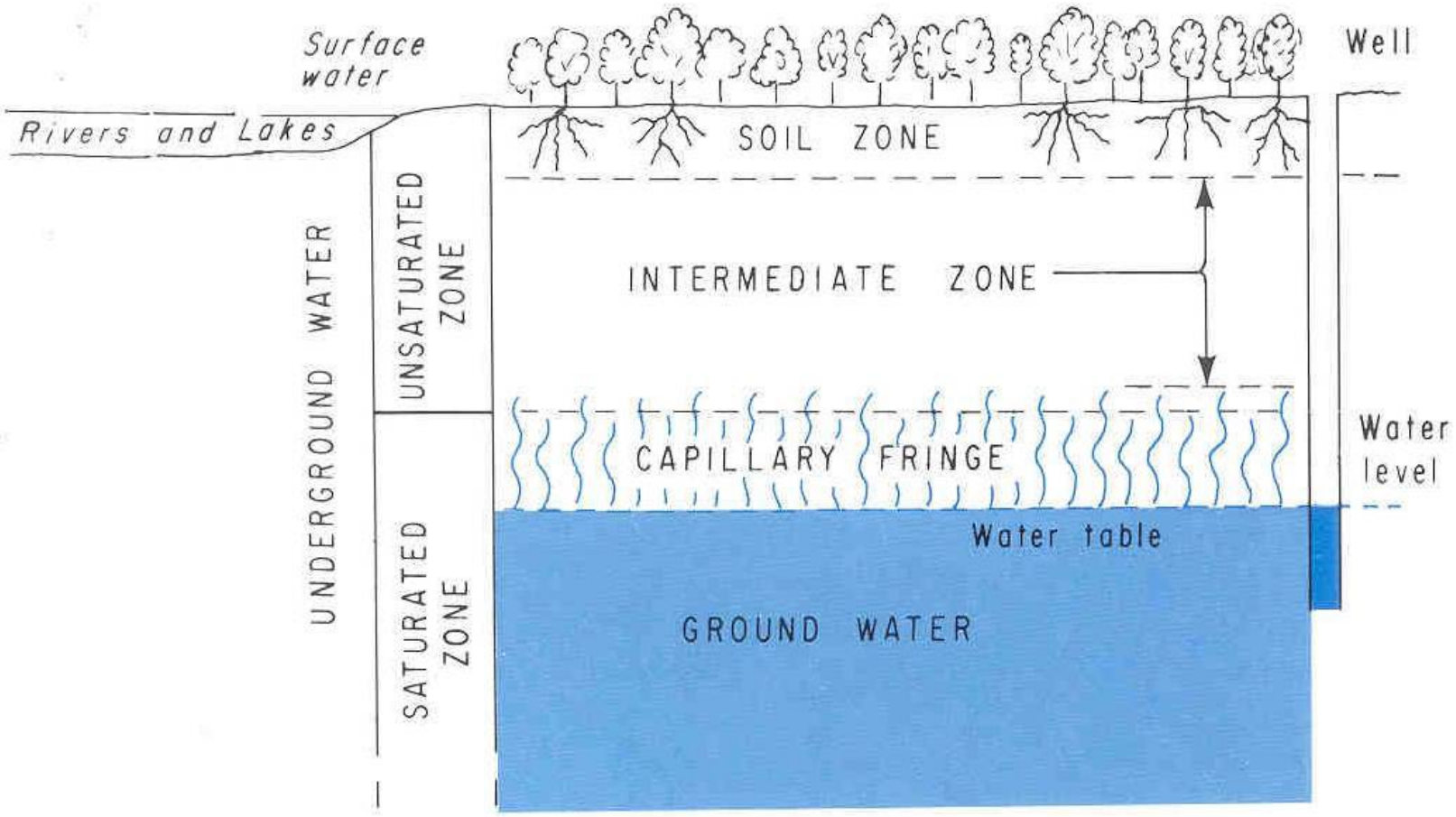
Groundwater Hydrology

- **Water in Natural Formations**
- **Porosity**
- **Specific Yield and Retention**
- **Functions of Groundwater Systems**



