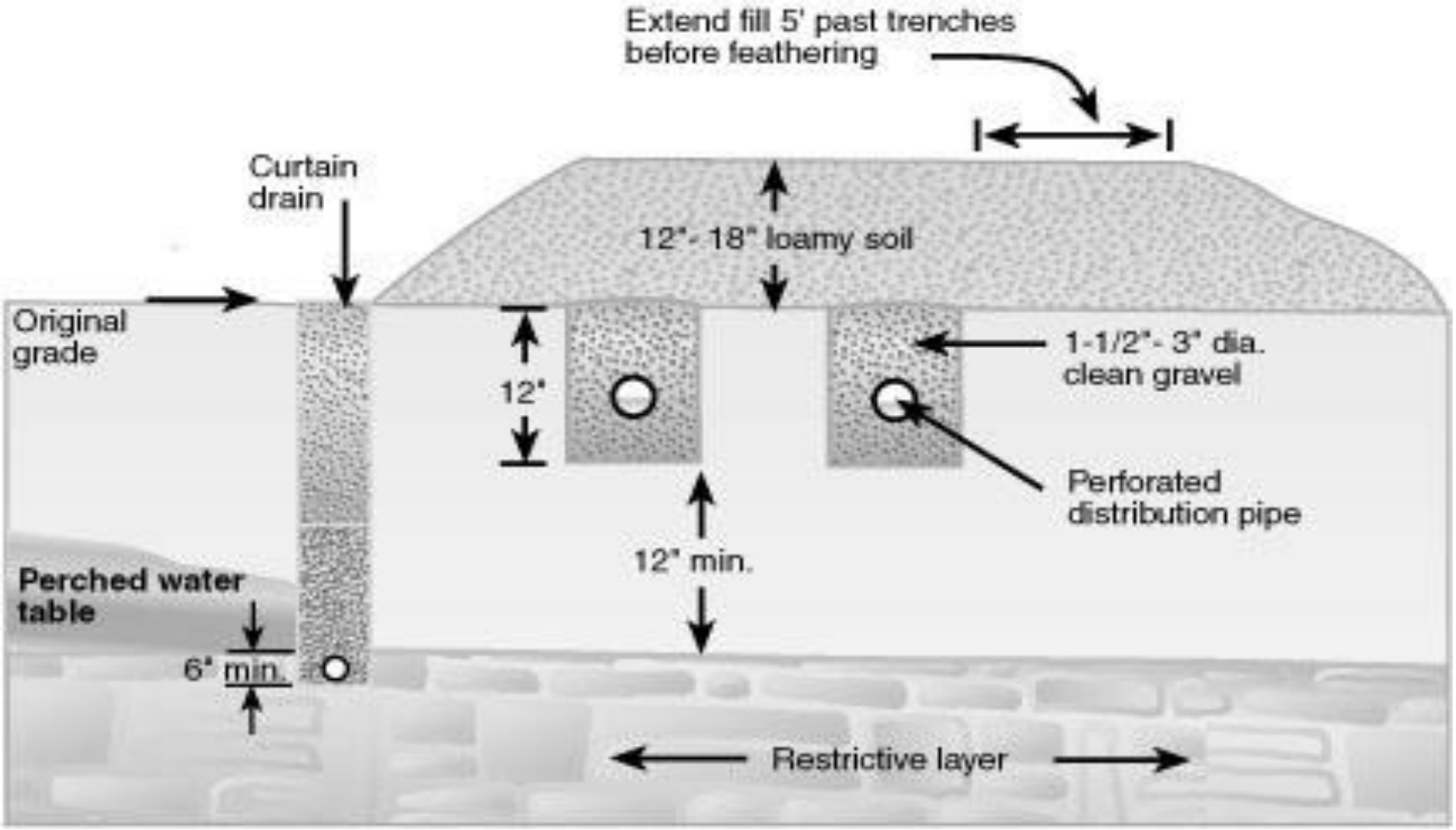
Based on the Principles of Water Movement under Saturated and Unsaturated Conditions: A Curtain Drain Should: (continued)

- Have a clear path for outlet discharge.
- Have rodent guard or screen over the open pipe.
- Not have soil over the coarse aggregate or similar material so that surface runoff can be collected and the system may breathe.

