Groundwater Hydrology and Water Wells

Objectives

- Introduce and review concepts of the hydrologic cycle and groundwater hydrology
- Introduce and review general water well concepts

Where is the world's water?

Saline water in oceans: 97.2%

Ice caps and glaciers: 2.14%

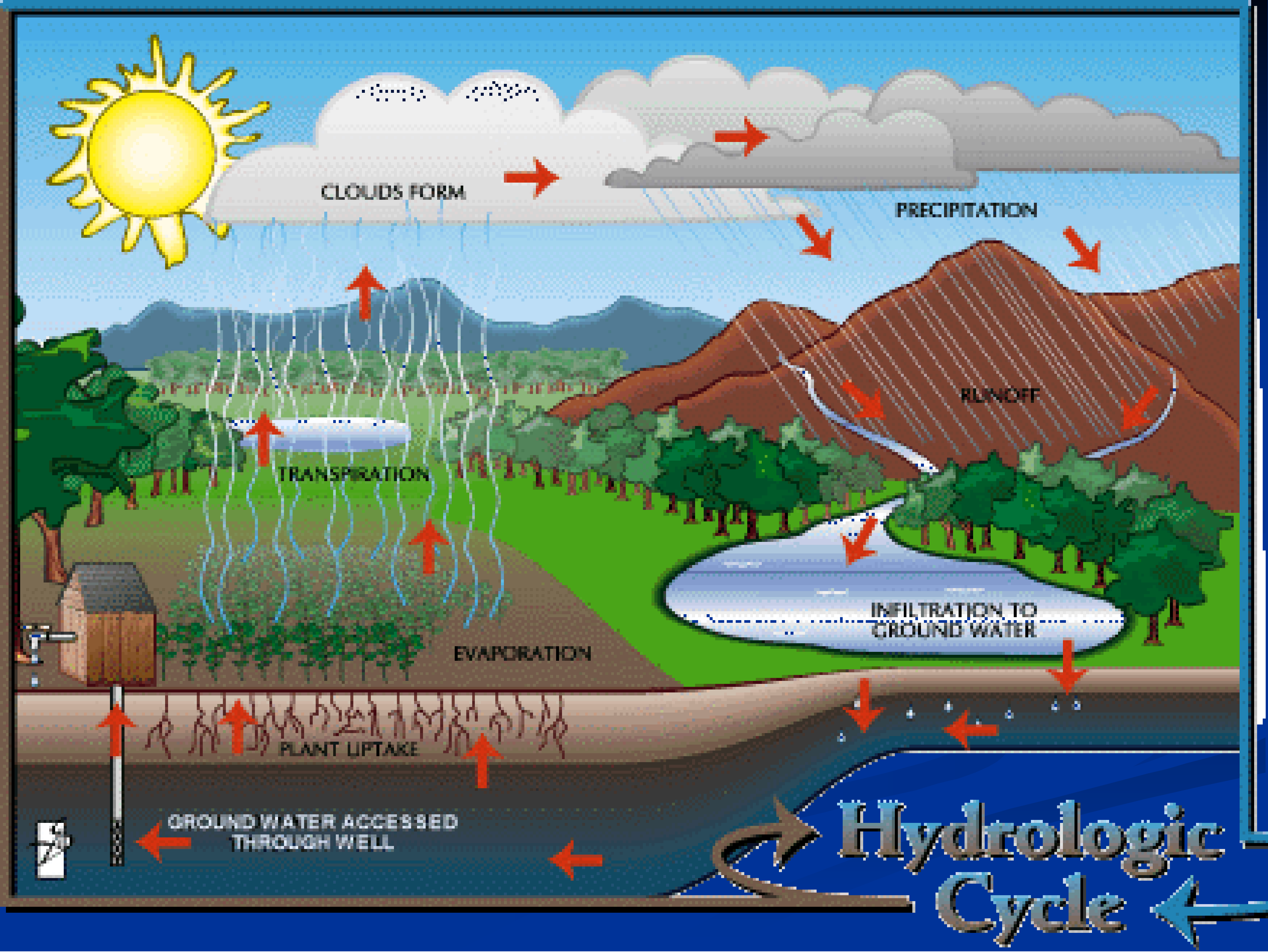
Groundwater: 0.61%

Surface water: 0.009%

Soil moisture: 0.005%

Atmosphere: 0.001%

Source: Fetter, 1994



CLOUDS FORM
PRECIPITATION
RUNOFF
TRANSPIRATION
INFILTRATION TO GROUND WATER
EVAPORATION
PLANT UPTAKE
GROUND WATER ACCESSED THROUGH WELL
Hydrologic Cycle

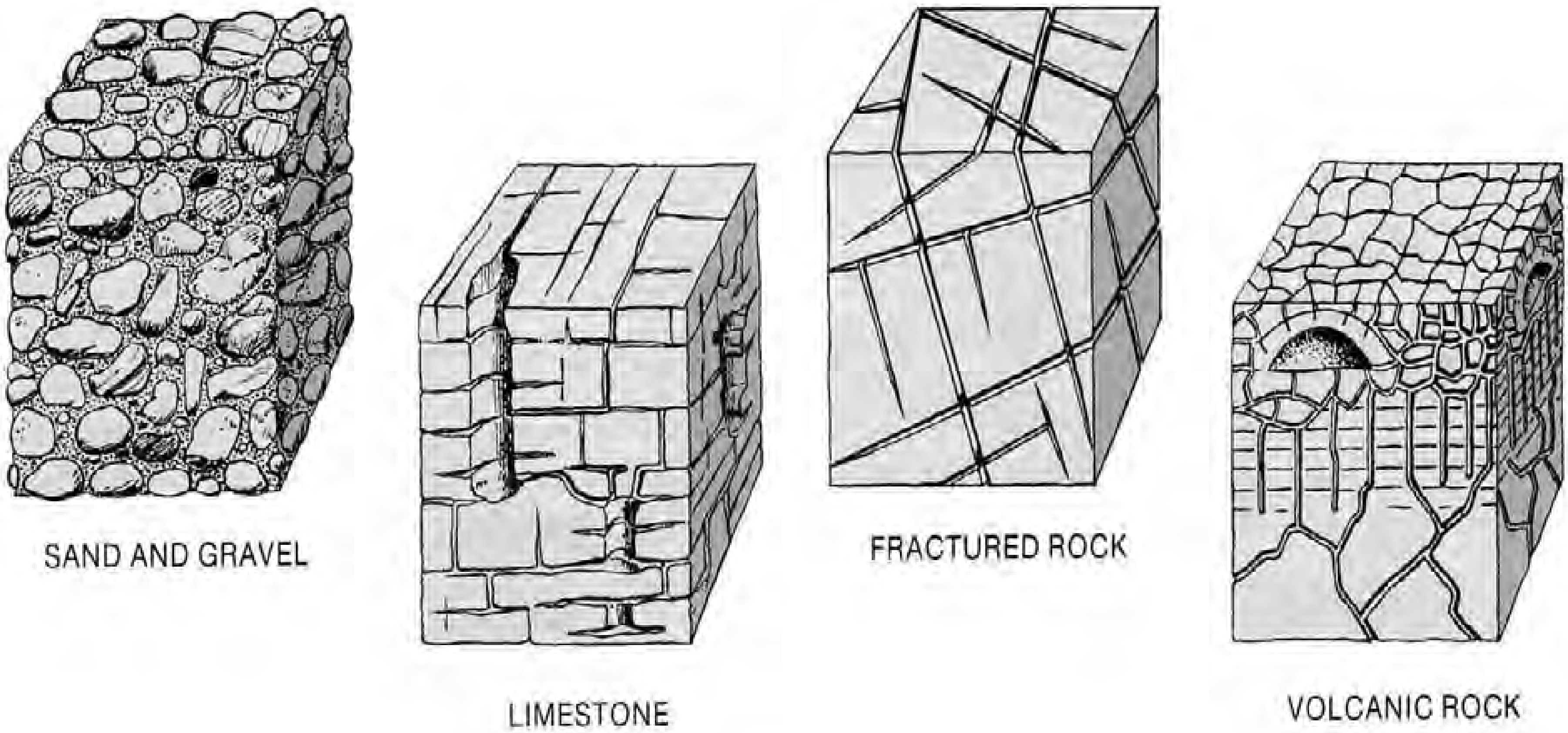
Introduction to Hydrogeology

What is an aquifer?

"A geologic formation with sufficient interconnected porosity and permeability to store and transmit significant quantities of water under natural hydraulic gradients"

source: The groundwater pollution and hydrology course, Cleary, R.W. 2003

4 Common Aquifer Materials



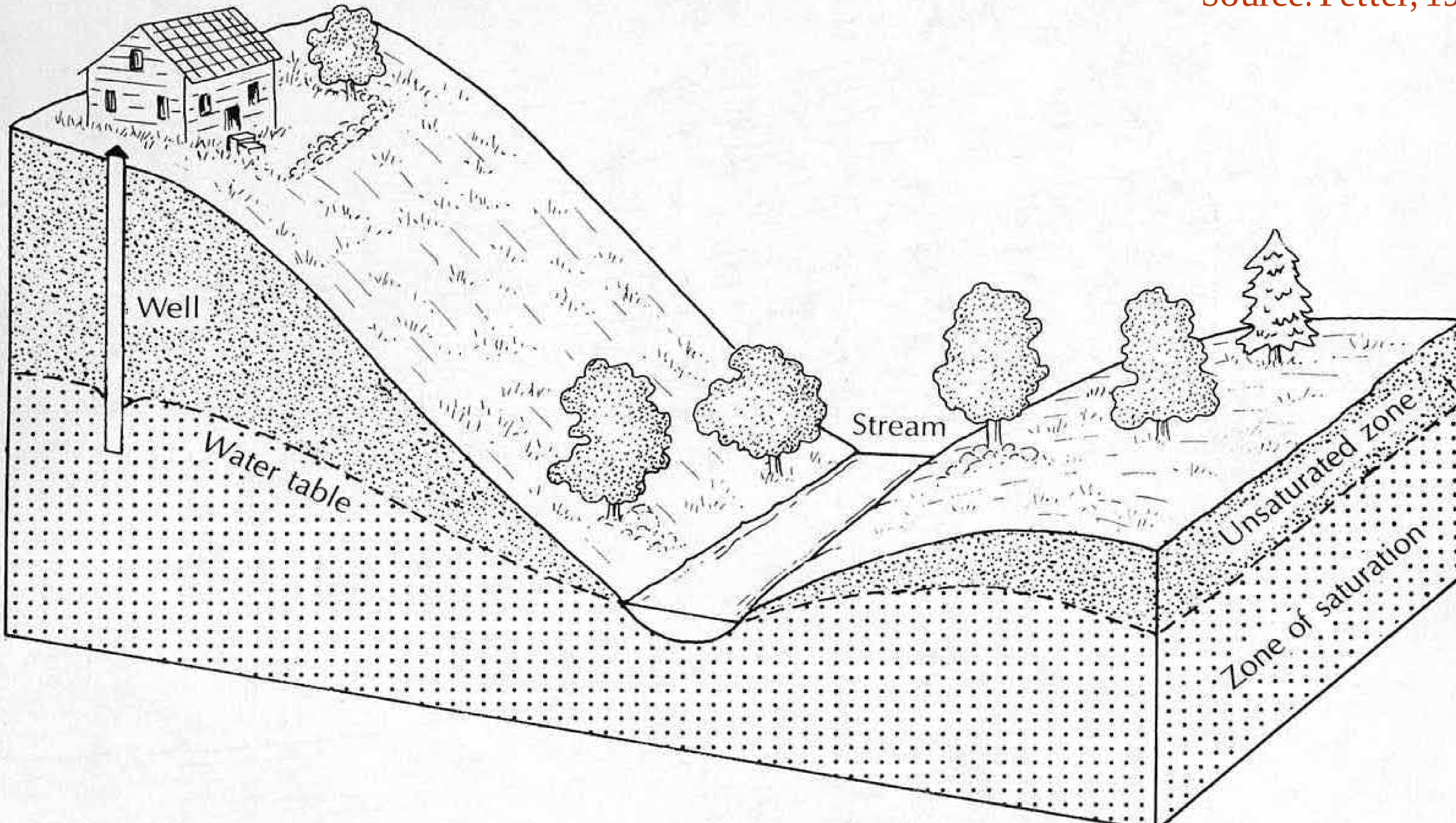
Source: AWWA well performance series – pt 1, 1986