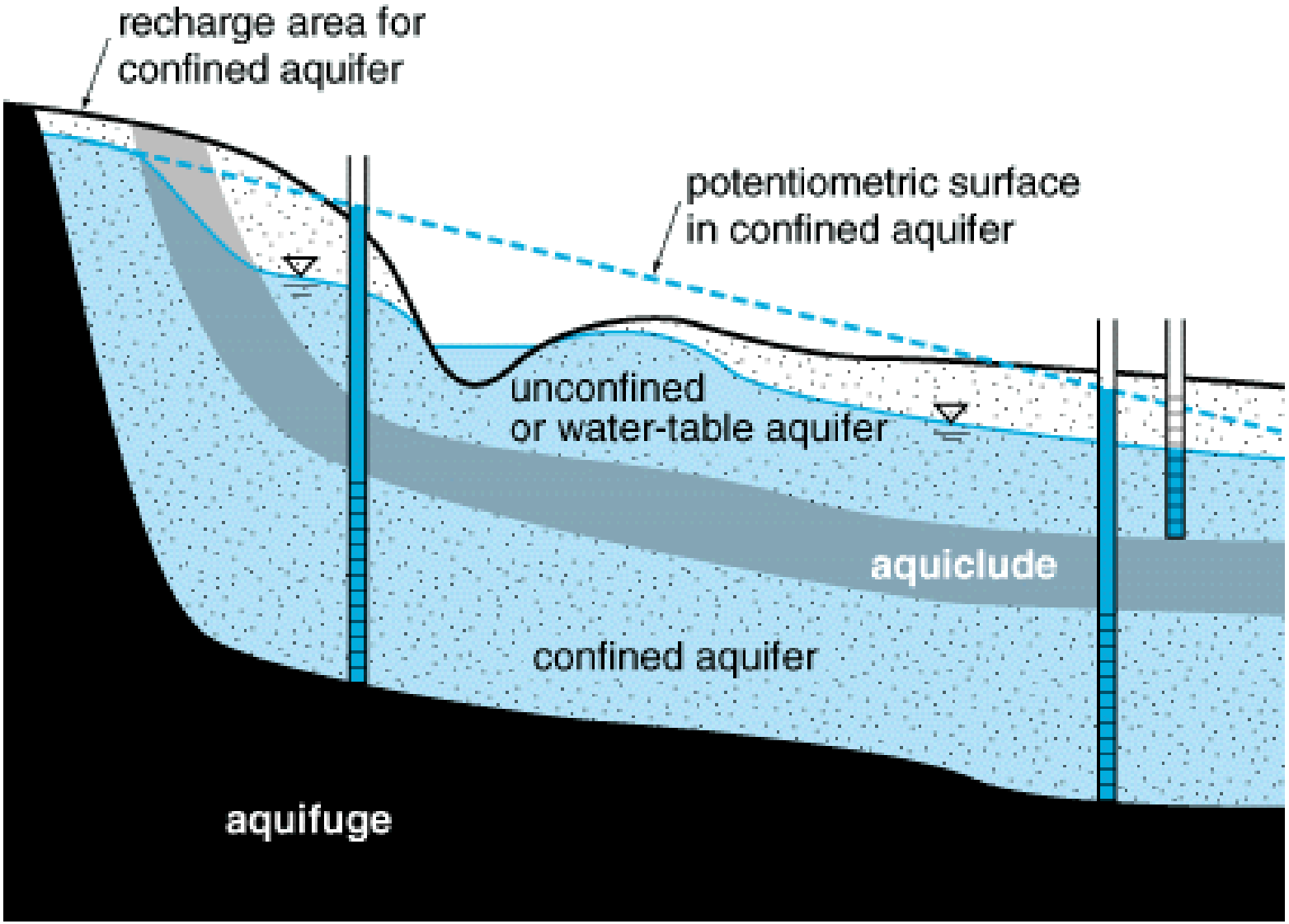
UNDERGROUND WATER

Water in Natural Formations

- Aquifer: a rock unit that will yield water in a usable quantity to a well or spring.

(saturated geological formation, containing and transmitting significant quantities of water under normal field quantities); rock: unconsolidated sediments

- Aquiclude: formation containing water → do not transmit significant quantities
- Aquifuge: formation → doesnot contain nor transmit
- Aquitard: formations with low permeability…includes both aquiclude and aquifuge
- Confining bed: rock unit with low hydraulic conductivity to restrict movement of GW either into or out of adjacent aquifers



HYDROGEOLOGICAL UNITS

Unconfined Aquifers

- GW occurring in aquifers: water fills partly an aquifer: upper surface free to rise and decline: **UNCONFINED** or water-table aquifer: unsaturated or vadose zone

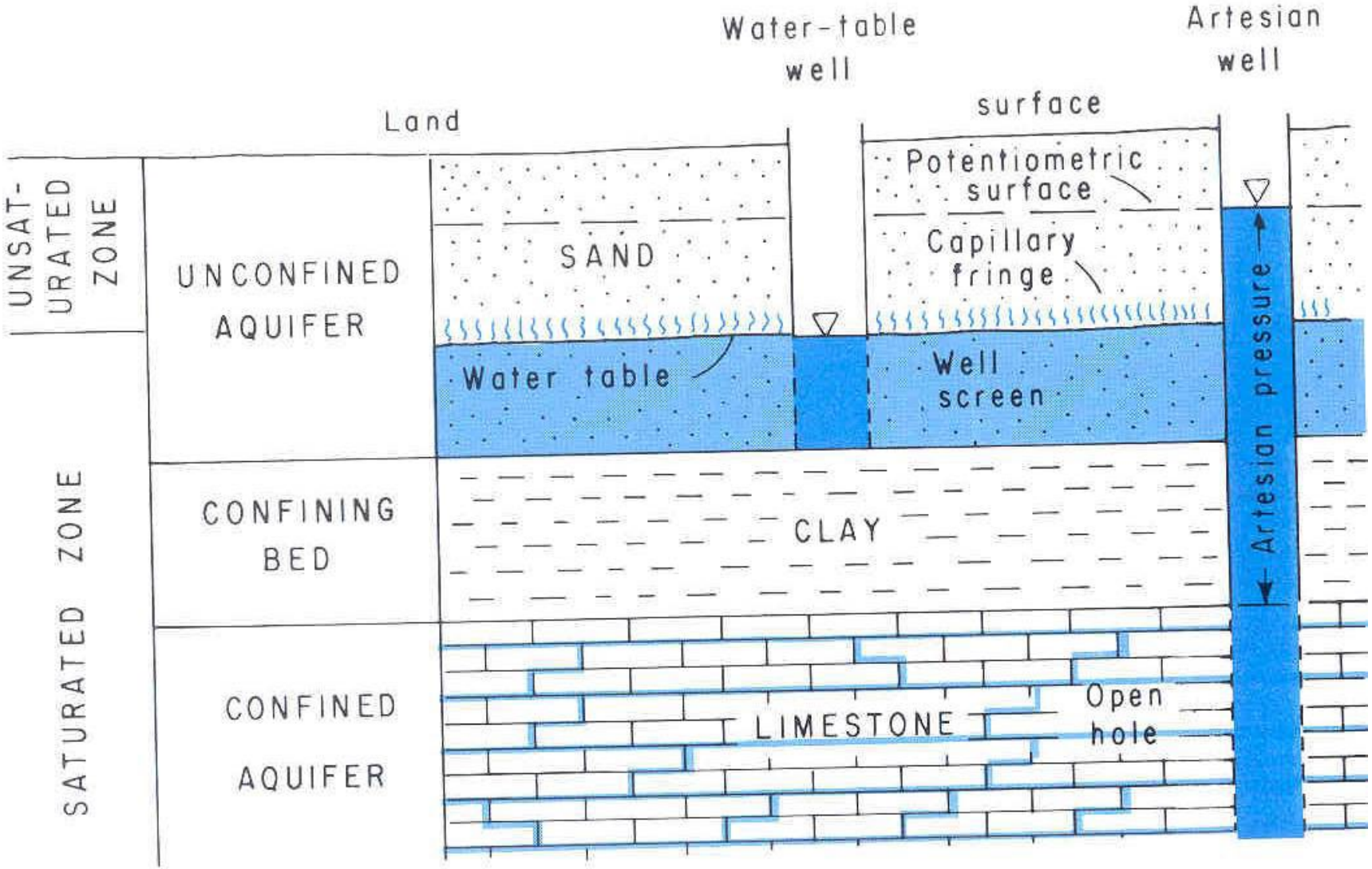
- Near surface material not saturated

- Water table: at zero gage pressure: separates saturated and unsaturated zones: free surface rise of water in a well

Confined Aquifer

- Artesian condition
- Permeable material overlain by relatively impermeable material
- Piezometric or potentiometric surface
- Water level in the piezometer is a measure of water pressure in the aquifer