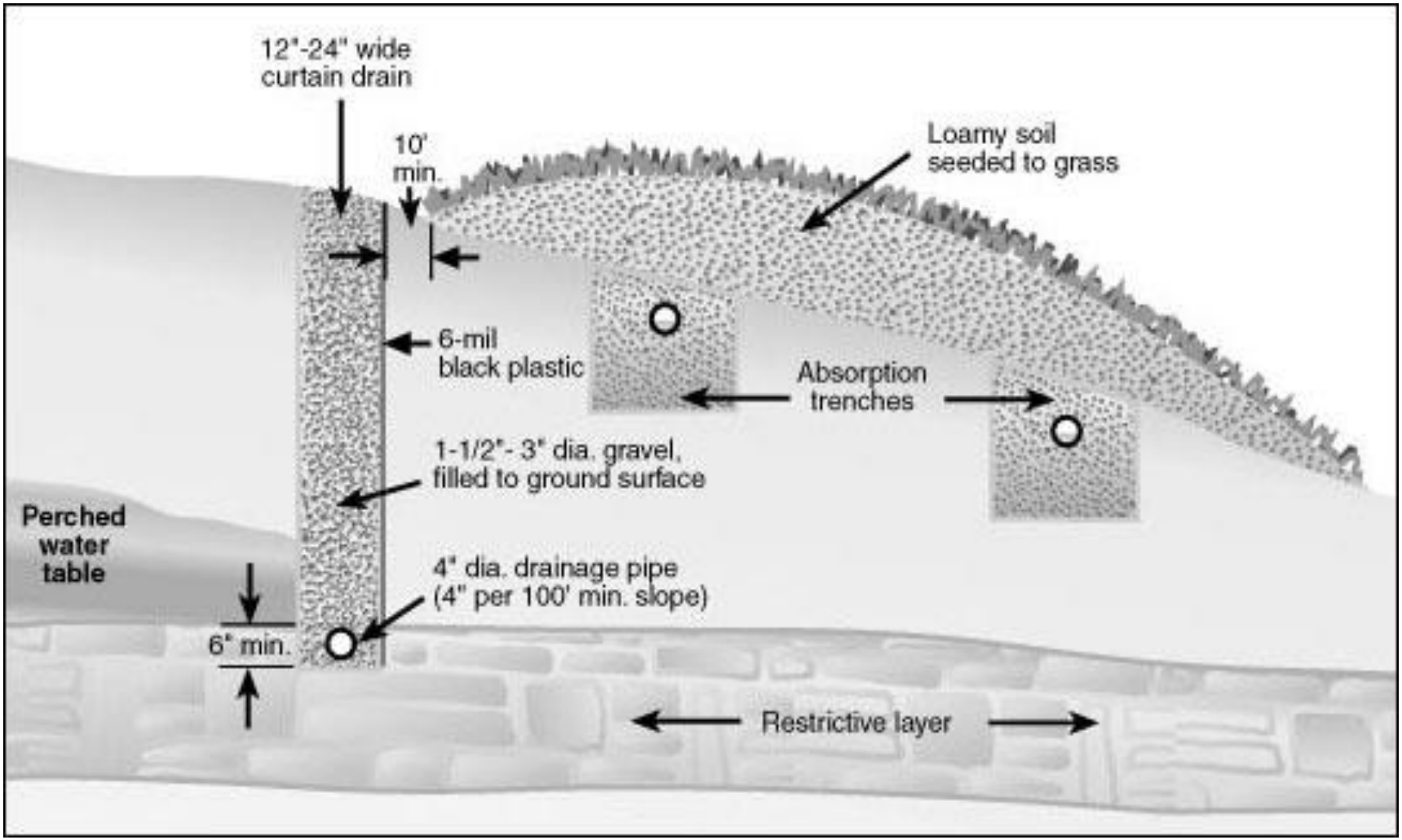
Potential Curtain Drain Site

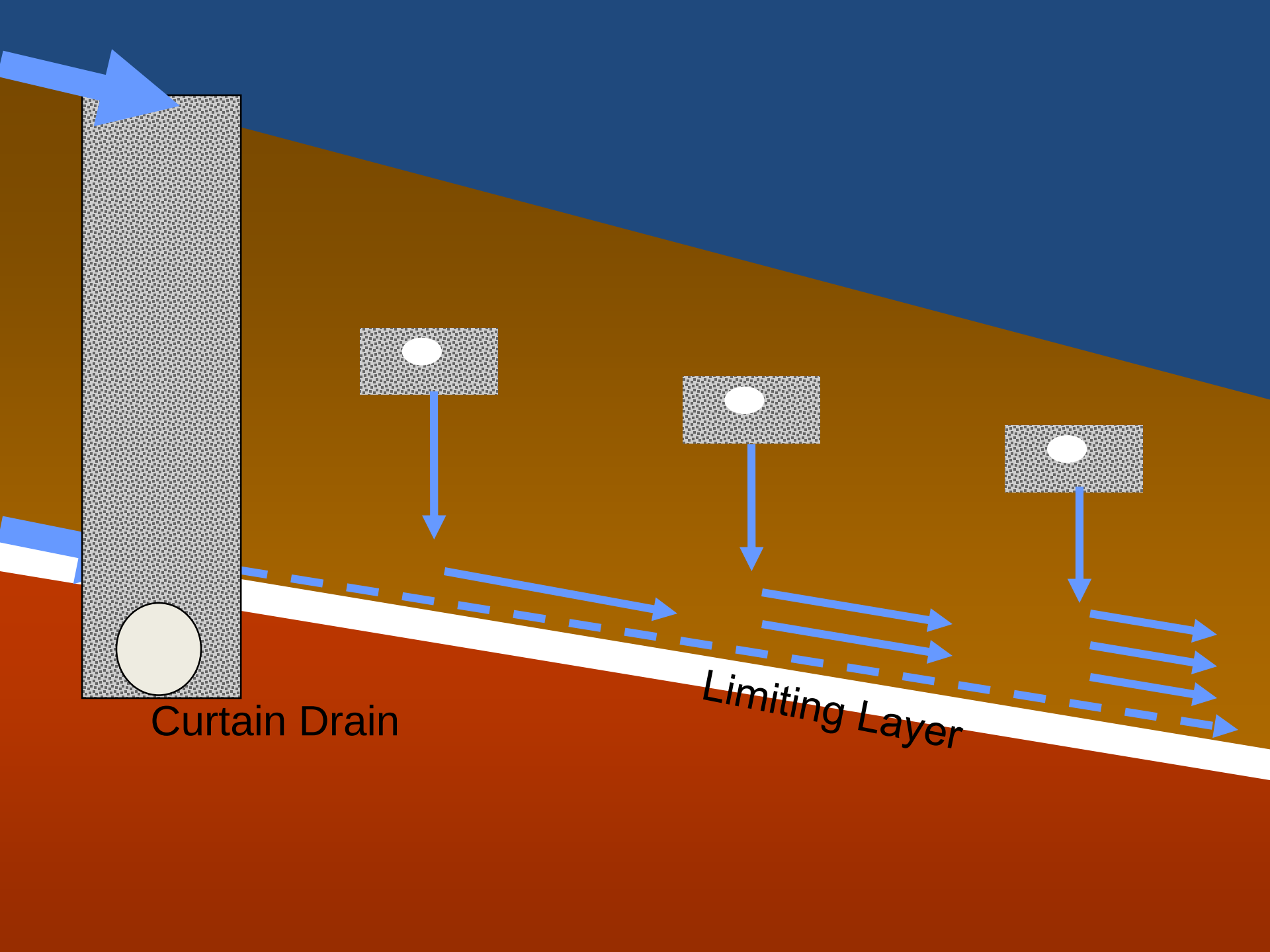


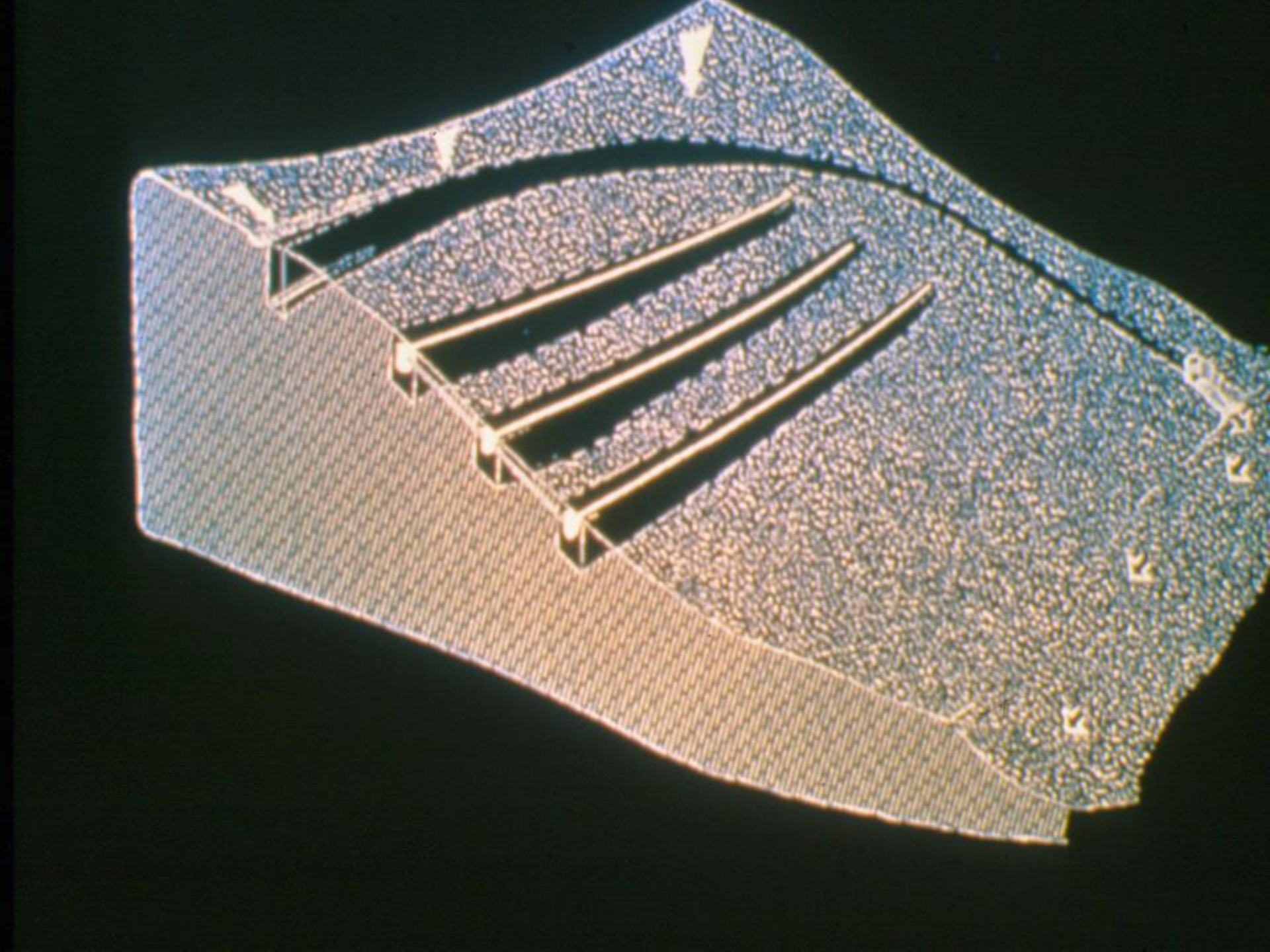
Curtain Drain Placed at Site