Aquifer Types

- Unconfined (water table)
- Confined
- Perched

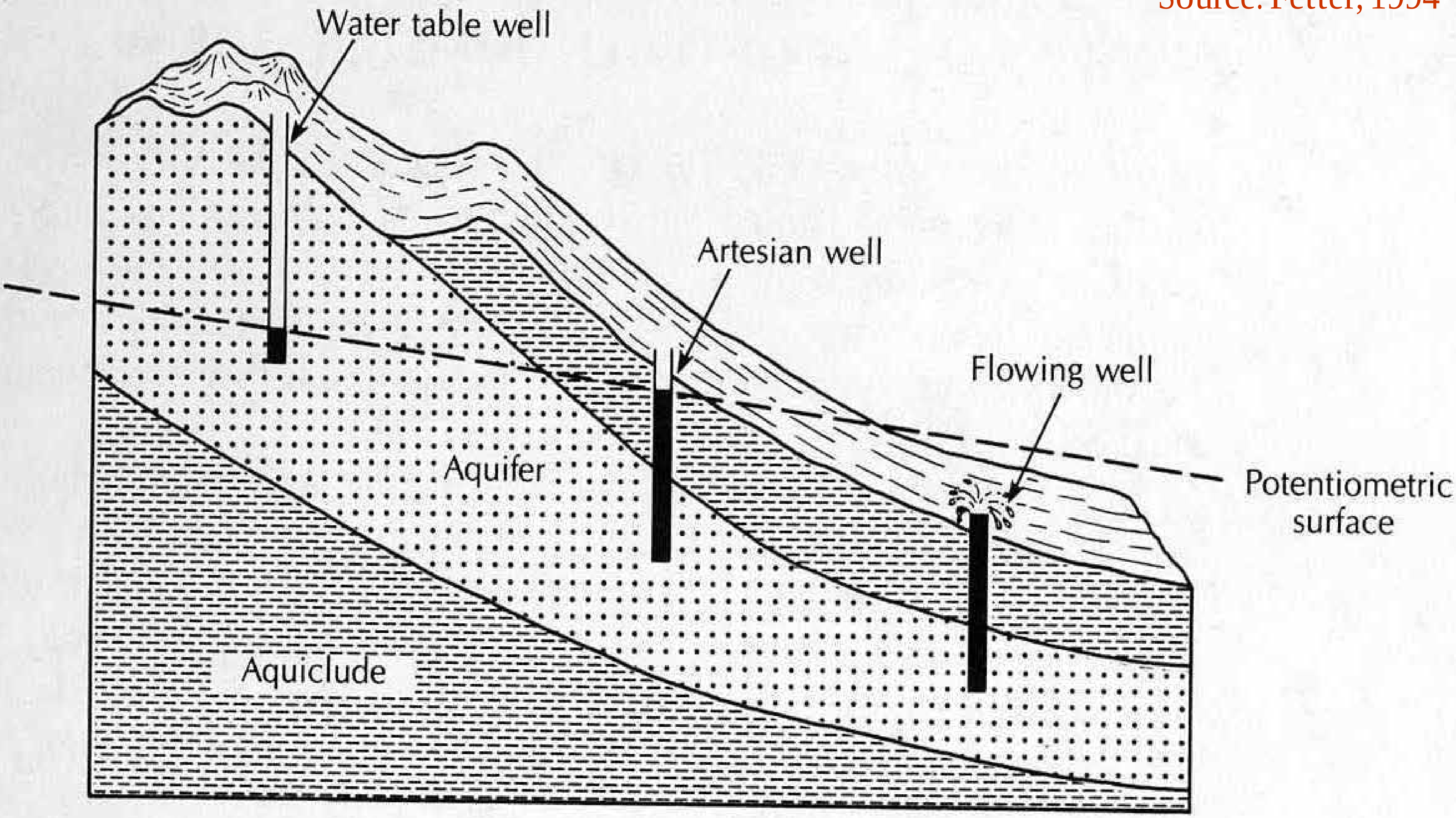
Unconfined Aquifer

Source: Fetter, 1994



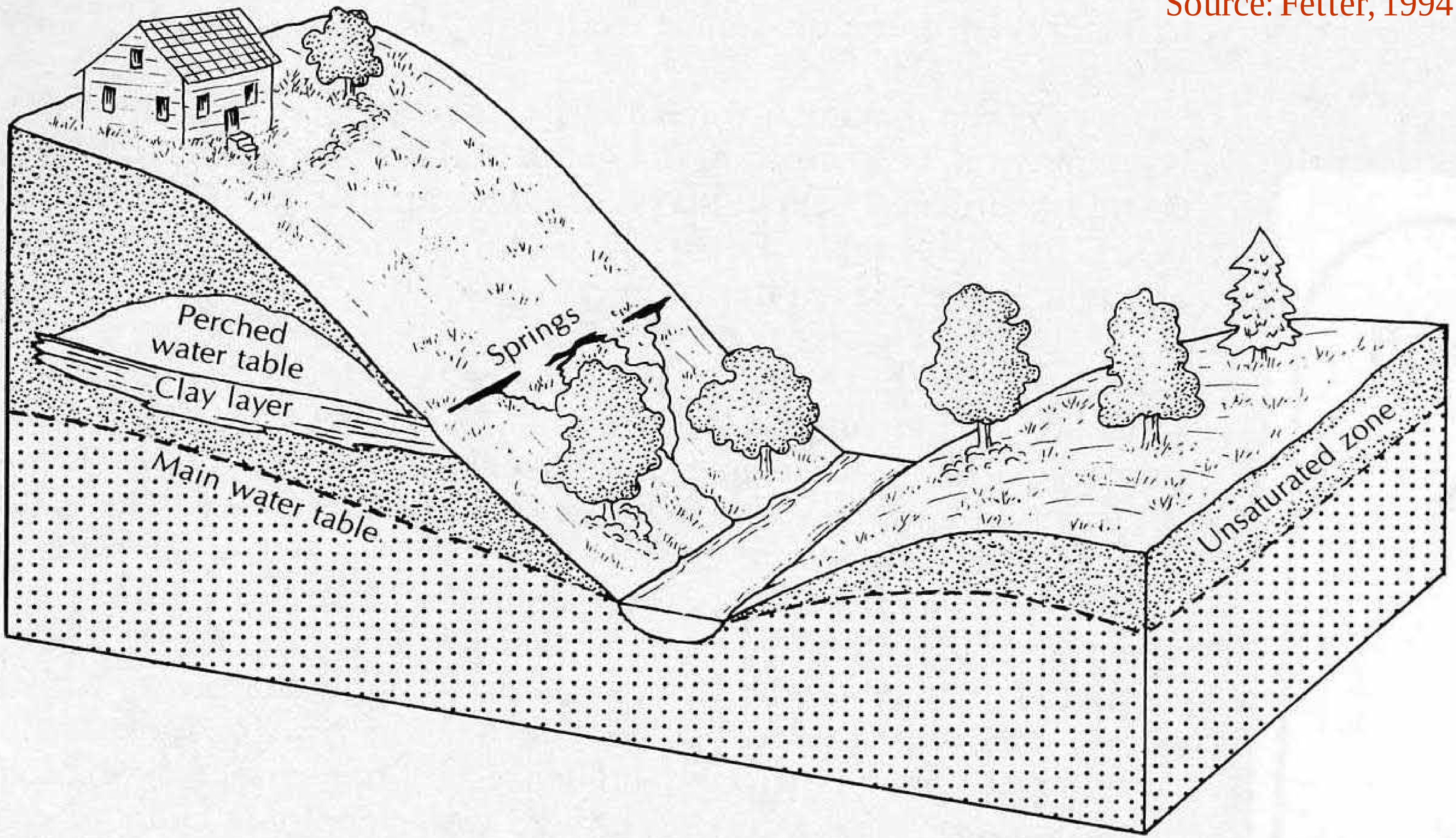
Confined Aquifer

Source: Fetter, 1994



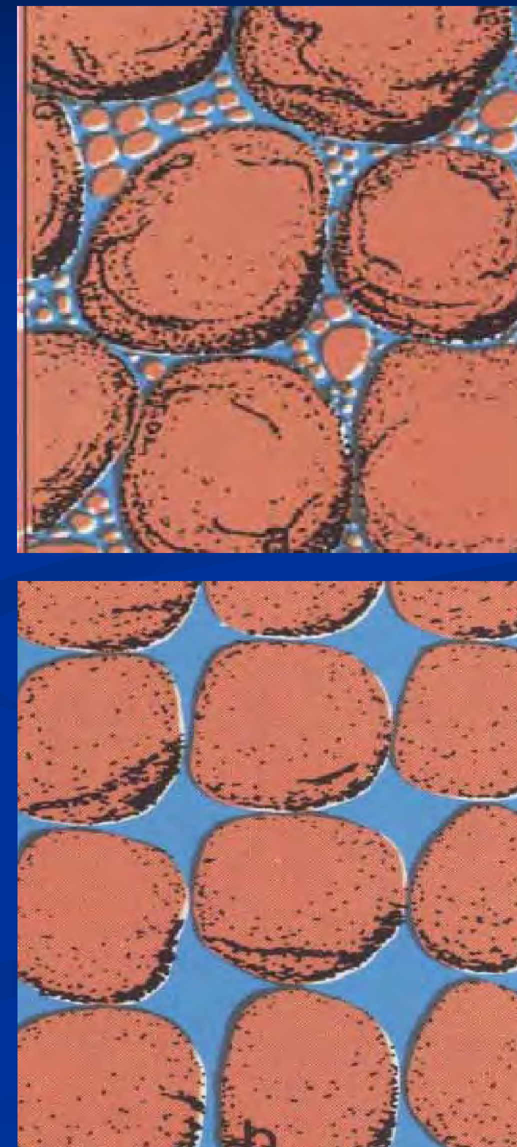
Perched Aquifer

Source: Fetter, 1994



Groundwater Movement (Henry Darcy)