AQUIFERS AND CONFINING BEDS



Porosity

- Ratio of openings (voids) to the total volume of a soil

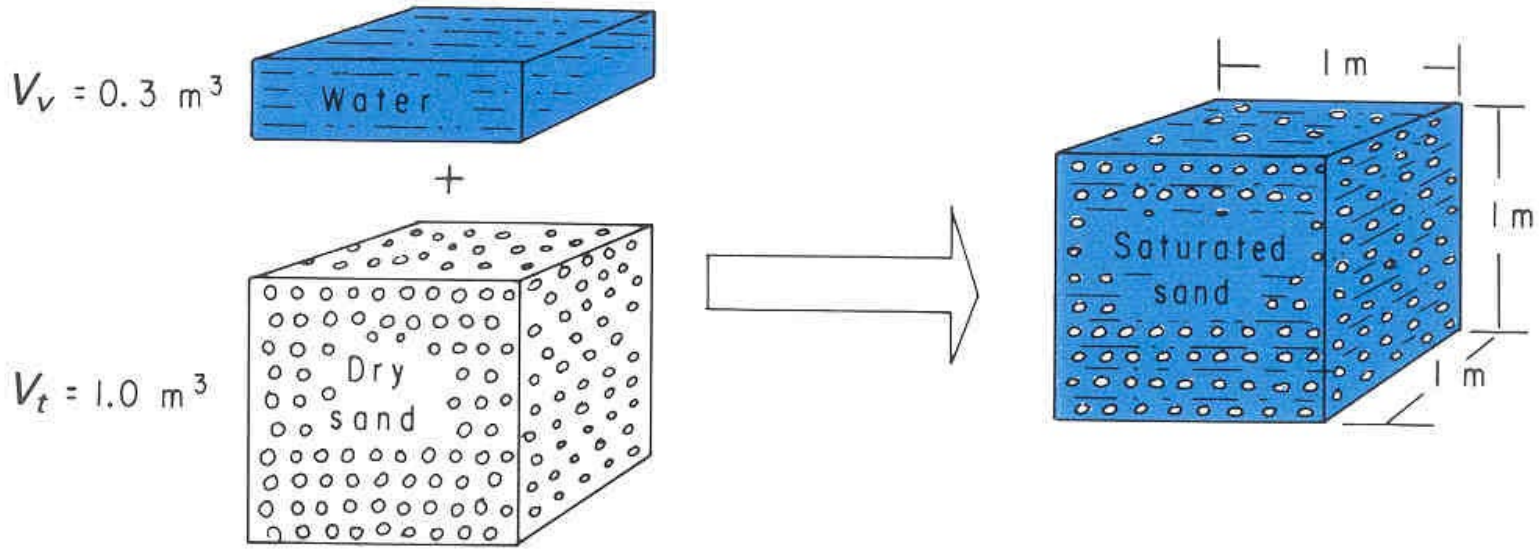
- $n = (V_t - V_s)/V_t = V_v/V_t$

V_t= total volume of the soil or rock

V_s=volume of solids in the sample

V_v= volume of openings (voids)

- Expressed as percentage

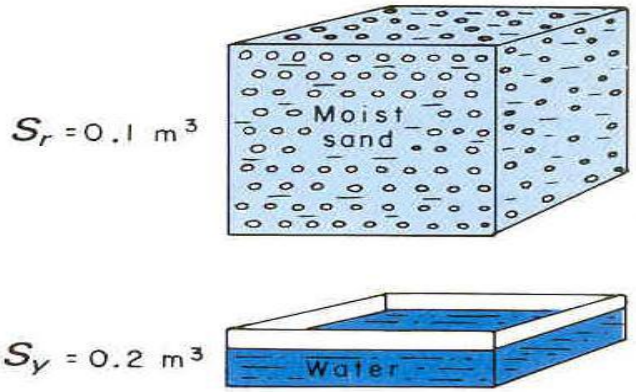


$$\text{Porosity } (n) = \frac{\text{Volume of voids } (V_v)}{\text{Total volume } (V_t)} = \frac{0.3 \text{ m}^3}{1.0 \text{ m}^3} = 0.30$$

SELECTED VALUES OF POROSITY

[Values in percent by volume]

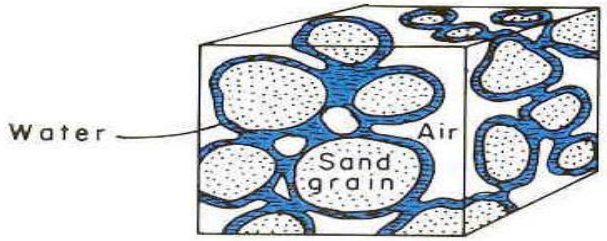
Material	Primary openings	Secondary openings
Equal-size spheres (marbles):		
Loosest packing	48	—
Tightest packing	26	—
Soil	55	—
Clay	50	—
Sand	25	—
Gravel	20	—
Limestone	10	10
Sandstone (semiconsolidated)	10	1
Granite	—	.1
Basalt (young)	10	1



$$n = S_y + S_r = \frac{0.2\ m^3}{1\ m^3} + \frac{0.1\ m^3}{1\ m^3} = 0.30$$

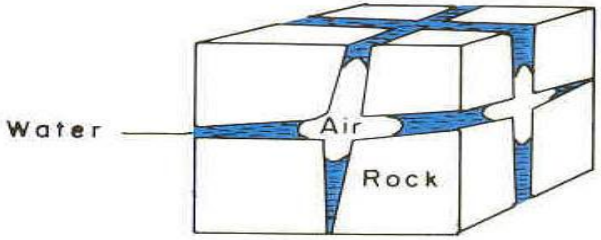
(1)

SPECIFIC YIELD AND RETENTION



GRANULAR MATERIAL

Water retained as a film on rock surfaces and in capillary-size openings after gravity drainage.