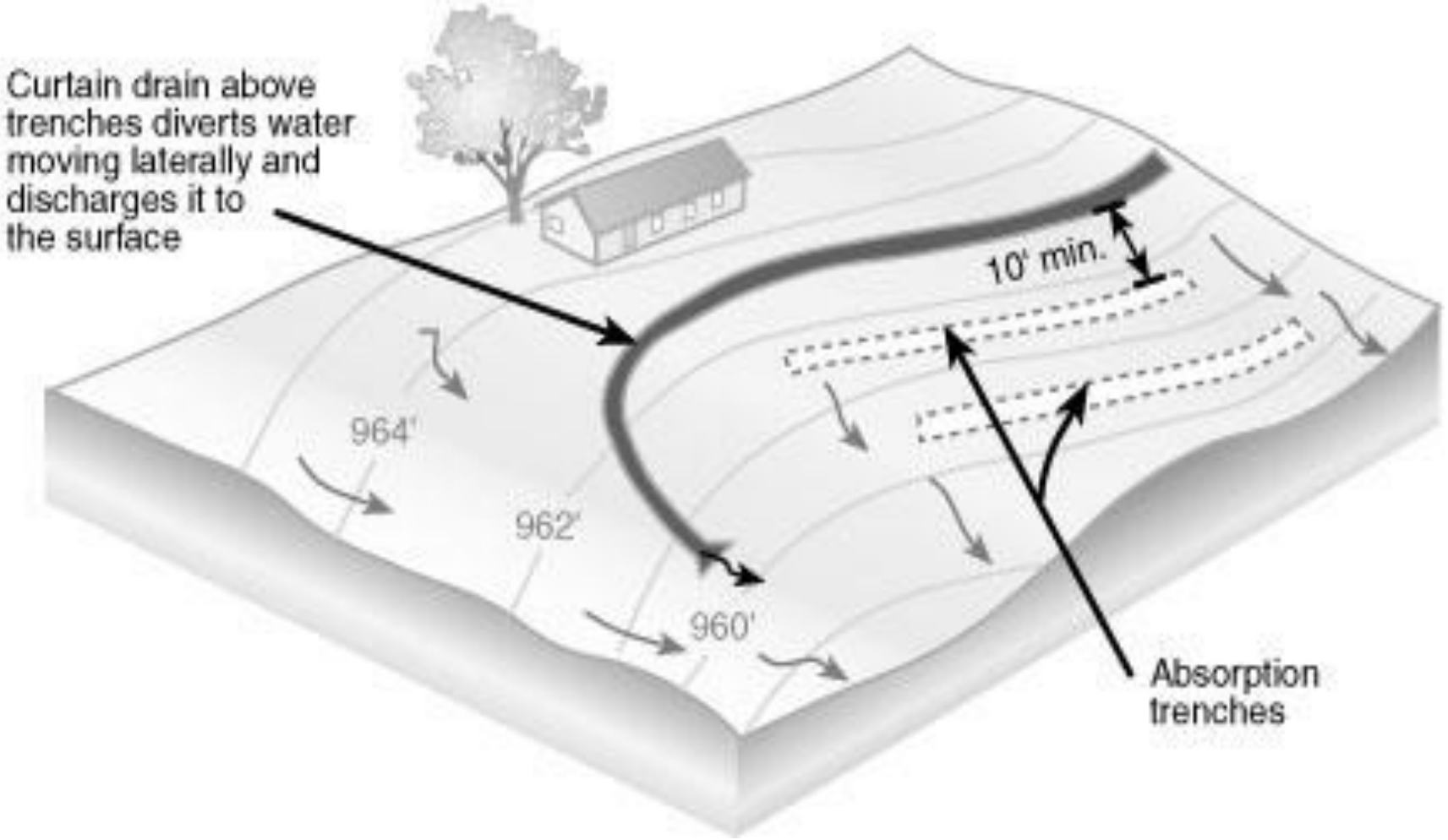
Curtain Drain




Curtain Drain
Limiting Layer



Proper Outlet for Curtain Drain



Outlet

A proper outlet must.