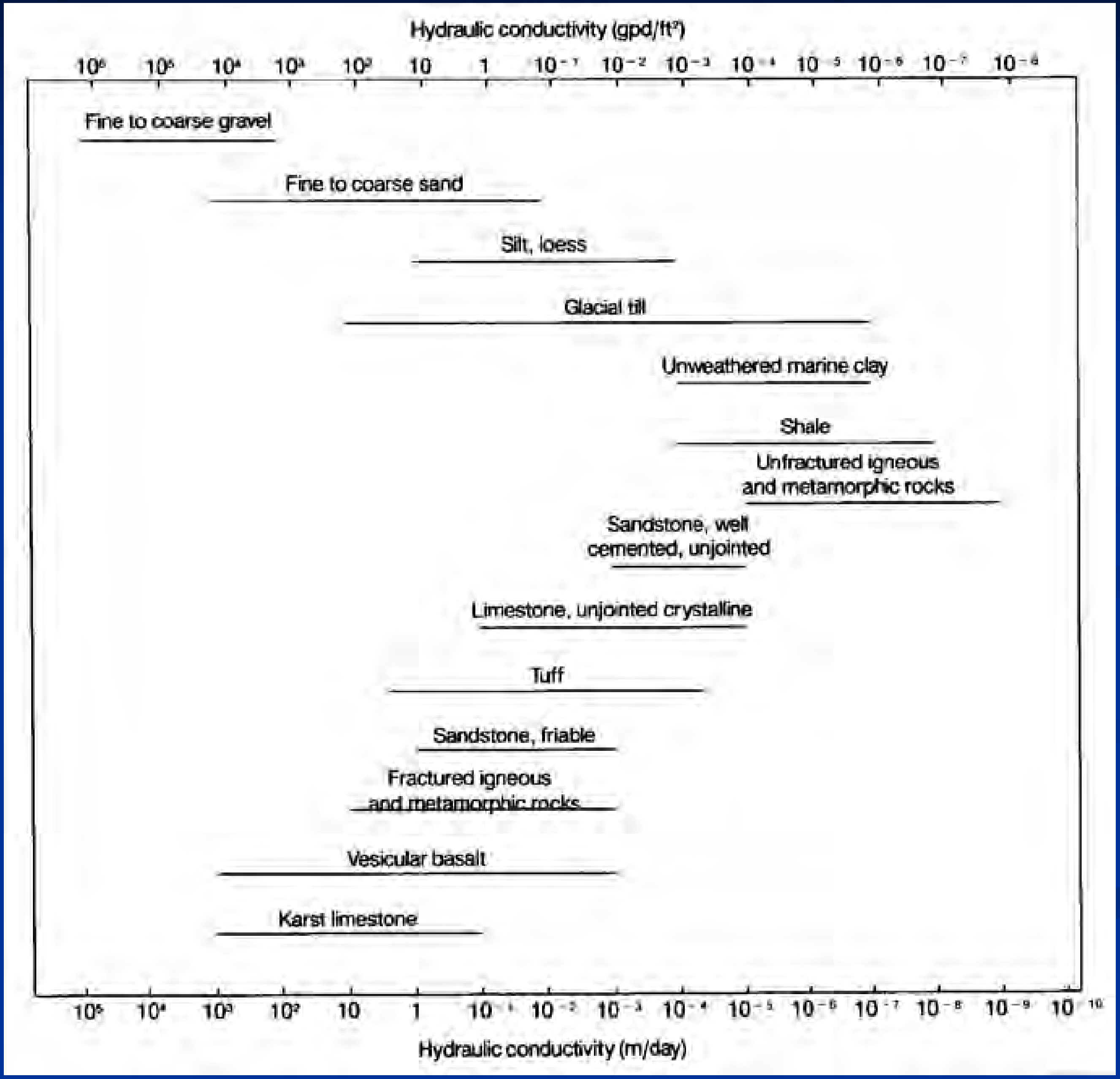
- 6 Key Concepts
  - Porosity (void volume)
  - Permeability (connectivity)
  - Hydraulic Conductivity (ability to conduct water)
  - Specific Yield (ratio of water per unit of rock or soil)
  - Transmissivity (volumetric flow rate (gal / ft / day)
  - Potential (pressure, elevation, kinetic energy)



Porosity Values

Unconsolidated Sediments	η (%)	Consolidated Rocks	η (%)
Clay	45–55	Sandstone	5–30
Silt	35–50	Limestone/dolomite (original & secondary porosity	1–20
Sand	25–40	Shale	0–10
Gravel	25–40	Fractured crystalline rock	0–10
Sand & gravel mixes	10–35	Vesicular basalt	10–50
Glacial till	10–25	Dense, solid rock	< 1

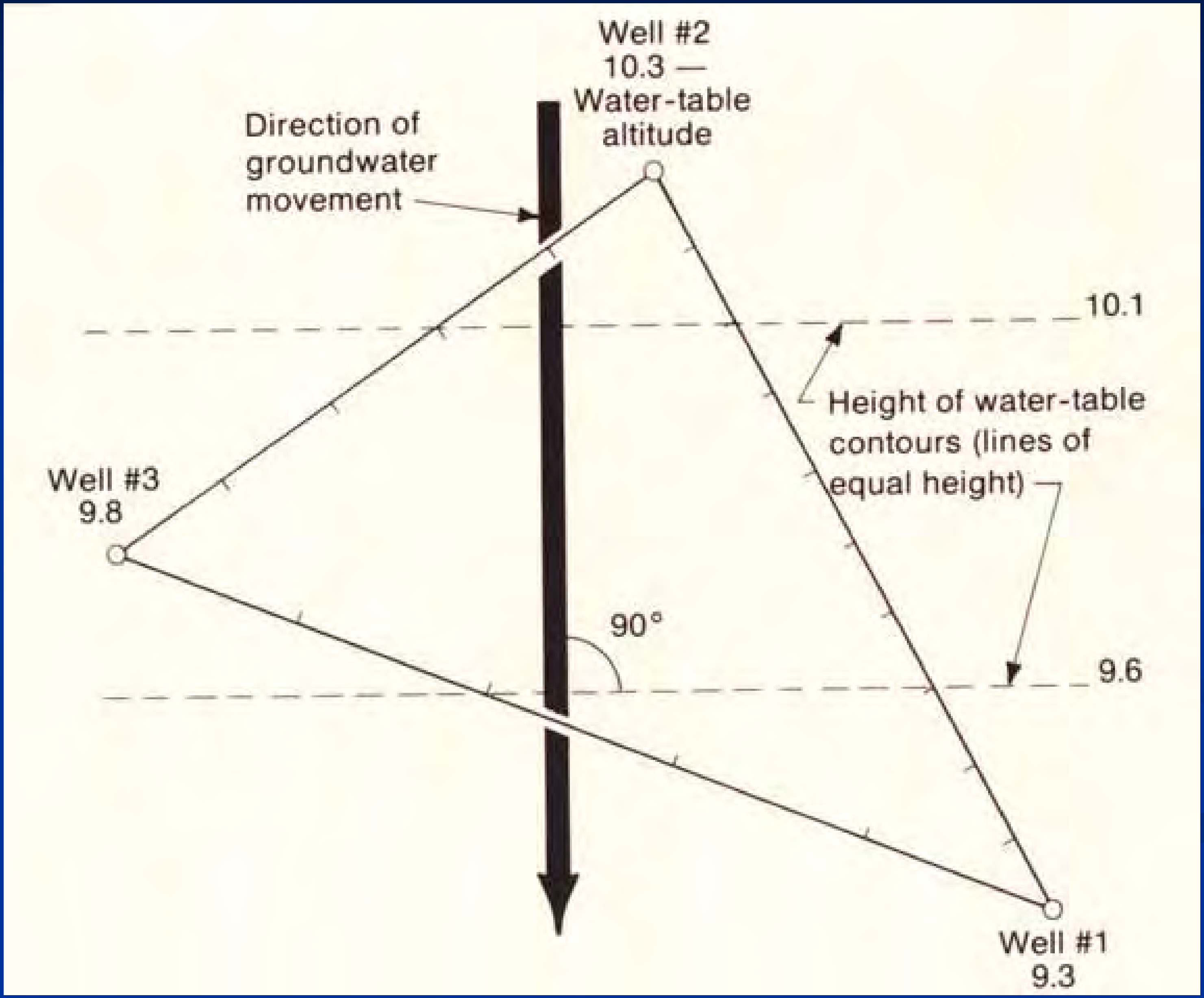
Hydraulic Conductivity Values



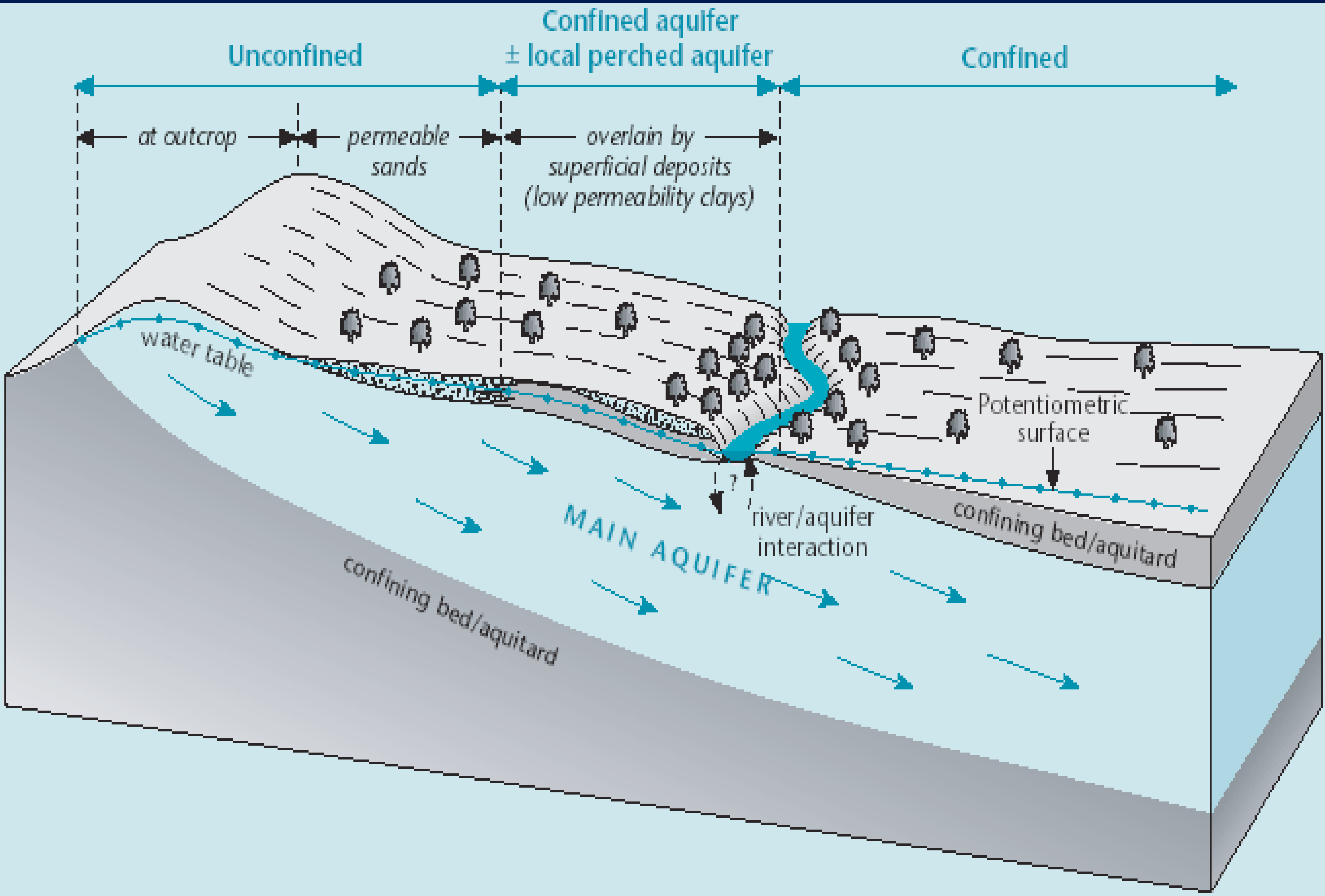
Specific Yield Values

Sediment	Specific Yield, %
Clay	1–10
Sand	10–30
Gravel	15–30
Sand and Gravel	15–25
Sandstone	5–15
Shale	0.5– 5
Limestone	0.5– 5