FRACTURED ROCK

(2)

$n = S_y + S_r$

$S_y = V_d / V_t$

$S_r = V_r / V_t$

n=porosity

S_y=specific yield

S_r=specific retention

V_d=volume of water that drains from a total volume of V_t.,

V_r is the volume of water retained in a total volume of V_t

V_t=total volume of a soil or rock sample

Specific Yield and Retention

- Porosity: maximum amount of water that a rock can contain when saturated.
- Portion of the GW: draining under influence of gravity: **SPECIFIC YIELD**
- Portion of the GW: retained as a film on rock surfaces and in very small openings: **SPECIFIC RETENTION**

SELECTED VALUES OF POROSITY, SPECIFIC YIELD, AND SPECIFIC RETENTION

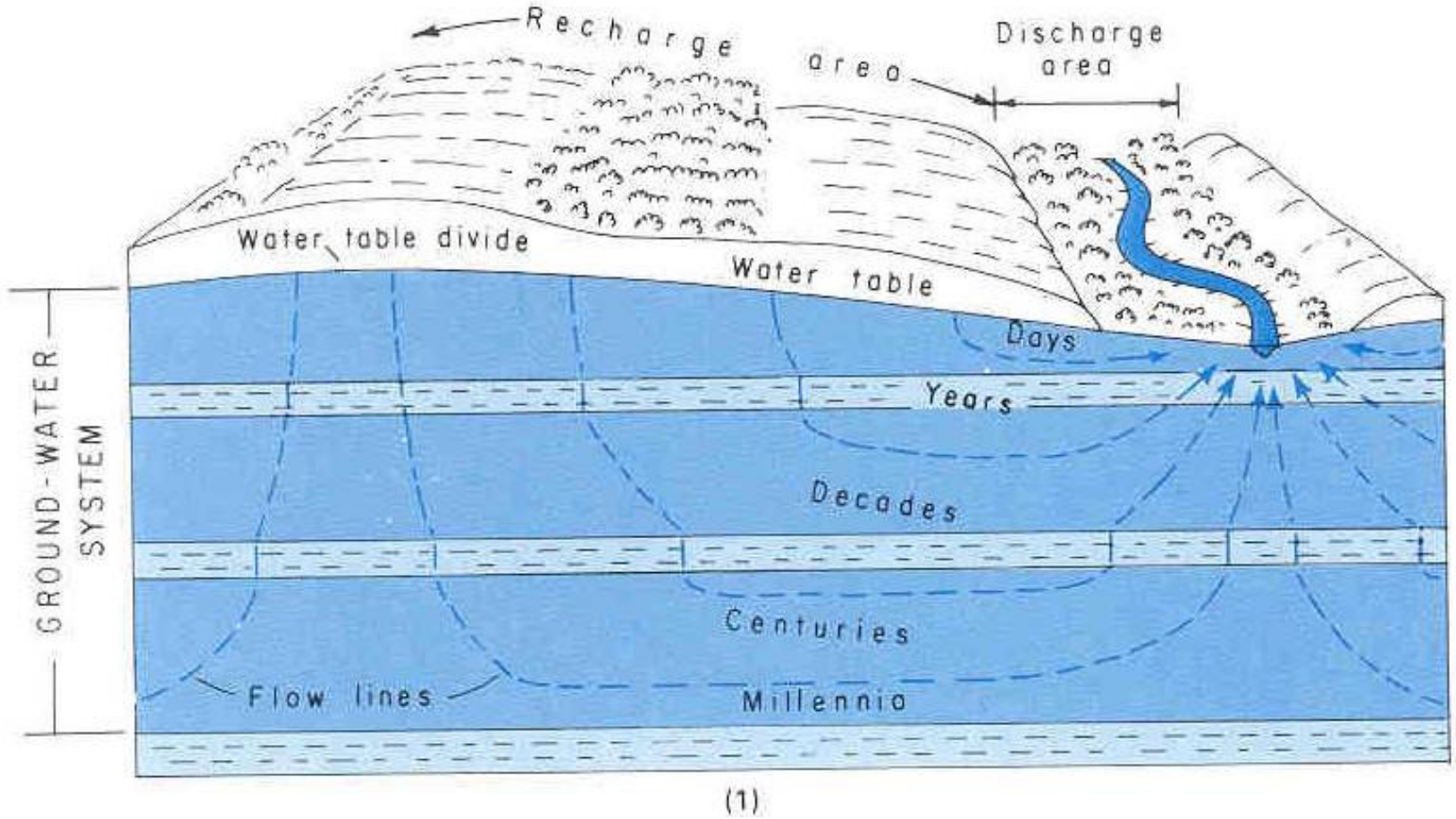
[Values in percent by volume]

Material	Porosity	Specific yield	Specific retention
Soil	55	40	15
Clay	50	2	48
Sand	25	22	3
Gravel	20	19	1
Limestone	20	18	2
Sandstone (semiconsolidated)	11	6	5
Granite	.1	.09	.01
Basalt (young)	11	8	3

Functions of Groundwater Systems

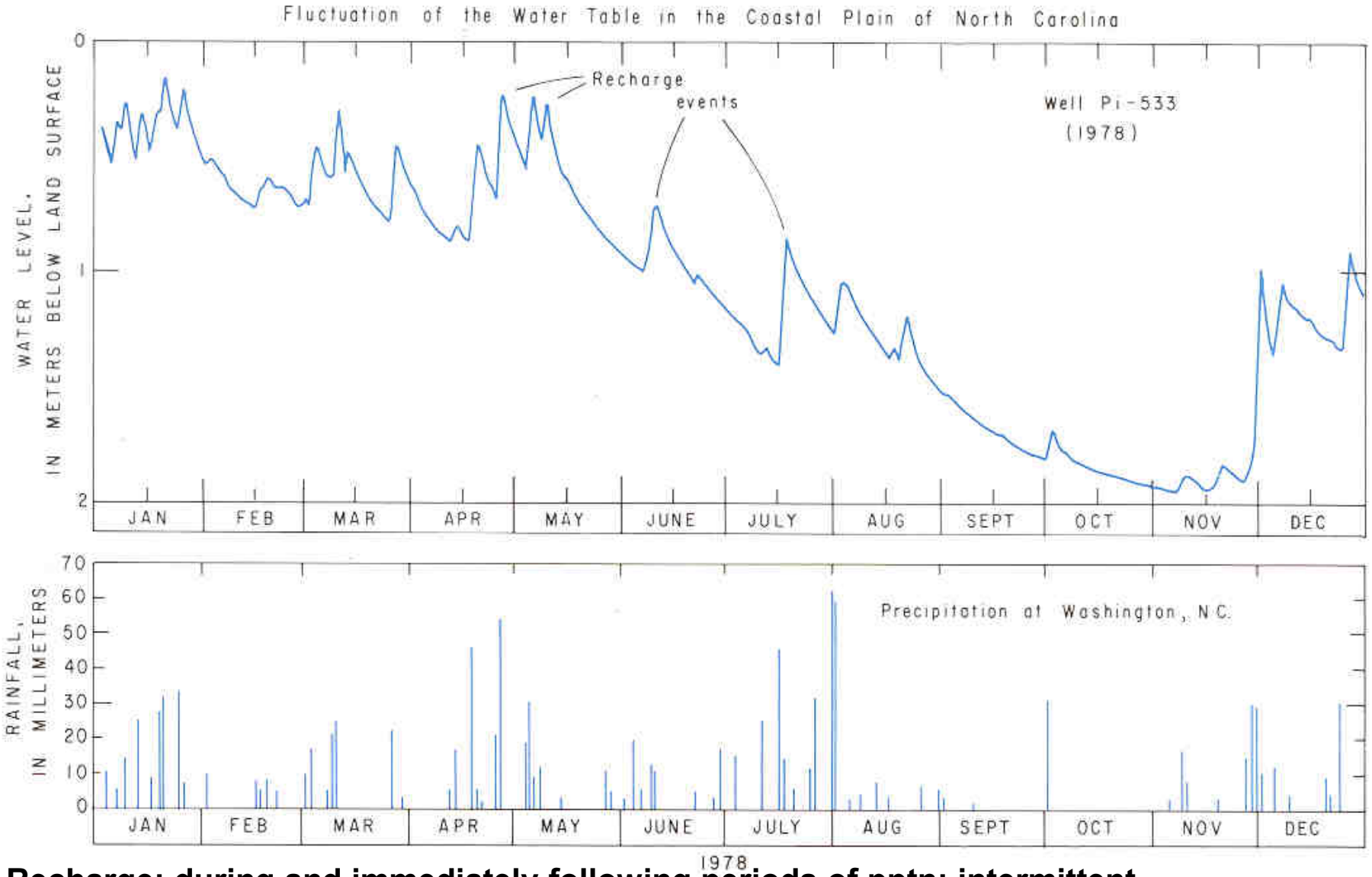
- Hydraulically: 1) stores water to extent of porosity; 2) transmits water from recharge areas to discharge areas(i.e., reservoir and conduit)
- Water from recharge areas→guided by hydraulic gradients and conductivity→ to discharge areas