- be clear and free flowing.
- exit topographically below the bottom of the deepest trench

Outlet open to drainage

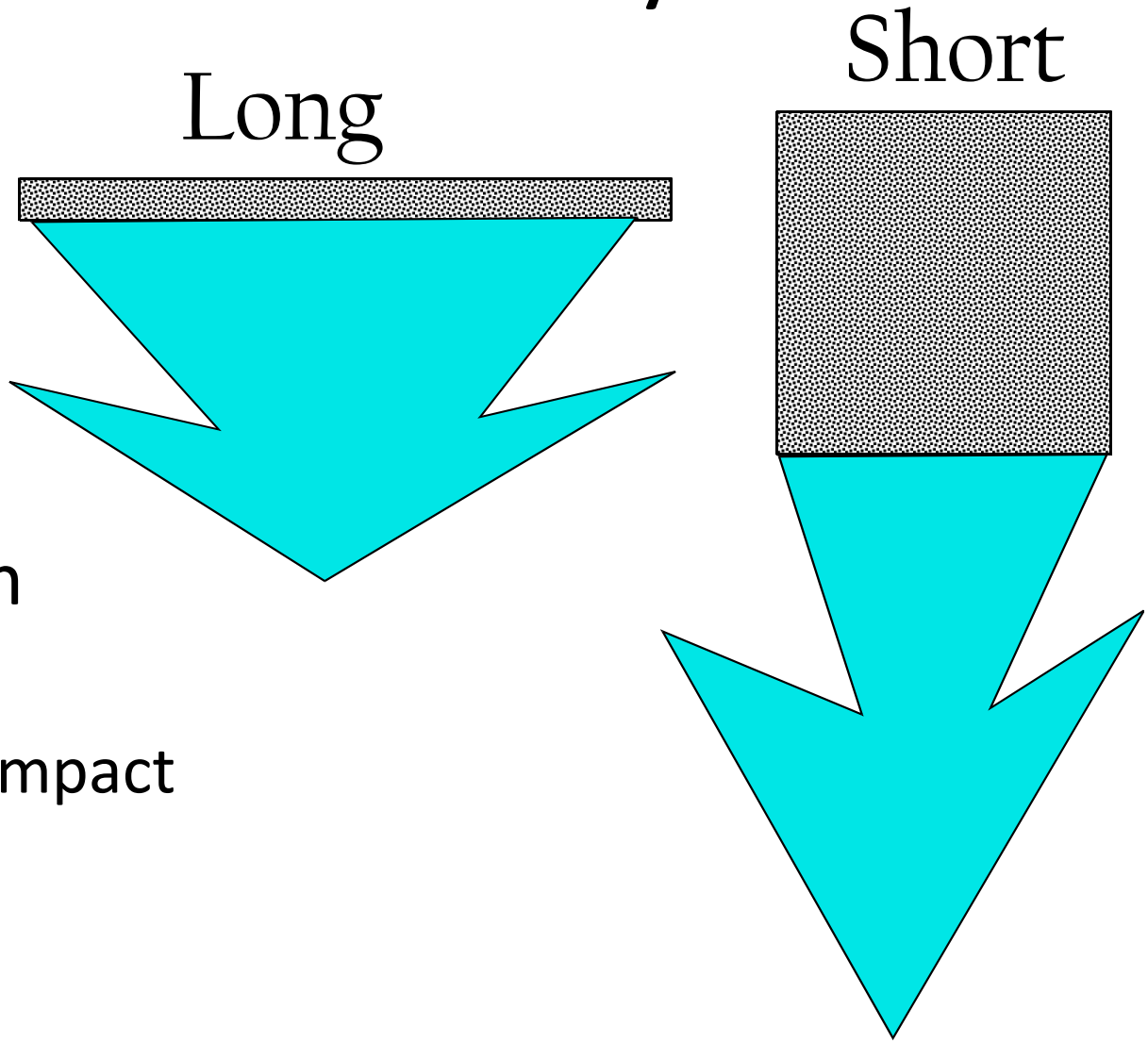
- Clear and free flowing
- Exit topographically below the bottom of the deepest trench