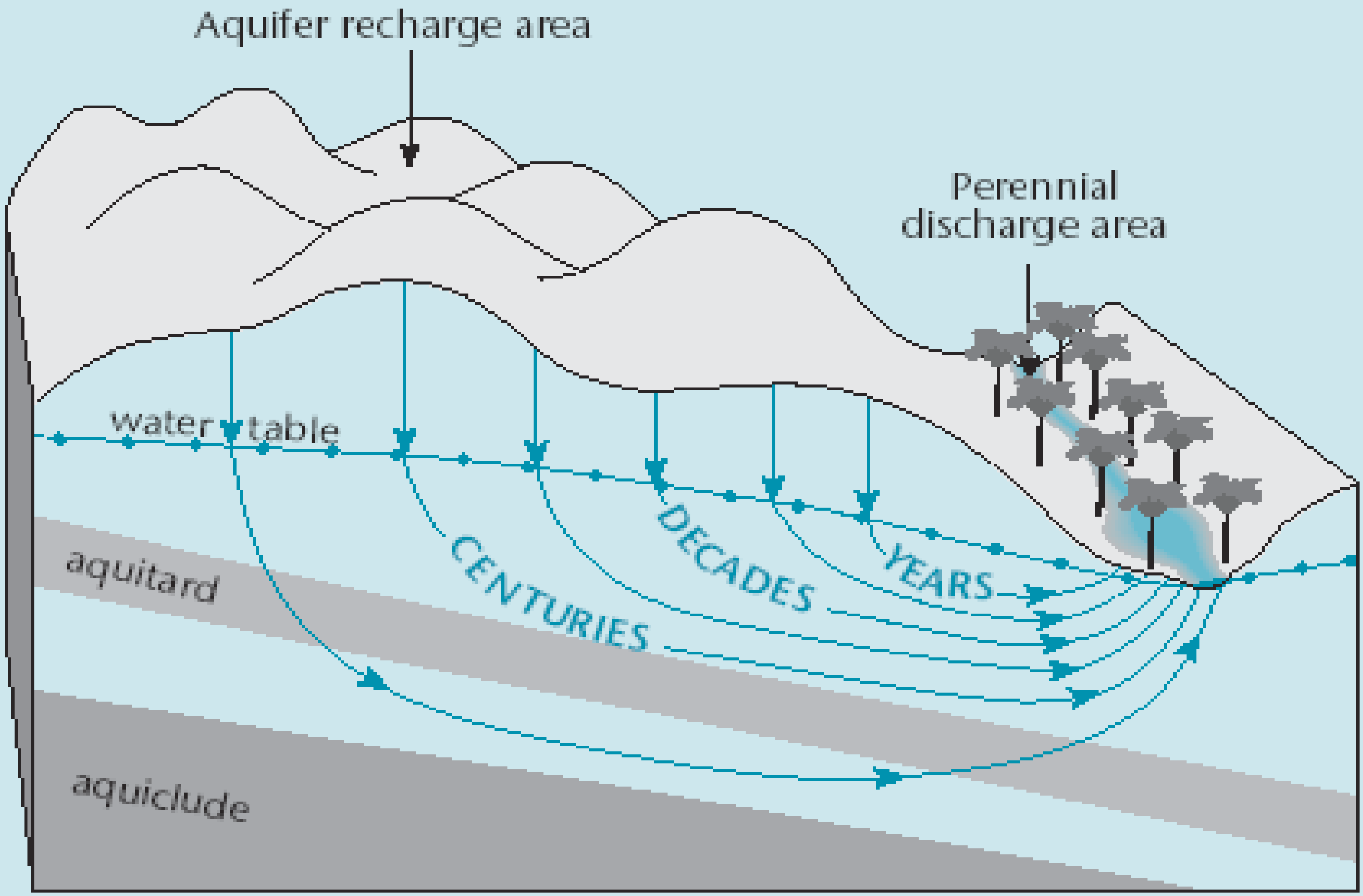
Determining Aquifer Flow



Common Aquifer System

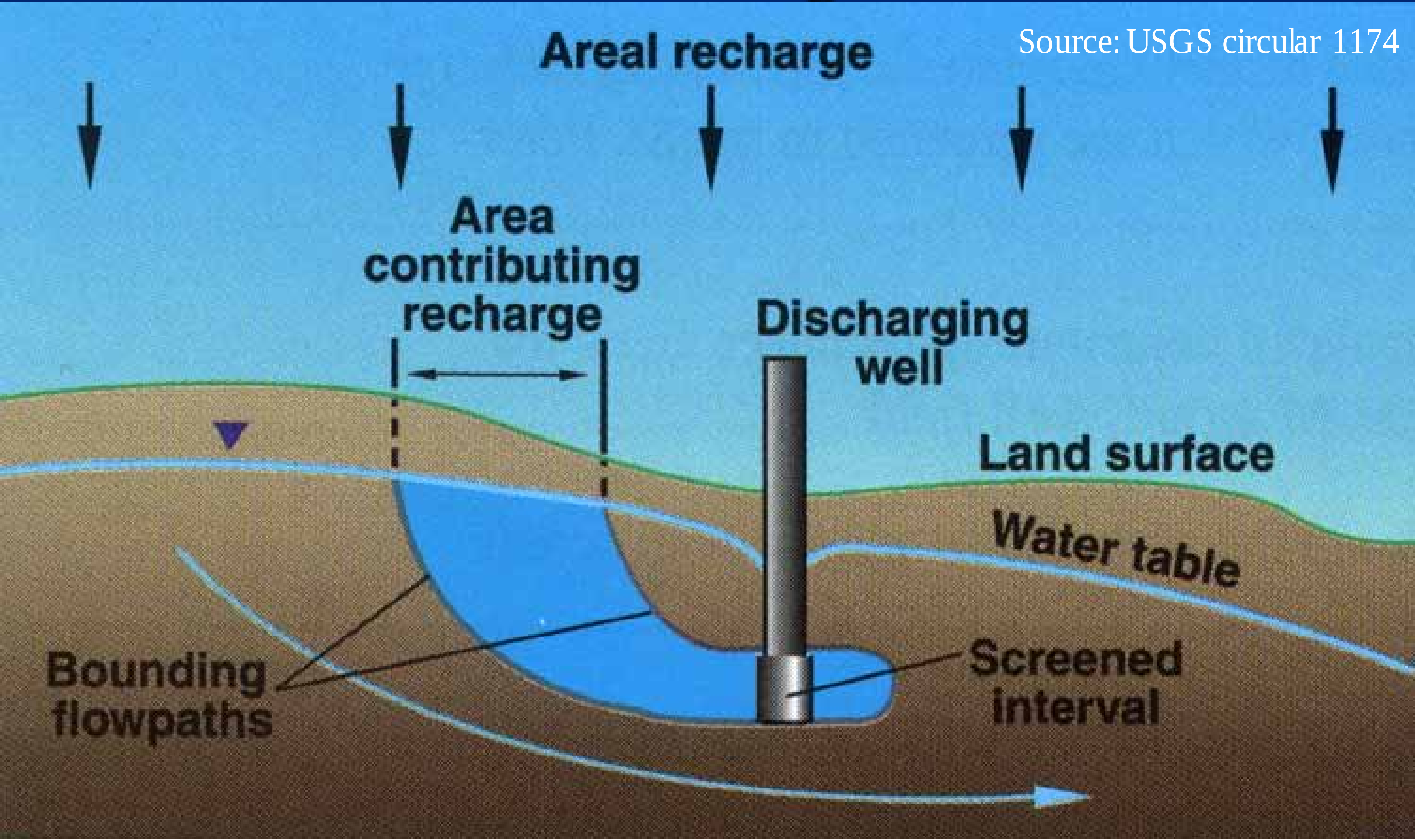


Regional Aquifer Flow System

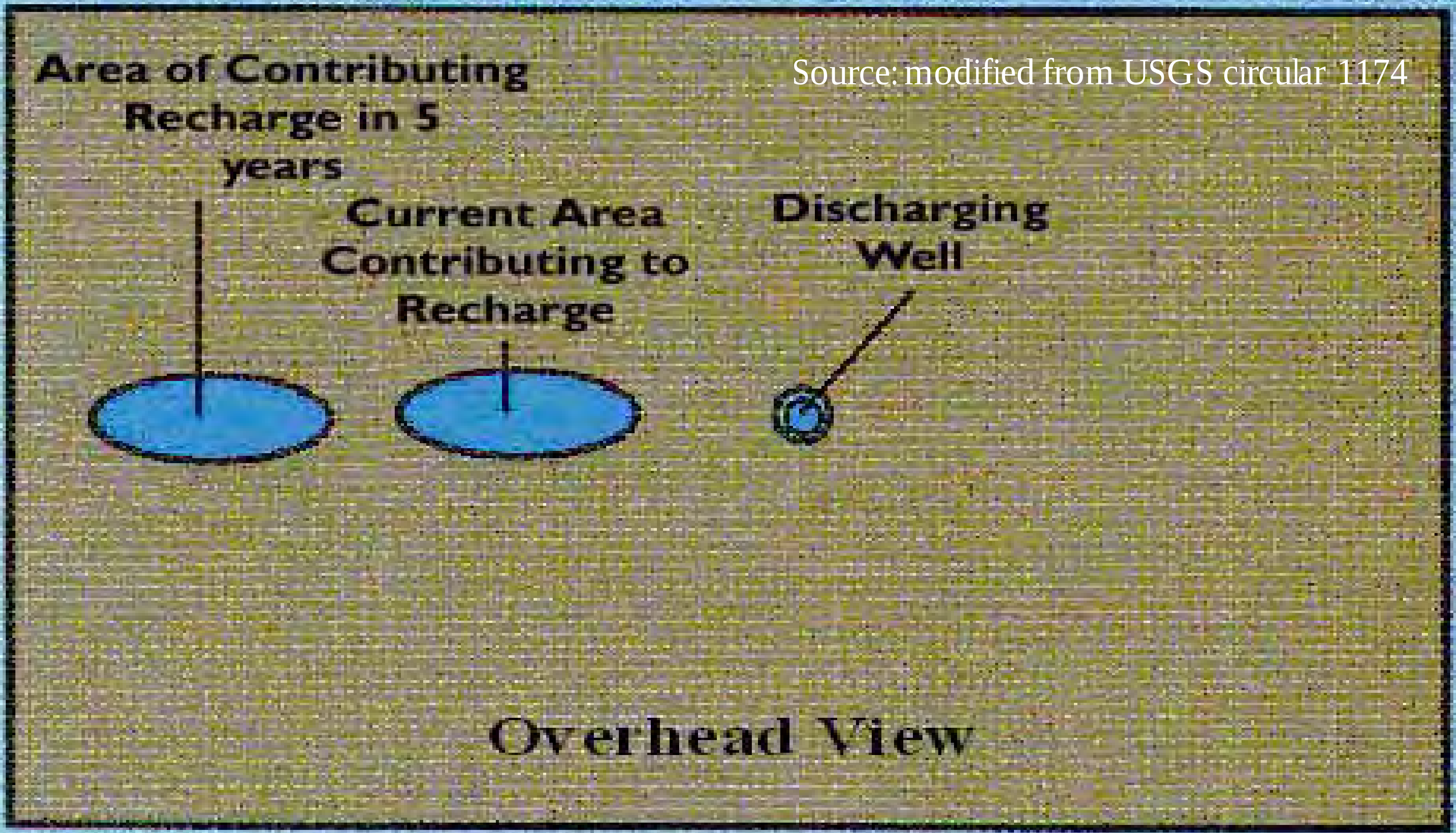


Basic Groundwater Recharge & Discharge

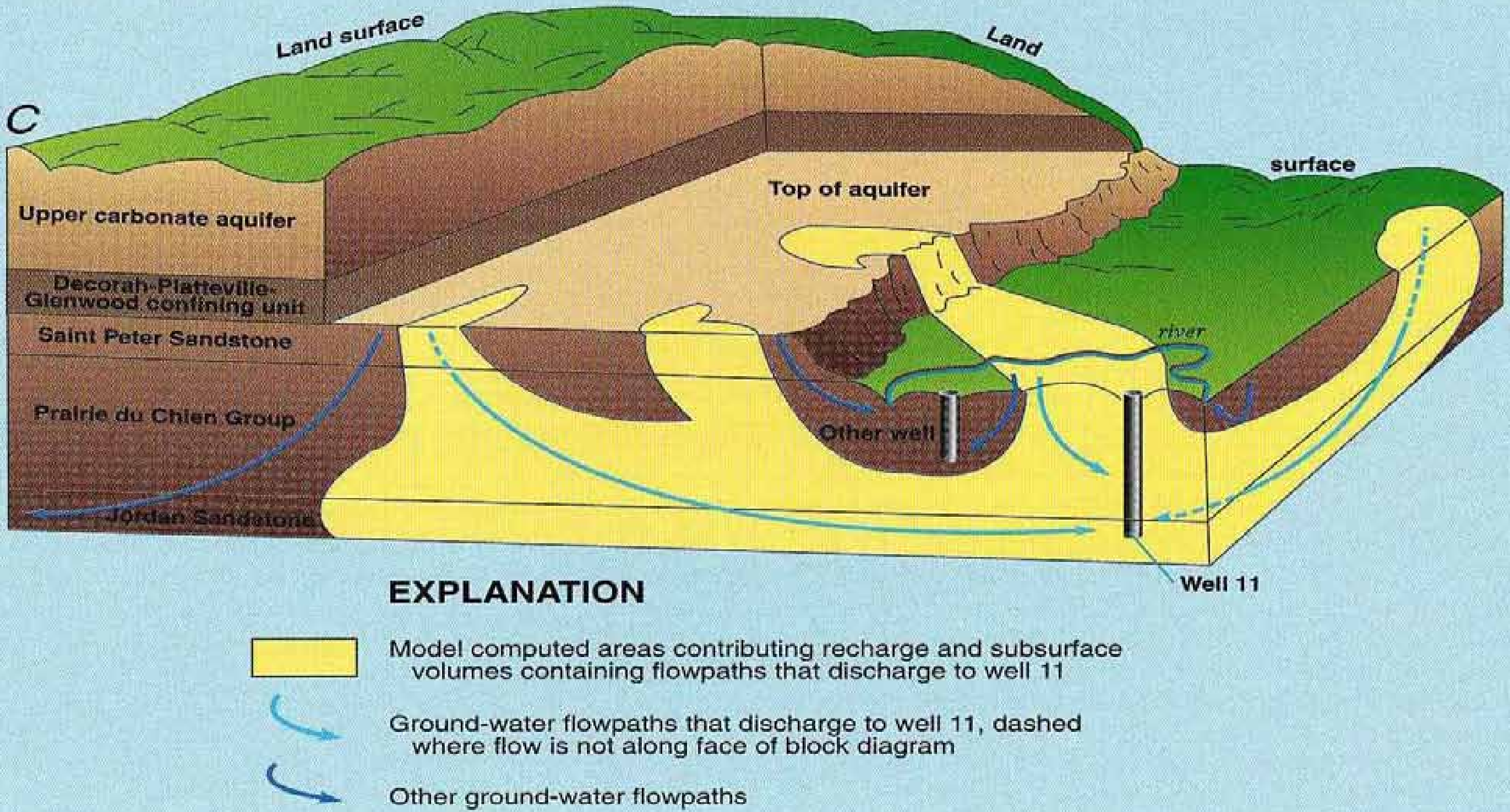
Source: USGS circular 1174



Basic Recharge & Discharge Continued



Complex Recharge & Discharge



Source: USGS circular 1174

Basic Groundwater Quality

Major constituents (greater than 5 mg/ℓ)		Copper	Rubidium
Bicarbonate	Silicon	Gallium	Ruthenium
Calcium	Sodium	Germanium	Scandium
Chloride	Sulfate	Gold	Selenium
Magnesium		Indium	Silver
Minor constituents (0.01-10.0 mg/ℓ)		Iodide	Thallium
Boron	Nitrate	Lanthanum	Thorium
Carbonate	Potassium	Lead	Tin
Fluoride	Strontium	Lithium	Titanium
Iron		Manganese	Tungsten