GROUNDWATER VELOCITY



Time reqd by groundwater to move from recharge to discharge areas

Few days (zones adjacent to discharge) to millennia (central part of some recharge through deeper GWsystems.



Recharge: during and immediately following periods of pptn: intermittent

Discharge: continuous process as long as groundwater heads are above the level at which discharge occur

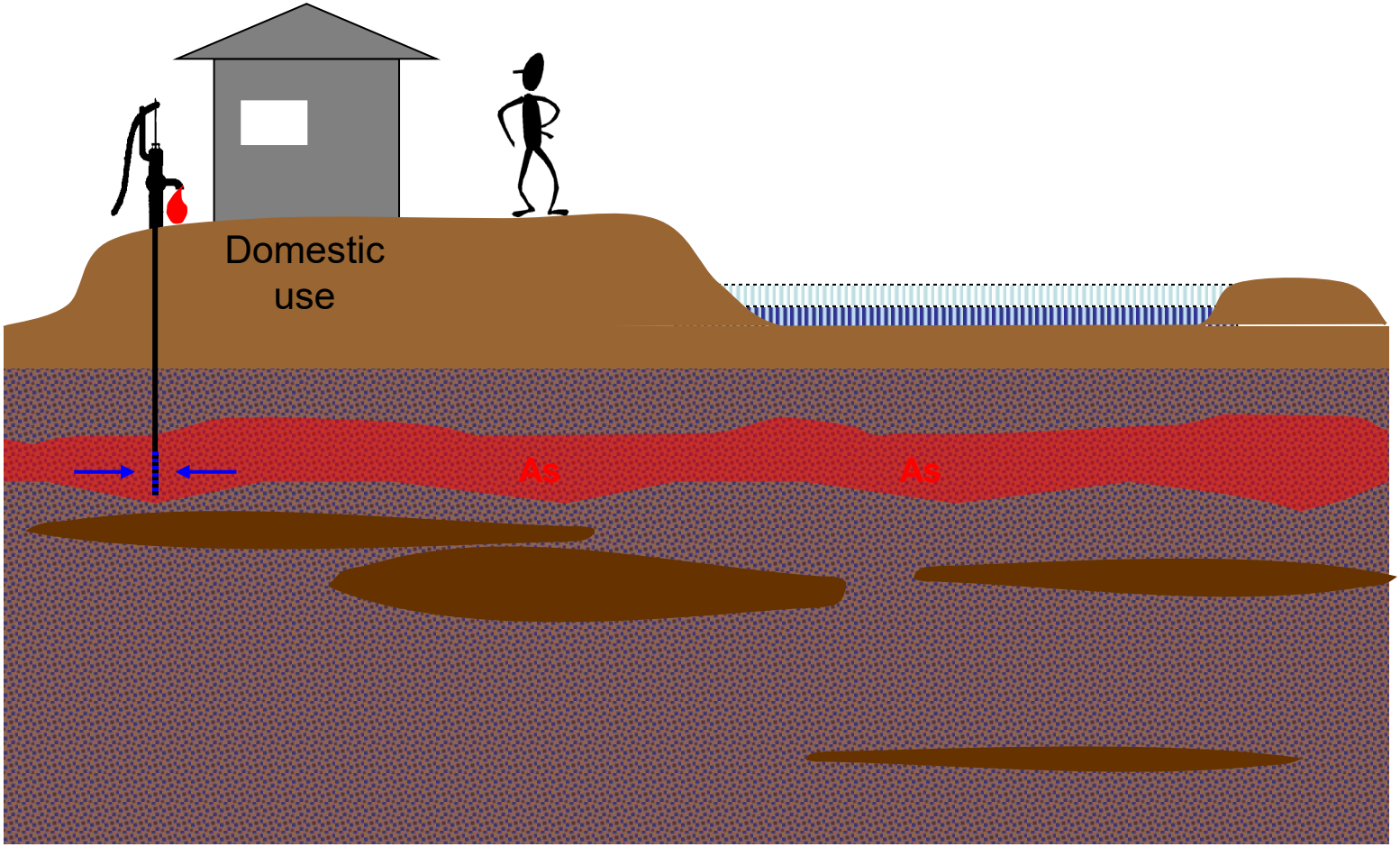
Aquifer Sustainability

Aquifer	shallow	deep
Residence time	10's of years	1000's of years
Recharge rate	>>10 cm/year	0.5 cm/year

Supply

Personal consumption	1 cm/year (2640 persons/km^2; 10L/person/day)
Irrigation	60 cm/year