Rodent guard on outlet

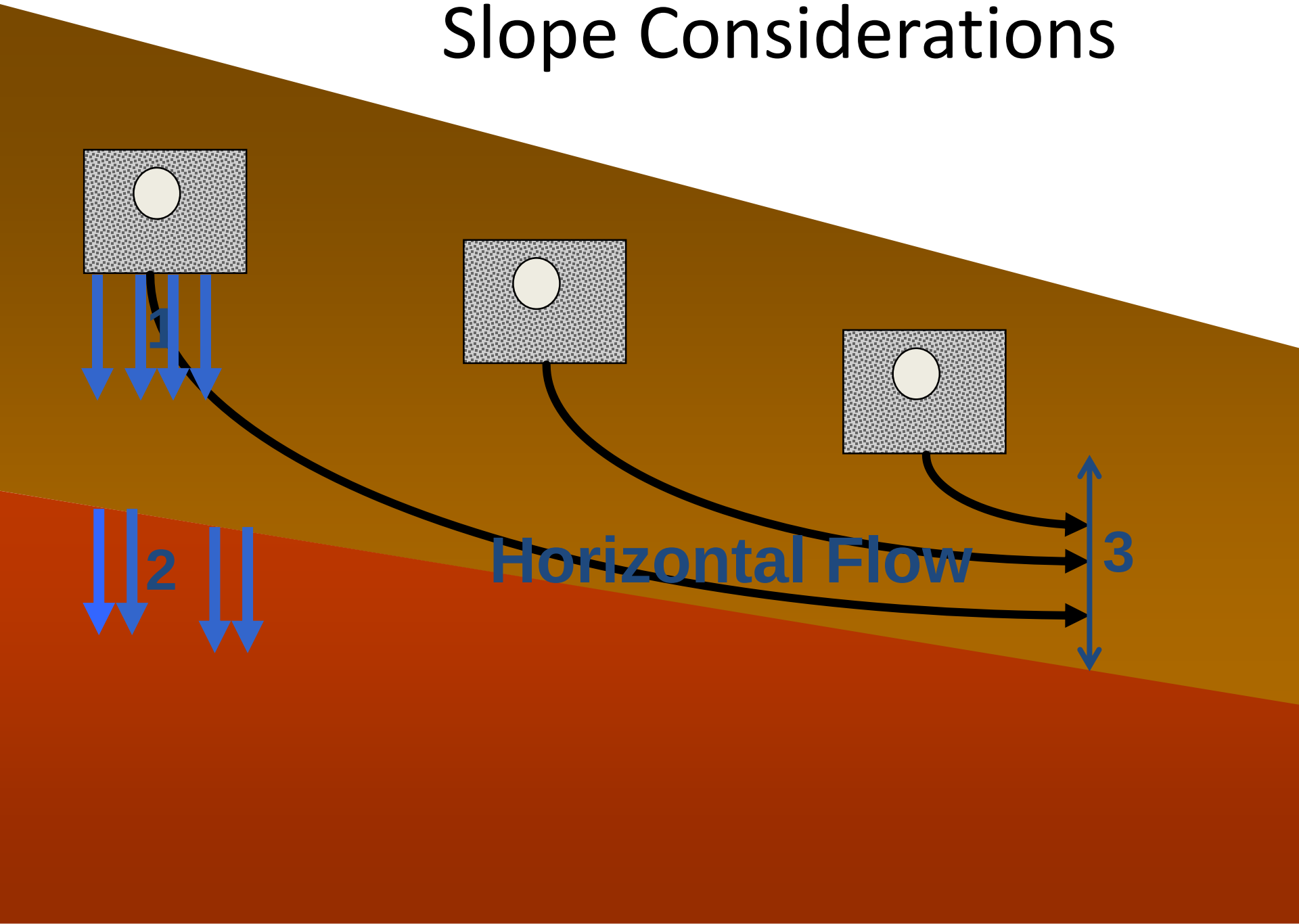
A well maintained surface water diversion ditch