Trace constituents (less than 0.1 mg/ℓ)		Molybdenum	Uranium
Aluminum	Bromide	Nickel	Vanadium
Antimony	Cadmium	Niobium	Ytterbium
Arsenic	Cerium	Phosphate	Yttrium
Barium	Cesium	Platinum	Zinc
Beryllium	Chromium	Radium	Zirconium
Bismuth	Cobalt		

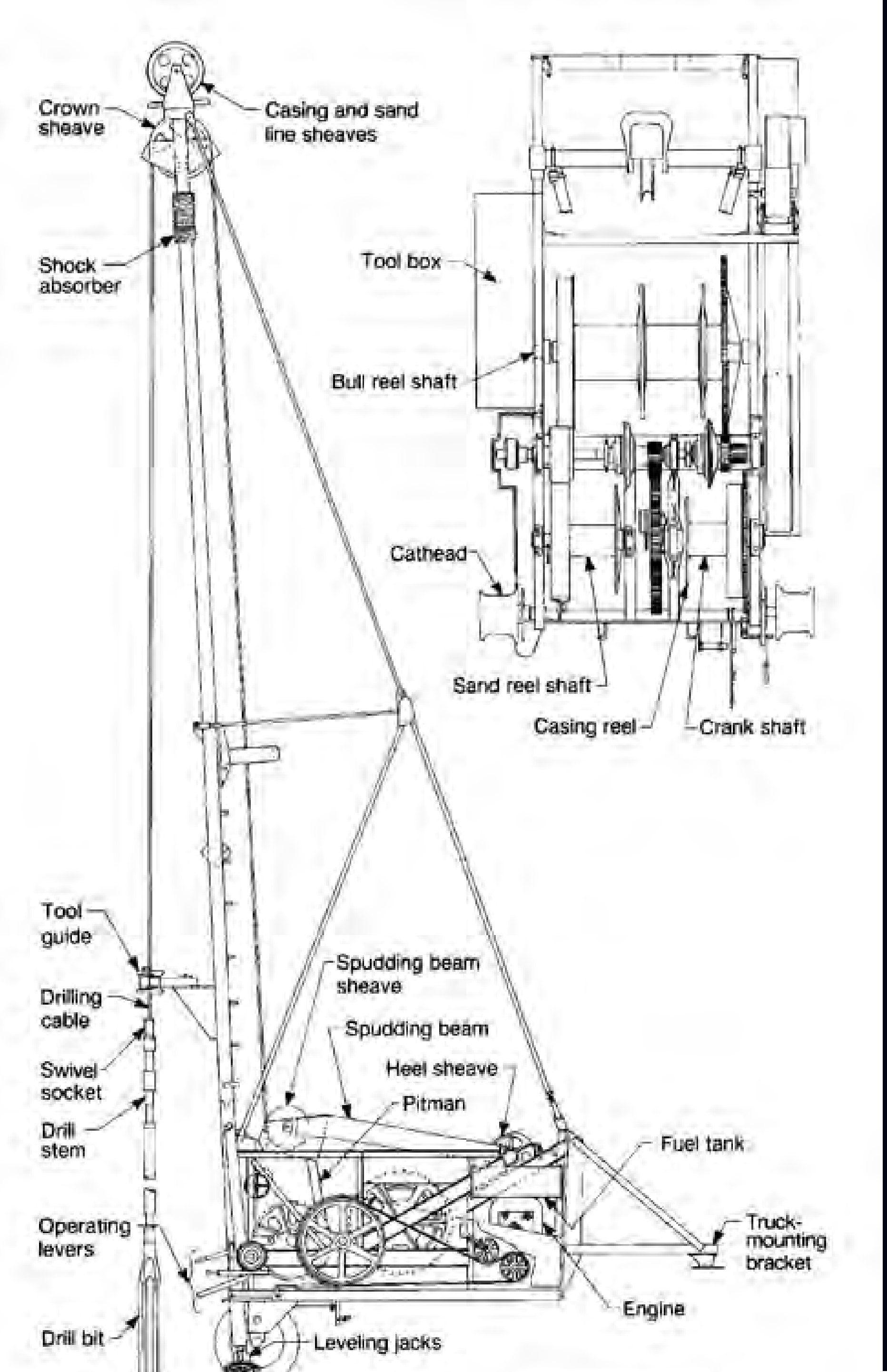
(Davis and De Wiest, 1966)

Water Wells 101

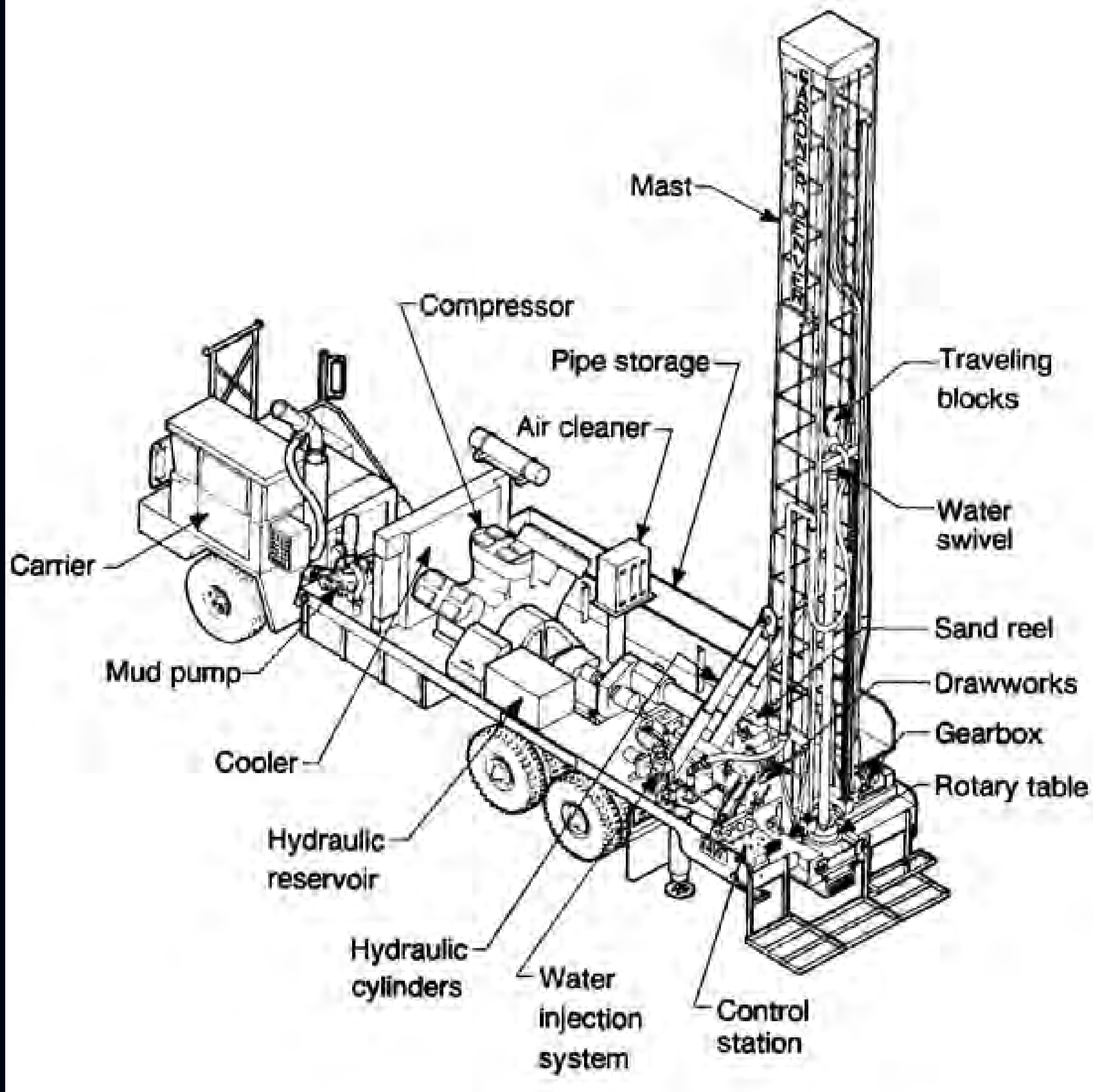
Types of Well Construction

- Cable Tool or Percussion Method
  - Impact created by raising and dropping a heavy drill bit
  - Cuttings are extracted with a bailer
- Rotary Drilled/Reverse Rotary Drilled
  - Power driven drill stems cut formation
  - Drilling mud is pumped down to cool the bit
  - Cuttings are brought to the surface via the casing or drill stem
- Air Rotary
  - Impact created by pneumatic air hammer
  - Cuttings are brought up to surface by air pressure