Demand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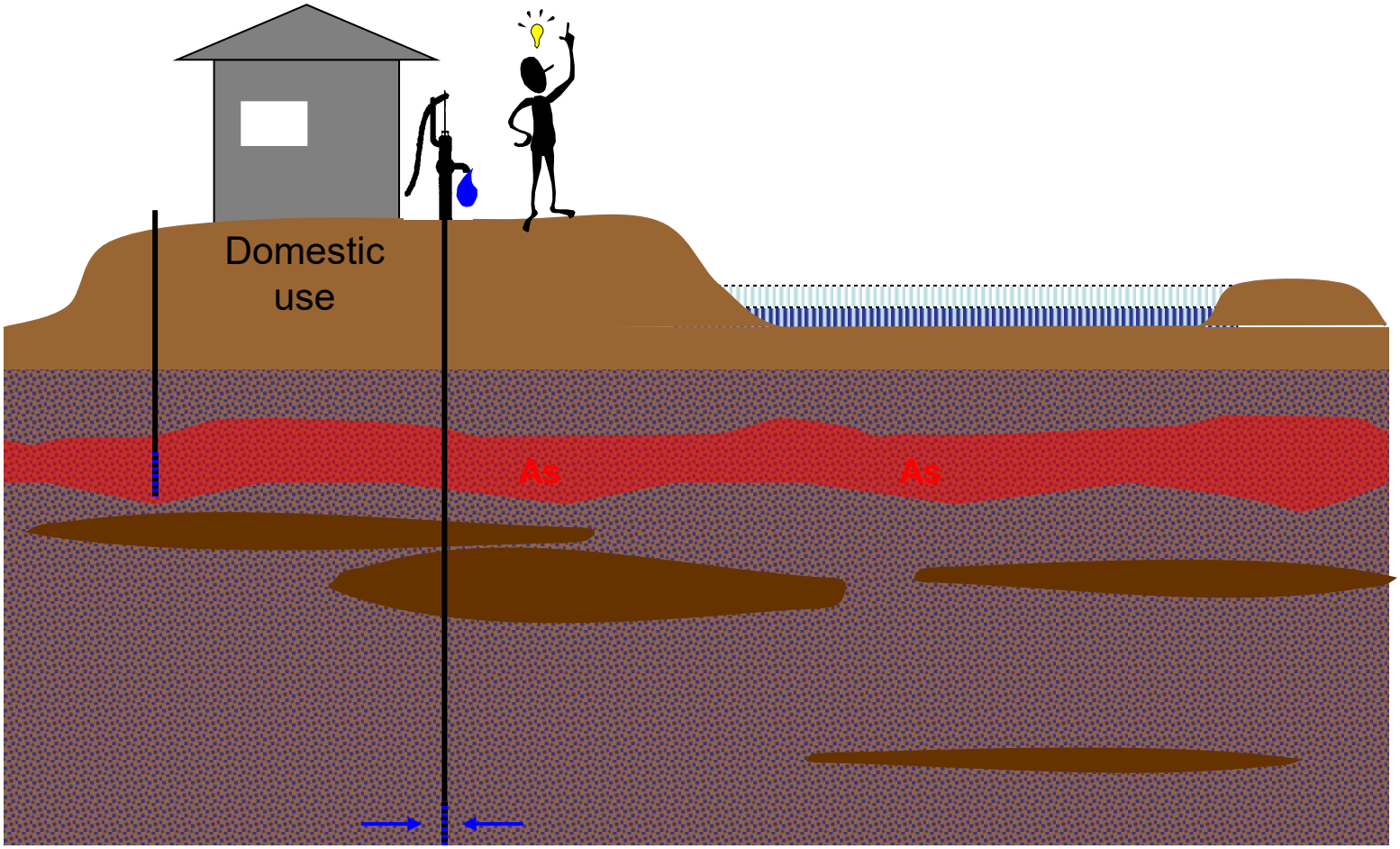
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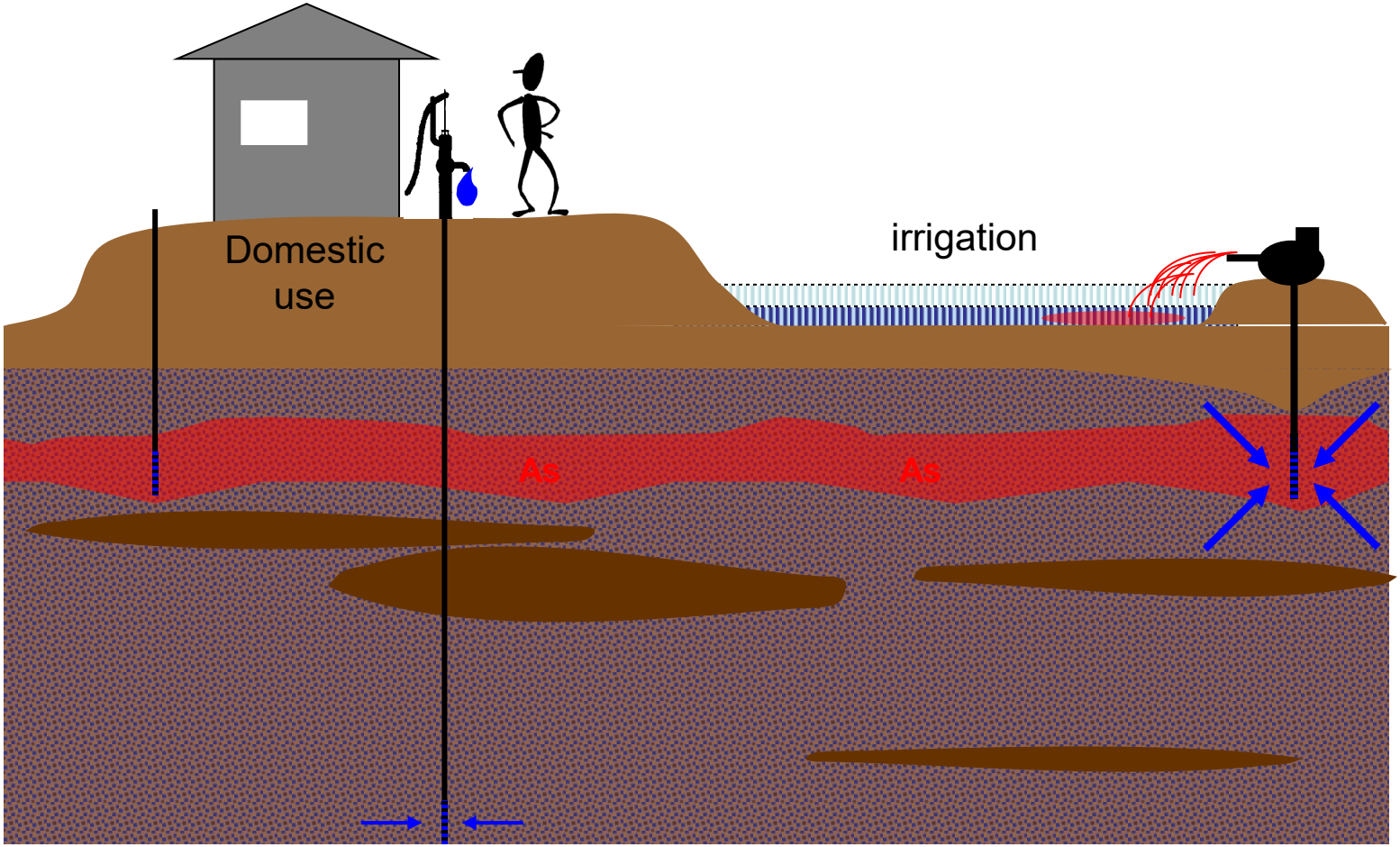