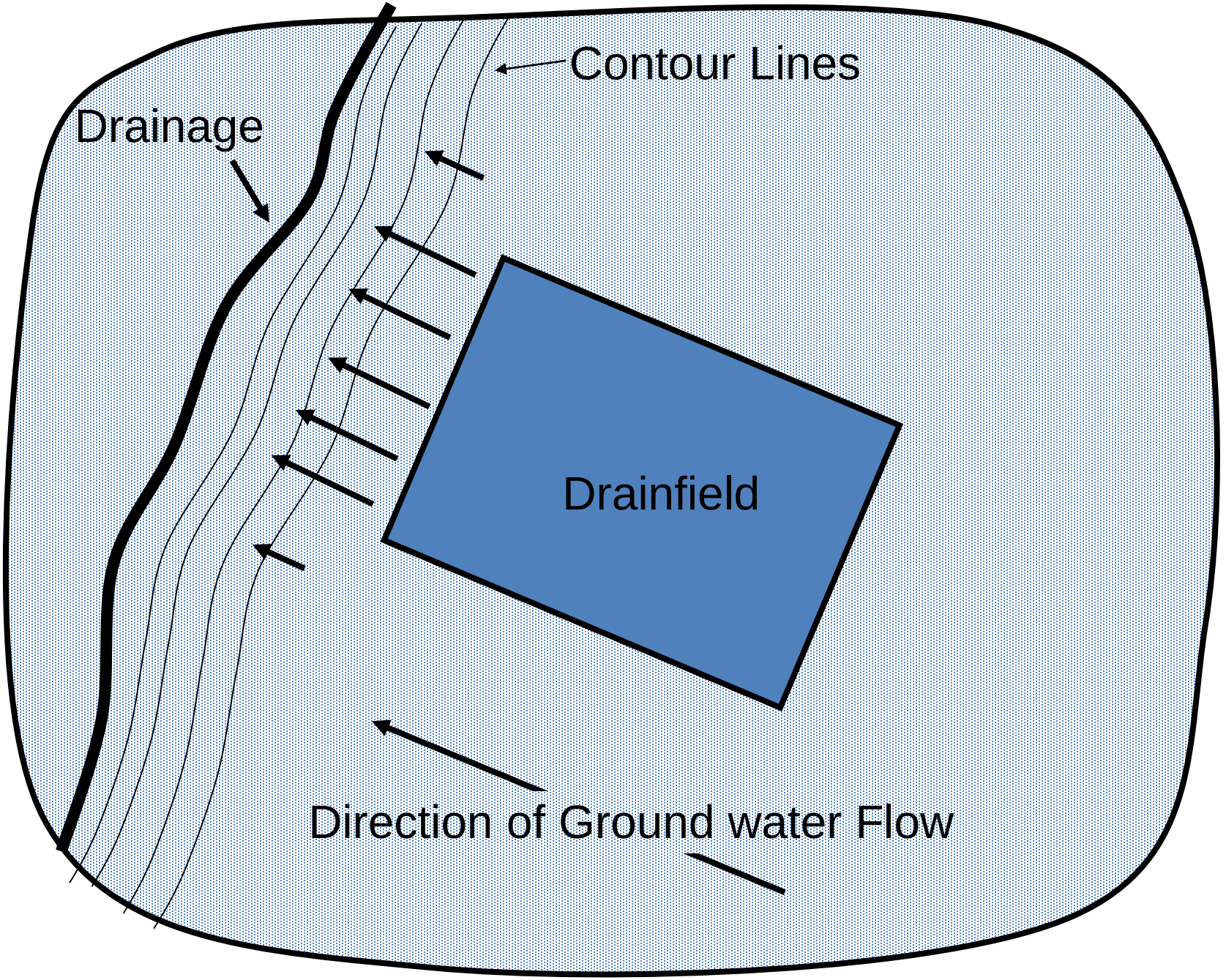
System Geometry

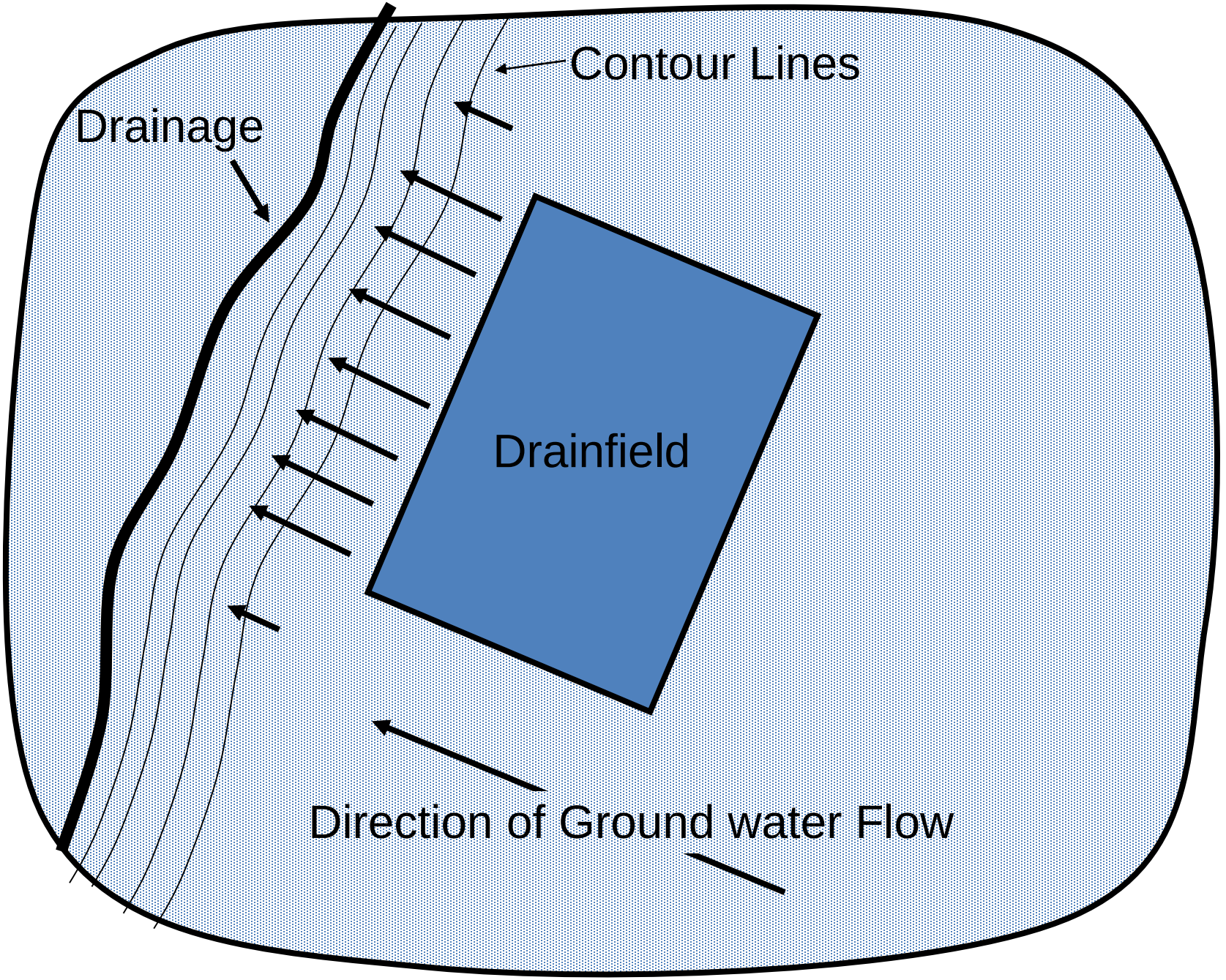
- Influences:
- Longer area
  - Smaller loading
- Shorter length
  - Greater down slope impact