Cable Tool Method



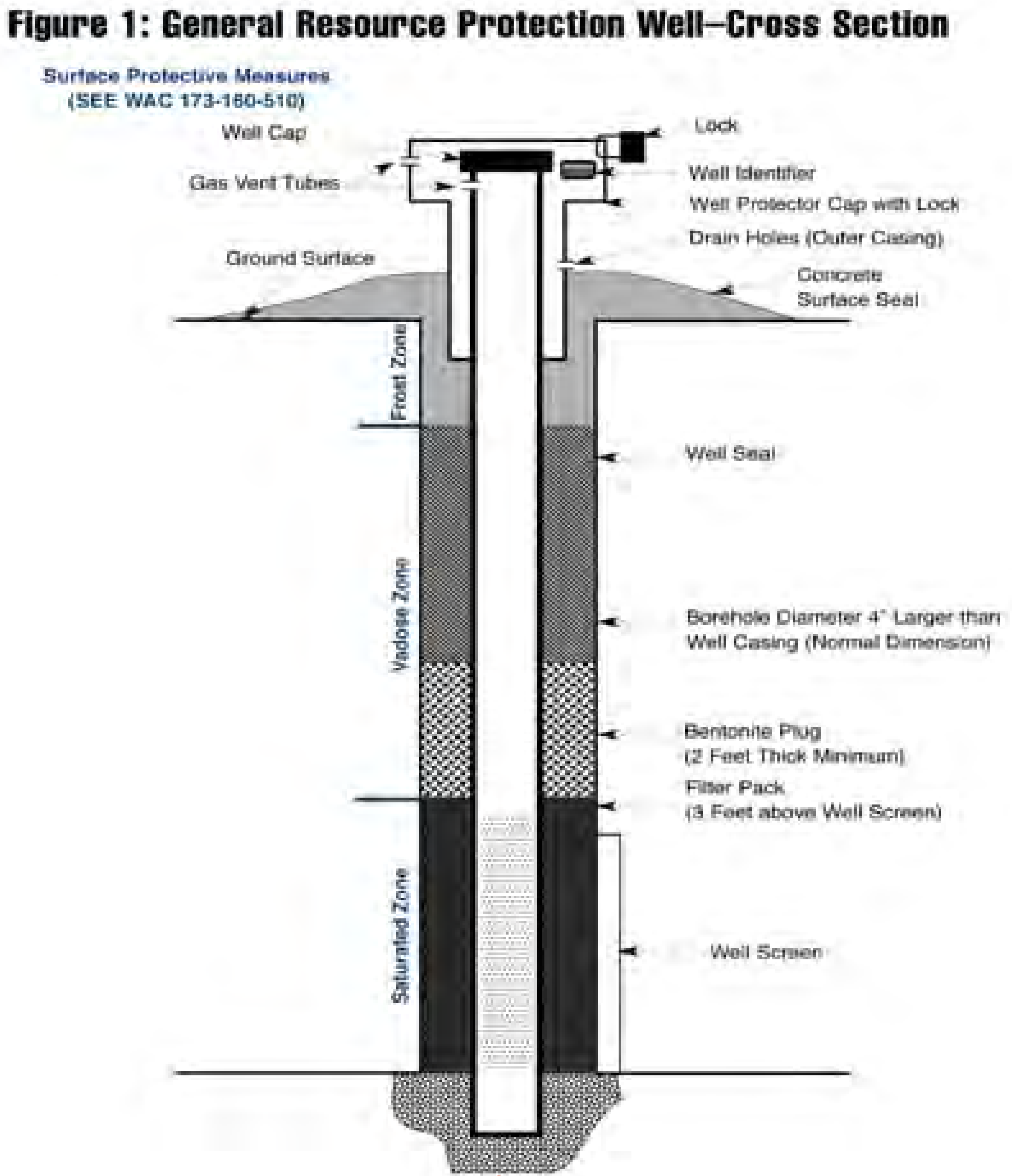
Rotary Method



Air Rotary Method

Well Development

Typical Water Well



Source: http://www.nesc.wvu.edu/ndwc/articles/OT/FA03/TB_figure1.html

Typical Water Well

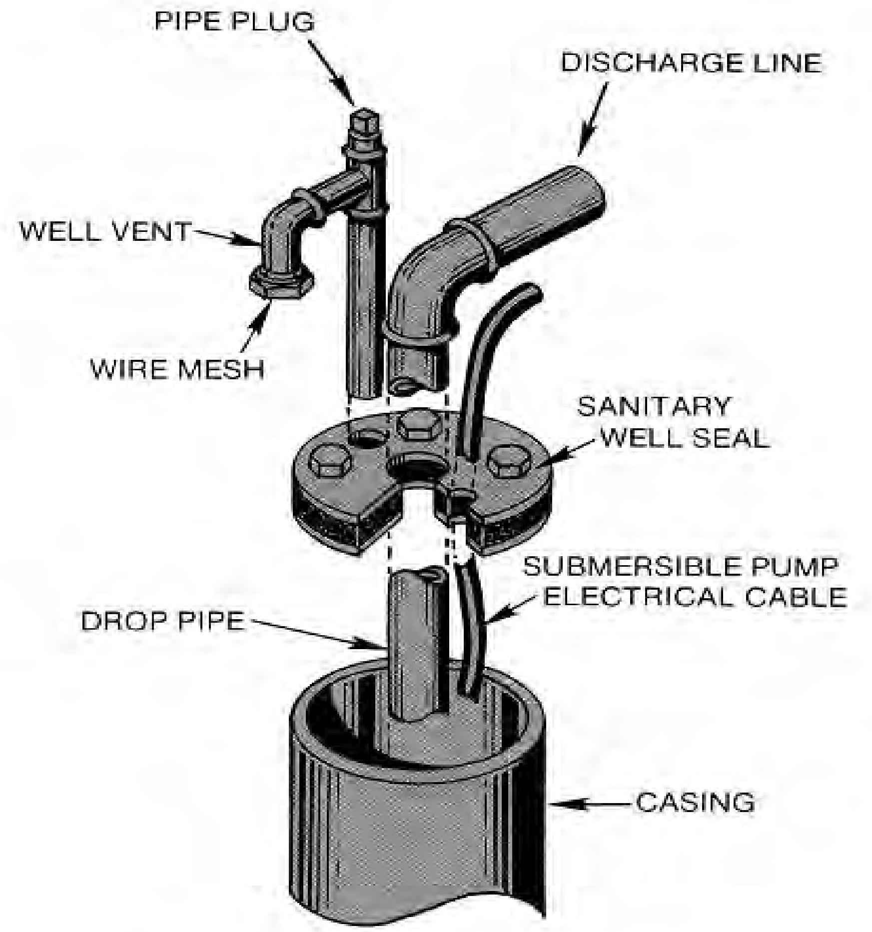
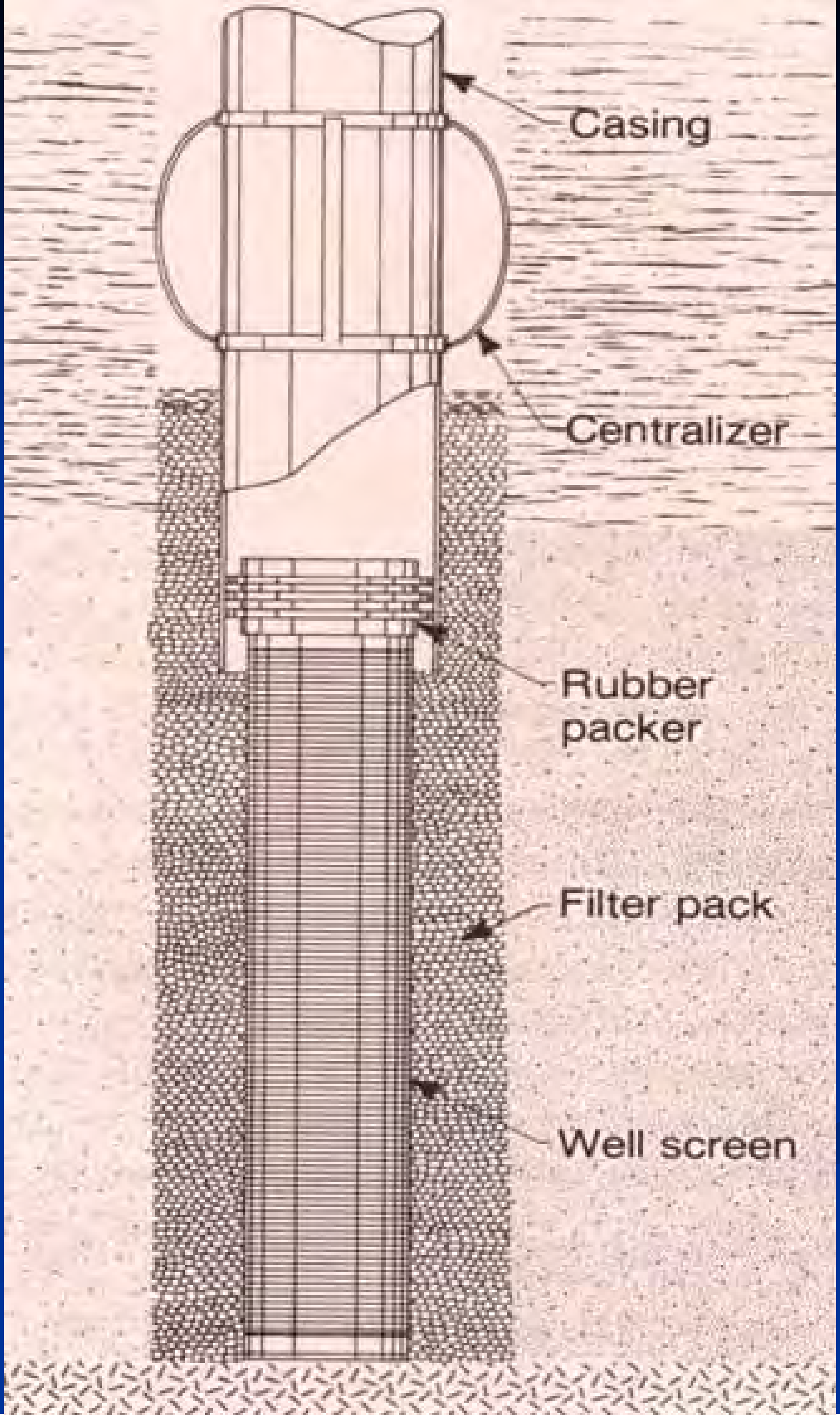


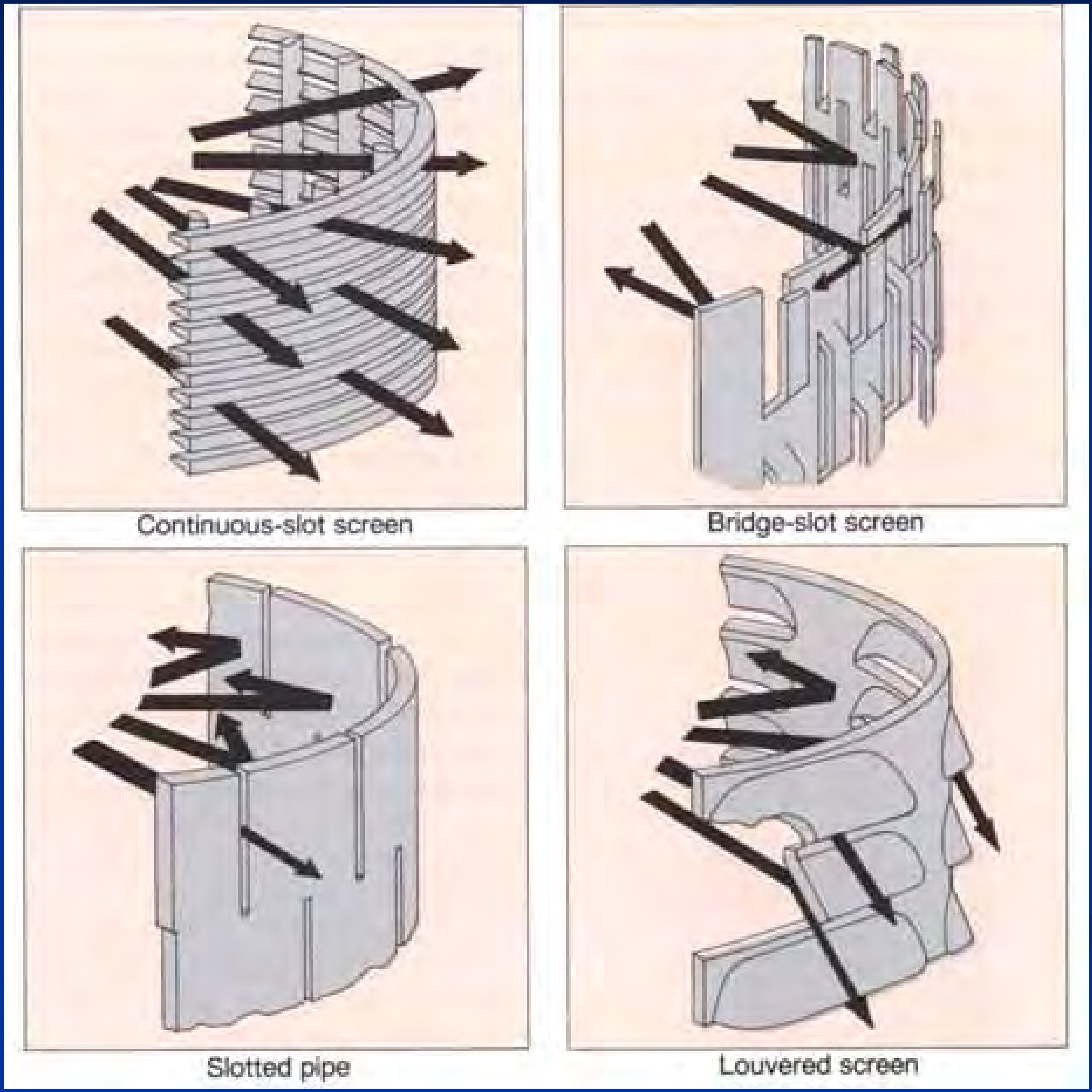
Figure 11 Sanitary Well Seal for Submersible Pump Installation