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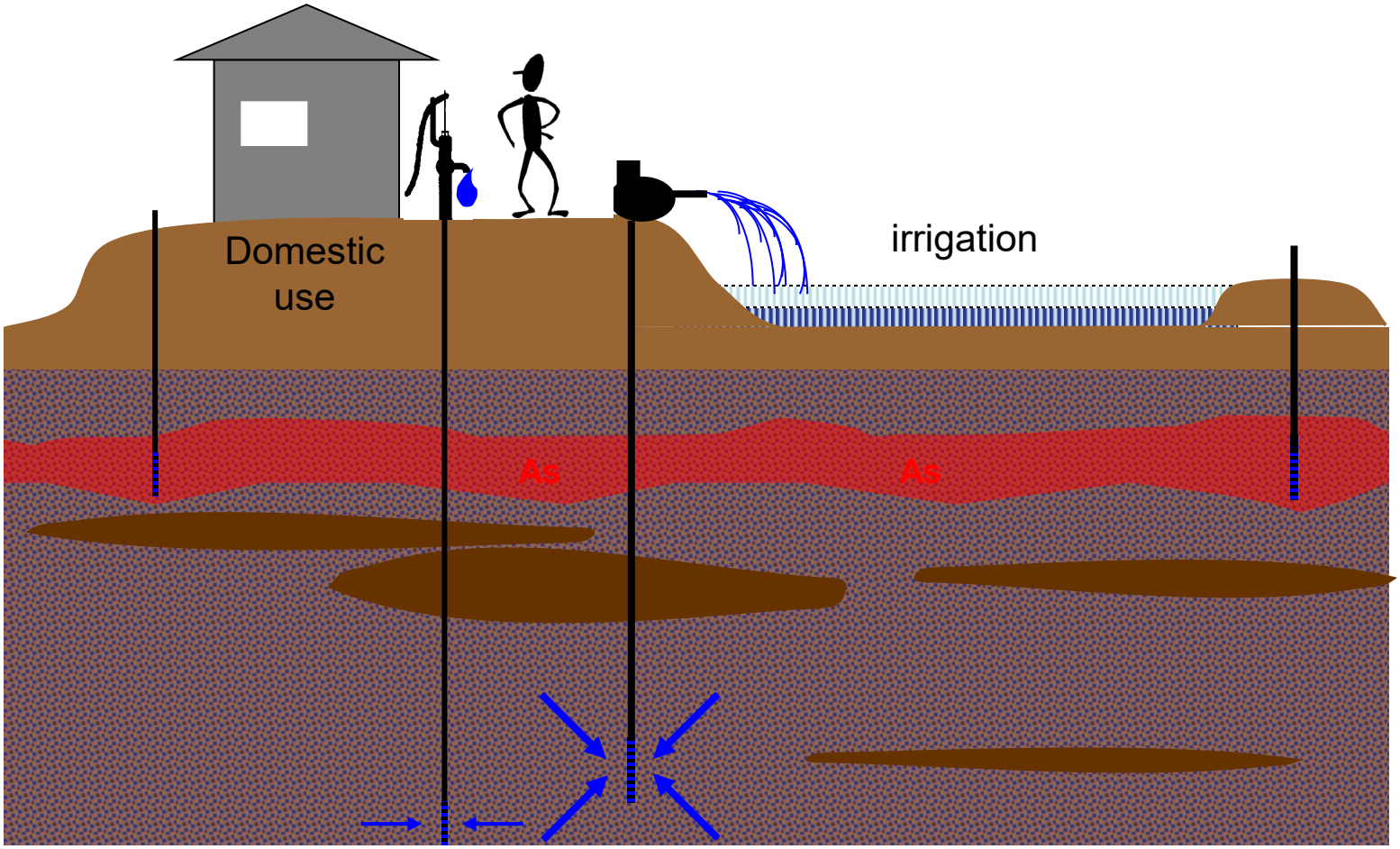
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