Slope Considerations




Contour Lines
Drainage
Drainfield
Direction of Ground water Flow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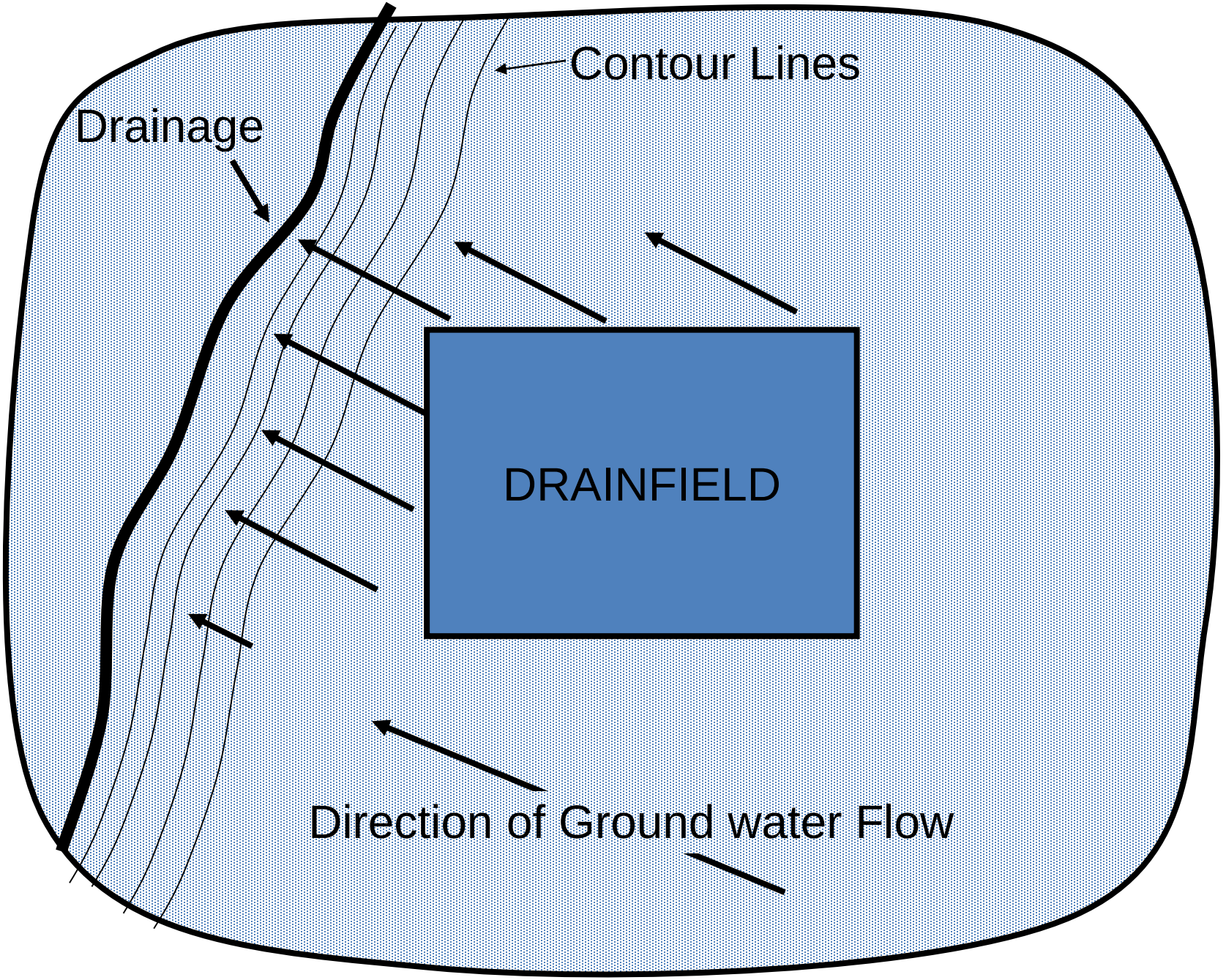
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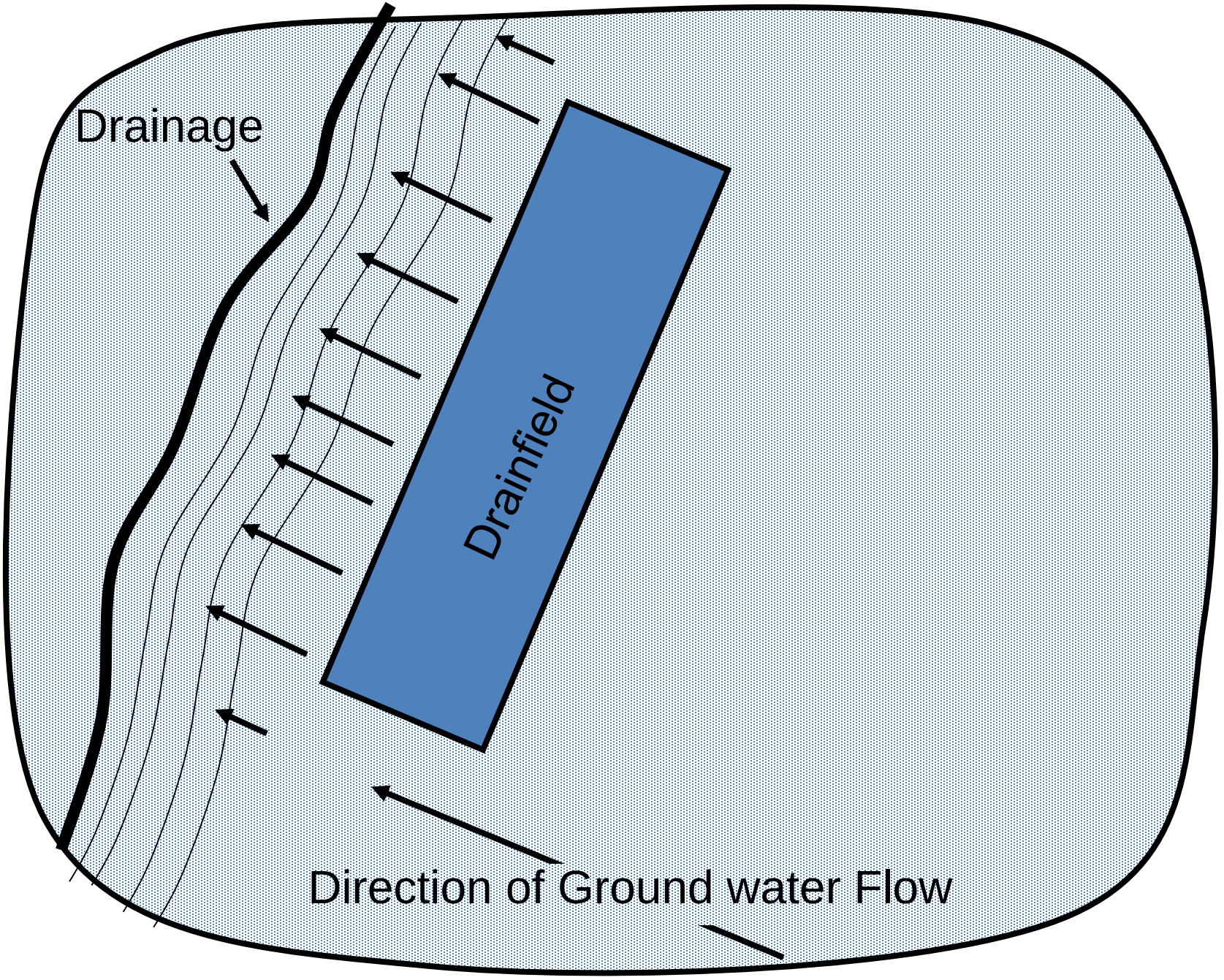
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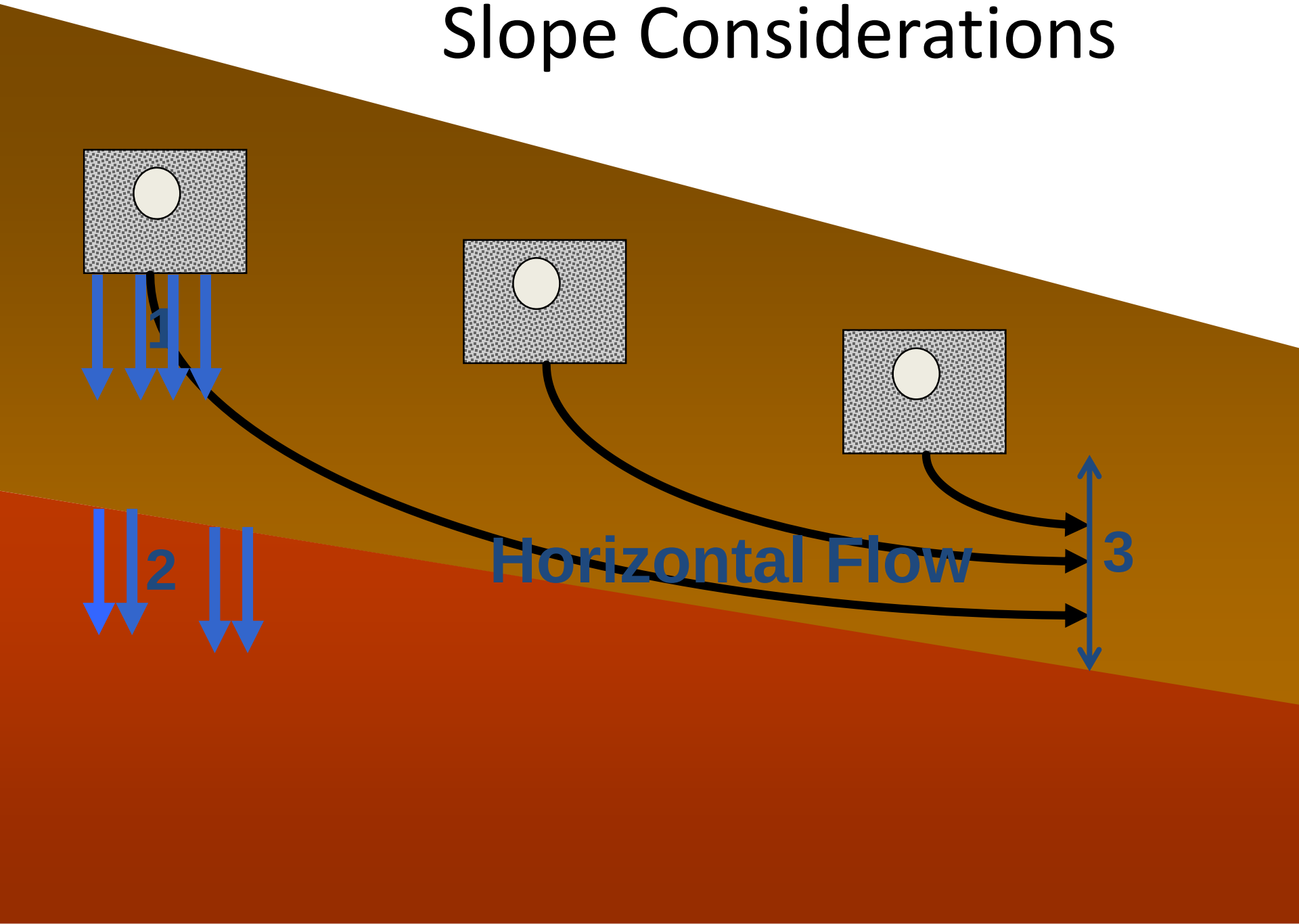