Gravel Pack and Screens



Well Screen and Slotted Casing

Screen Variety

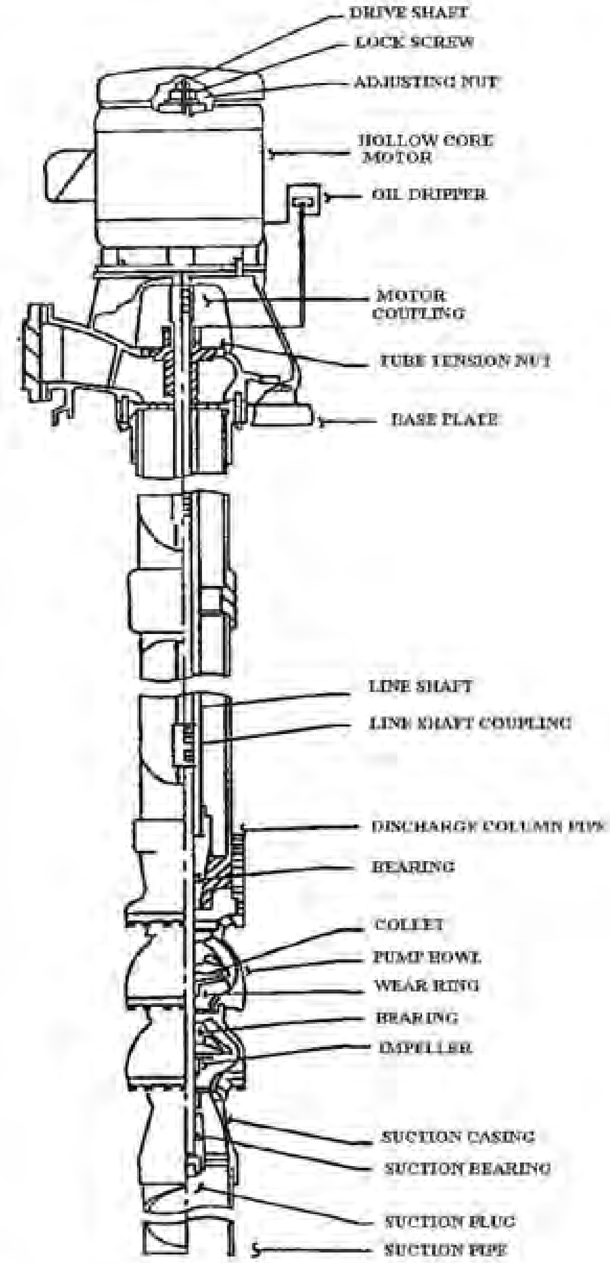


Water Well Pumps

(Vertical Turbine Centrifugal Pumps)

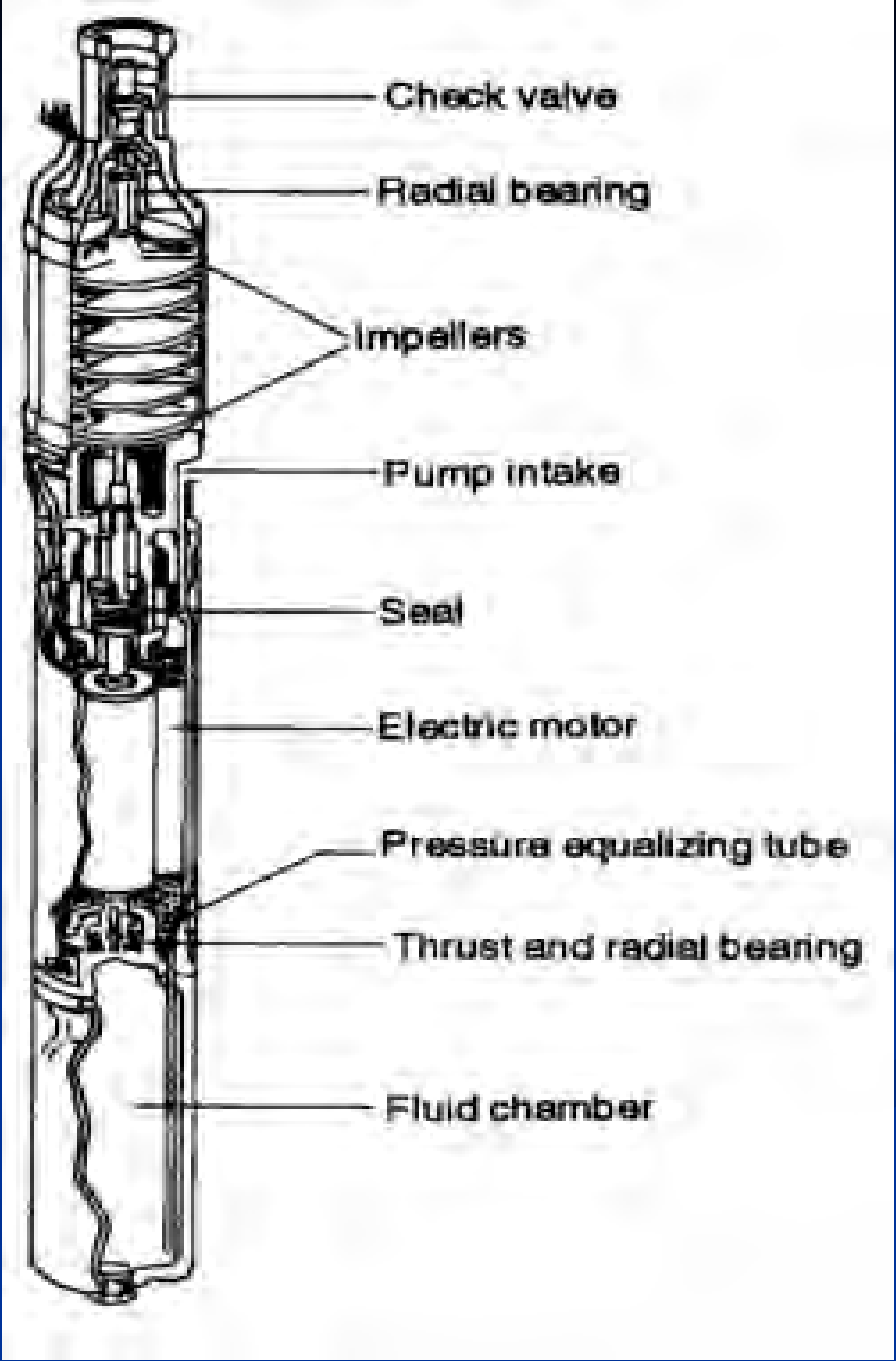
- Discharges water out of the top of the impeller rather than at a right angle
- Two types of VTCPs
  - Line-shaft pump
  - Submersible pump

Line Shaft VTCP



VERTICAL TURBINE CENTRIFUGAL PUMP

Submersible VTCP



Well Hydraulics

- Static water level
- Cone of depression
- Drawdown
- Pumping water level
- Zone of capture (radius of influence)
- Equilibrium
- Specific capacity
- Recovery Time