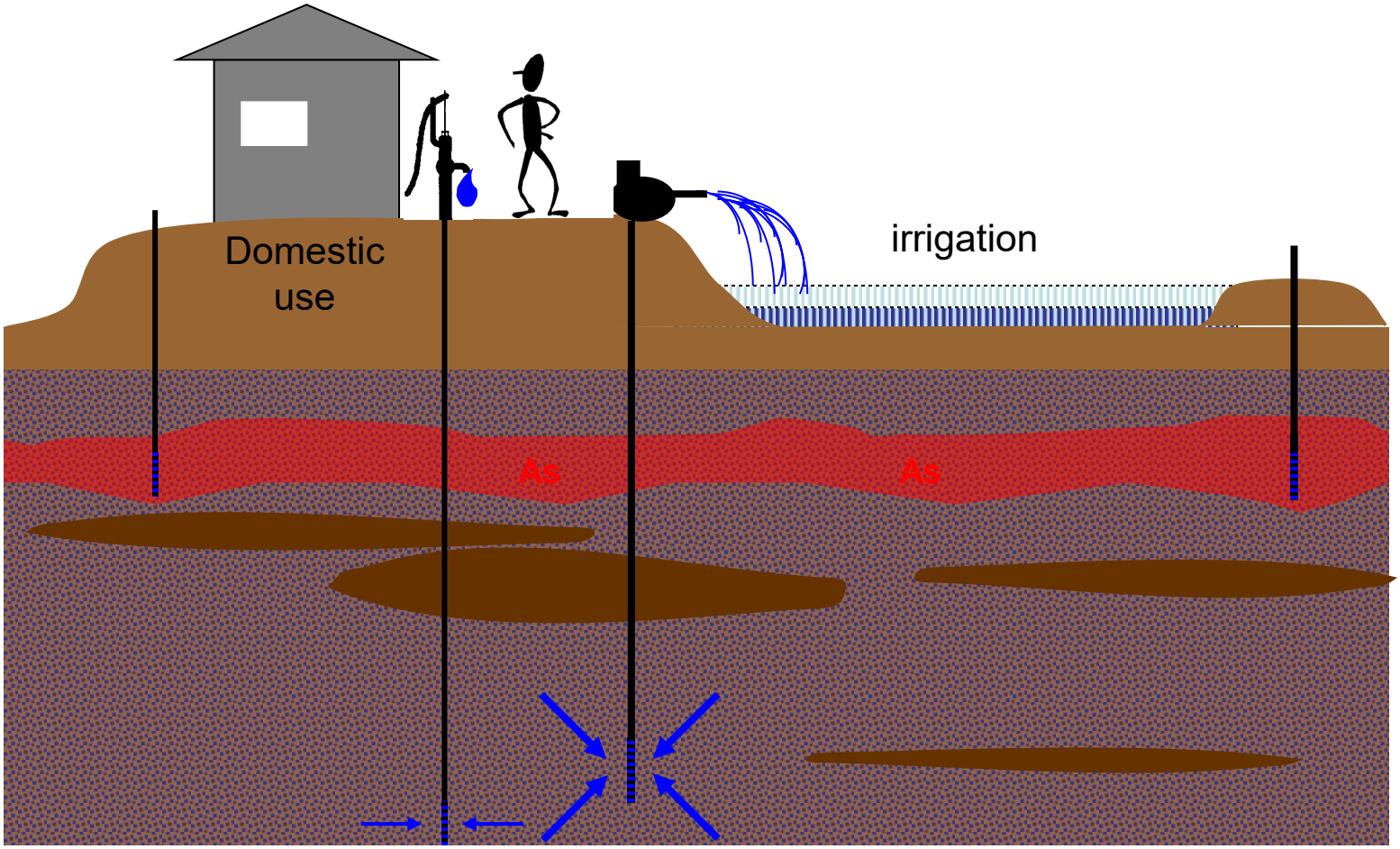
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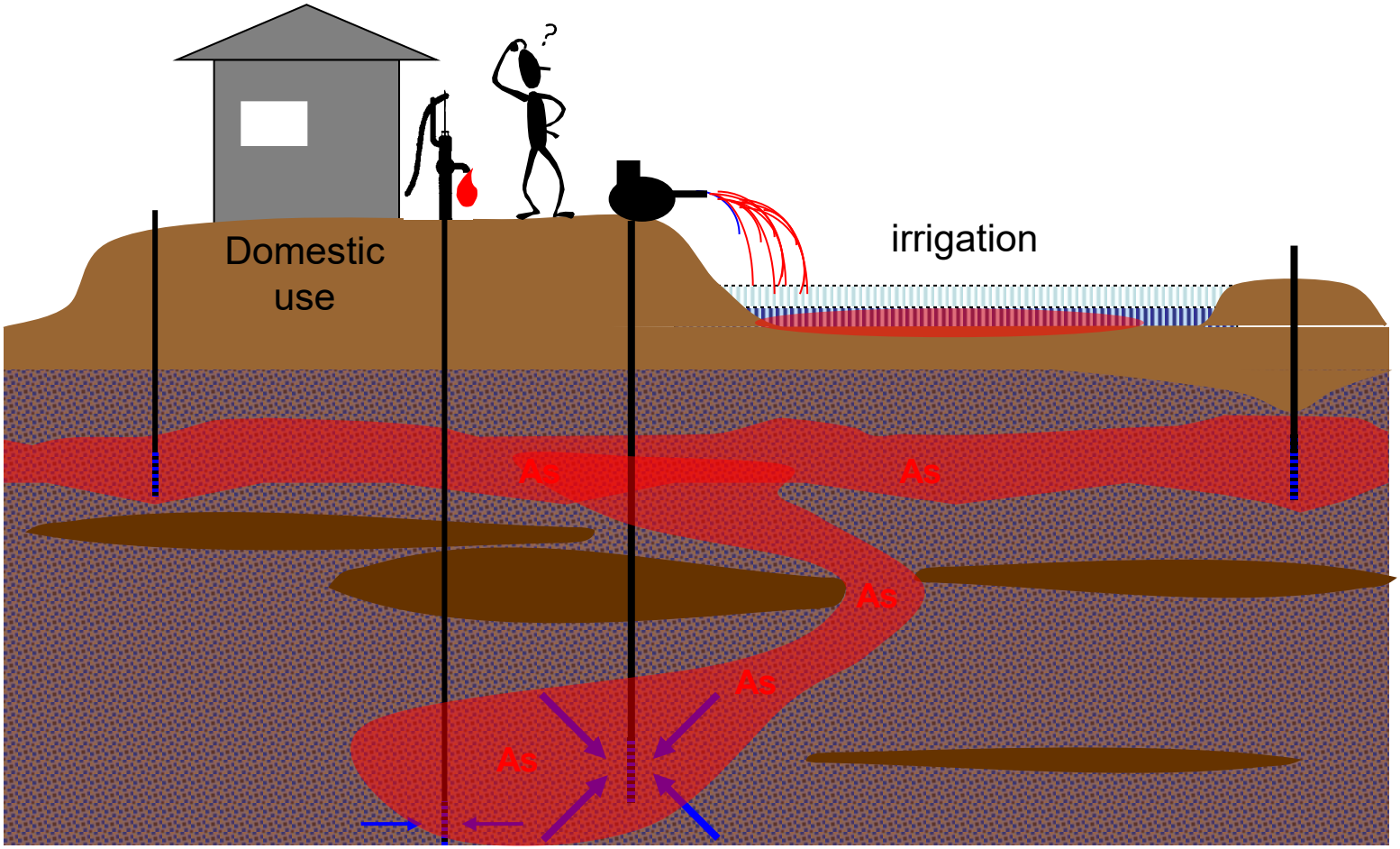
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