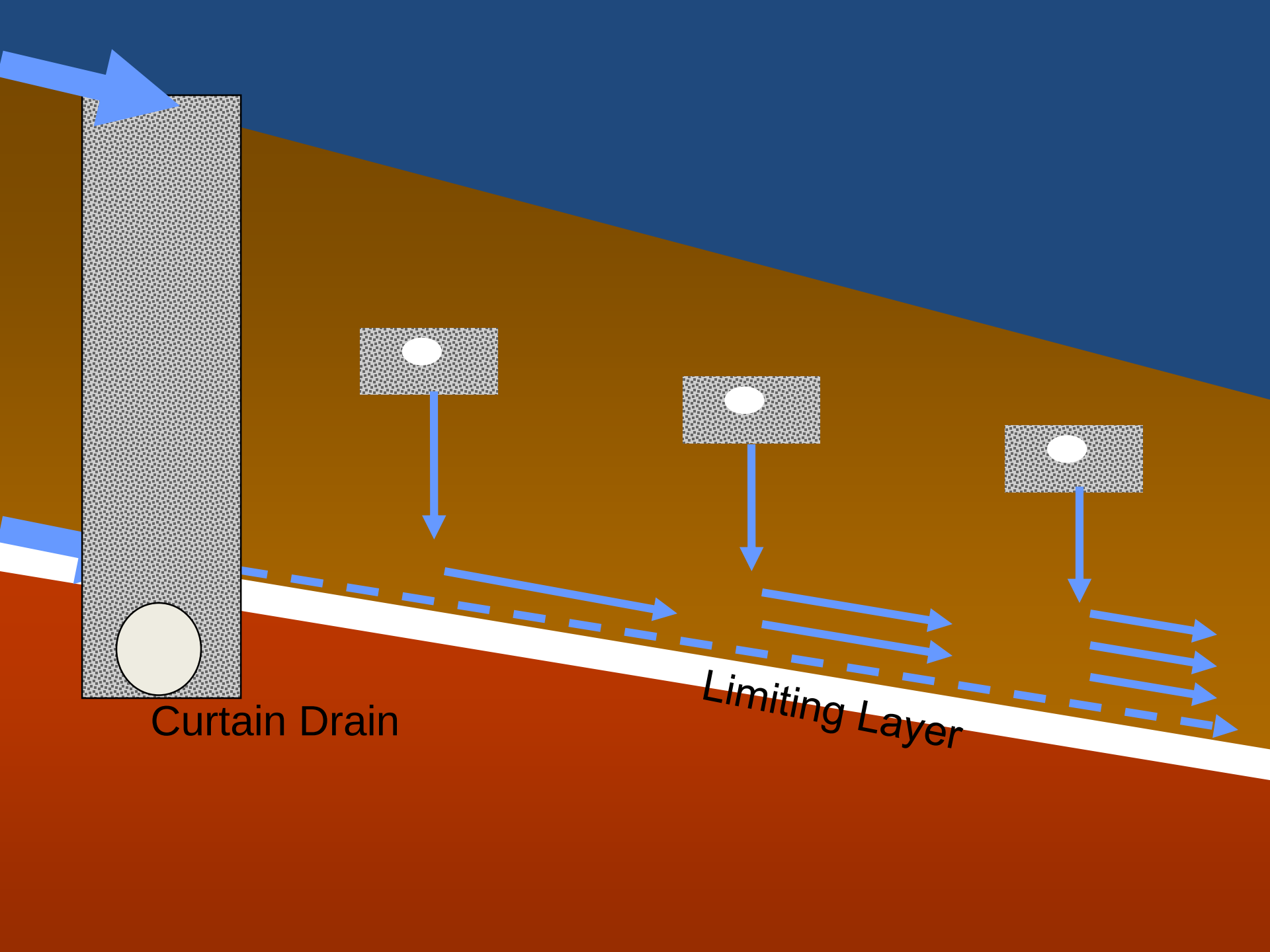
Slope Considerations



Critical considerations for drainage

- Conductivity of underlying material
- Zone of influence – draw down
- Depth of ditch/outlet
- Outlet for drain
- Long-term maintenance of water lowering system
- Topographic position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