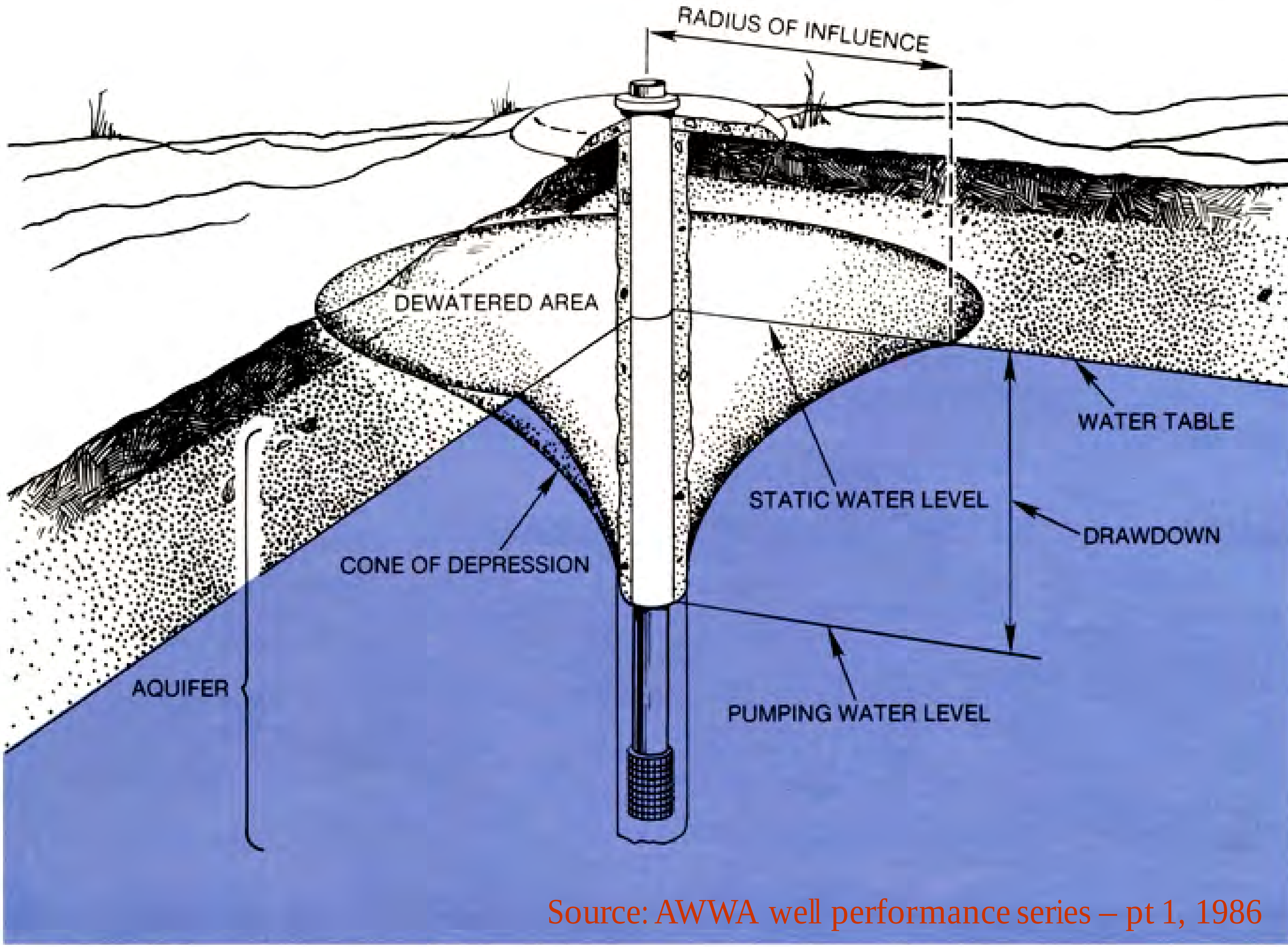
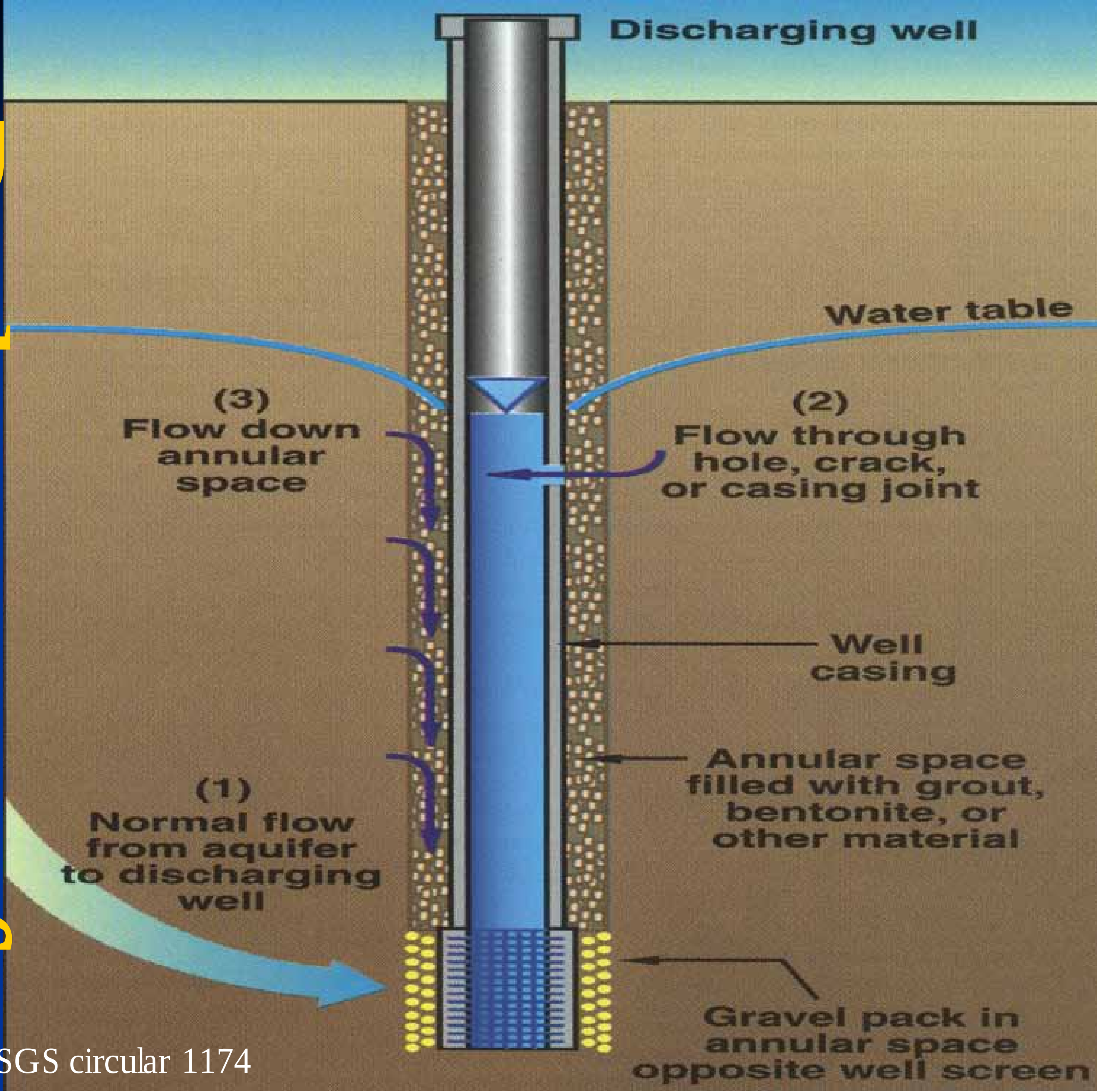


Figure 5 Common Water Well Terms and Measurements

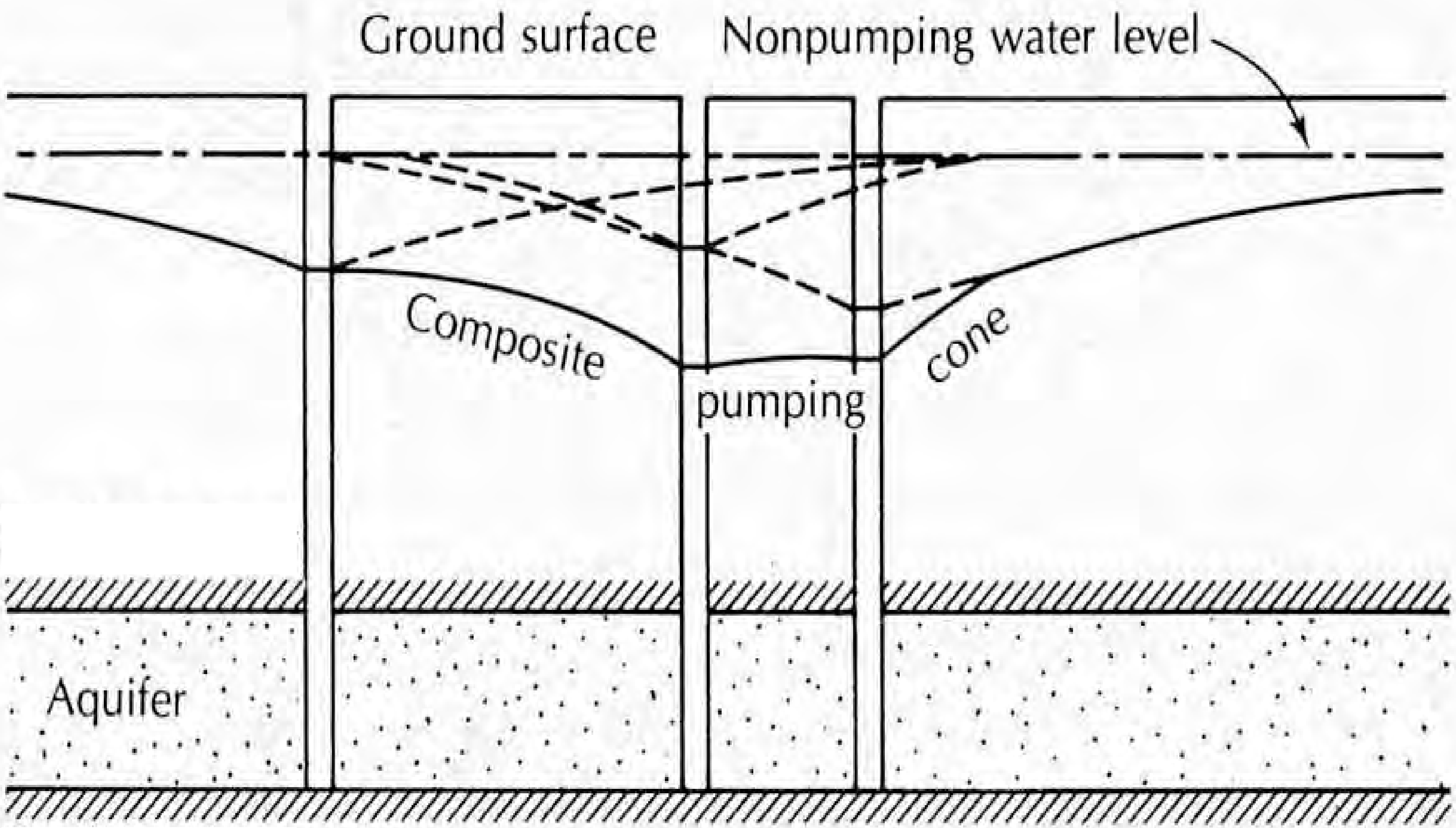
Well and Pump Problems

Pathways of Contamination

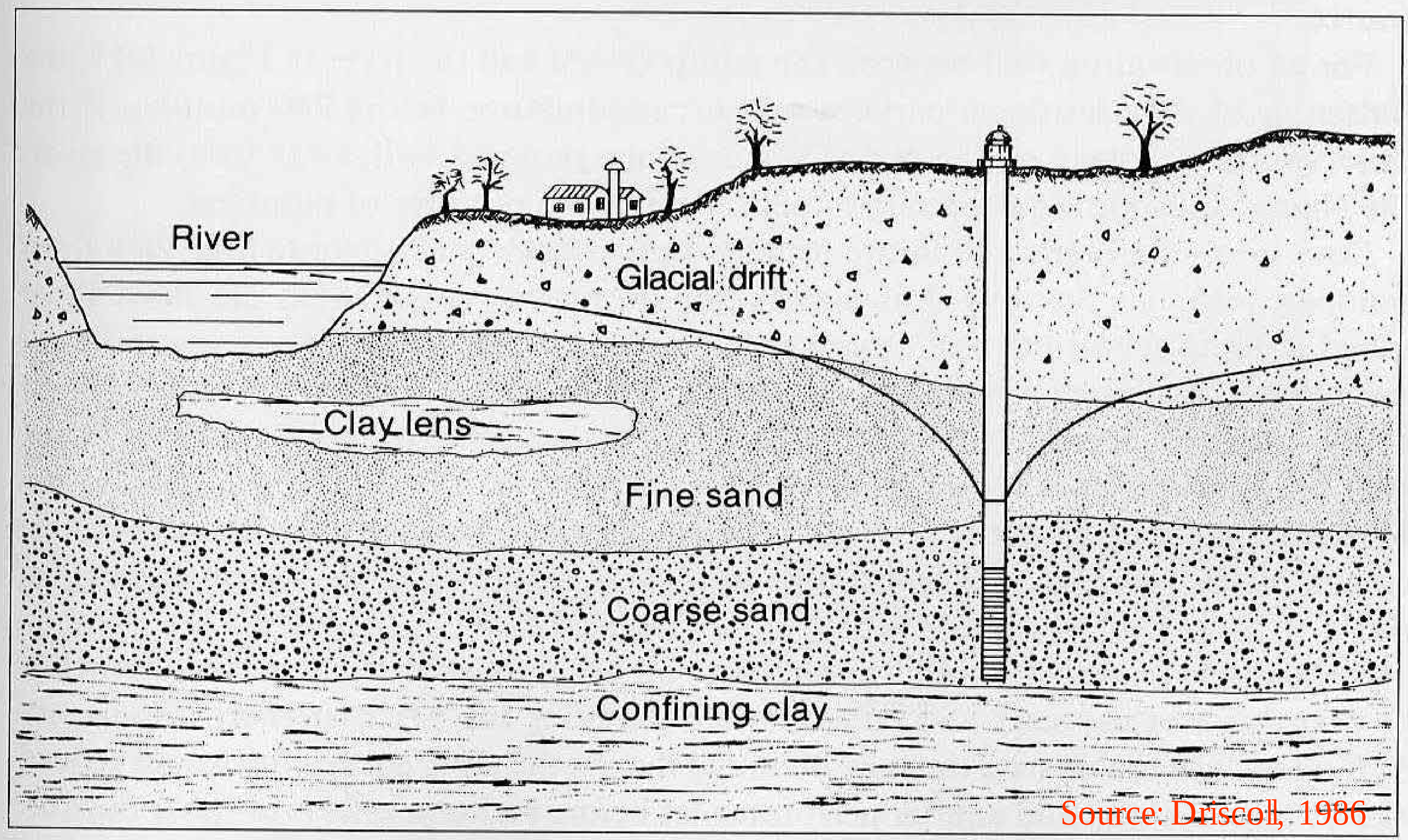


Source: USGS circular 1174

Well Interference



Well Equilibrium



Source: Driscoll, 1986

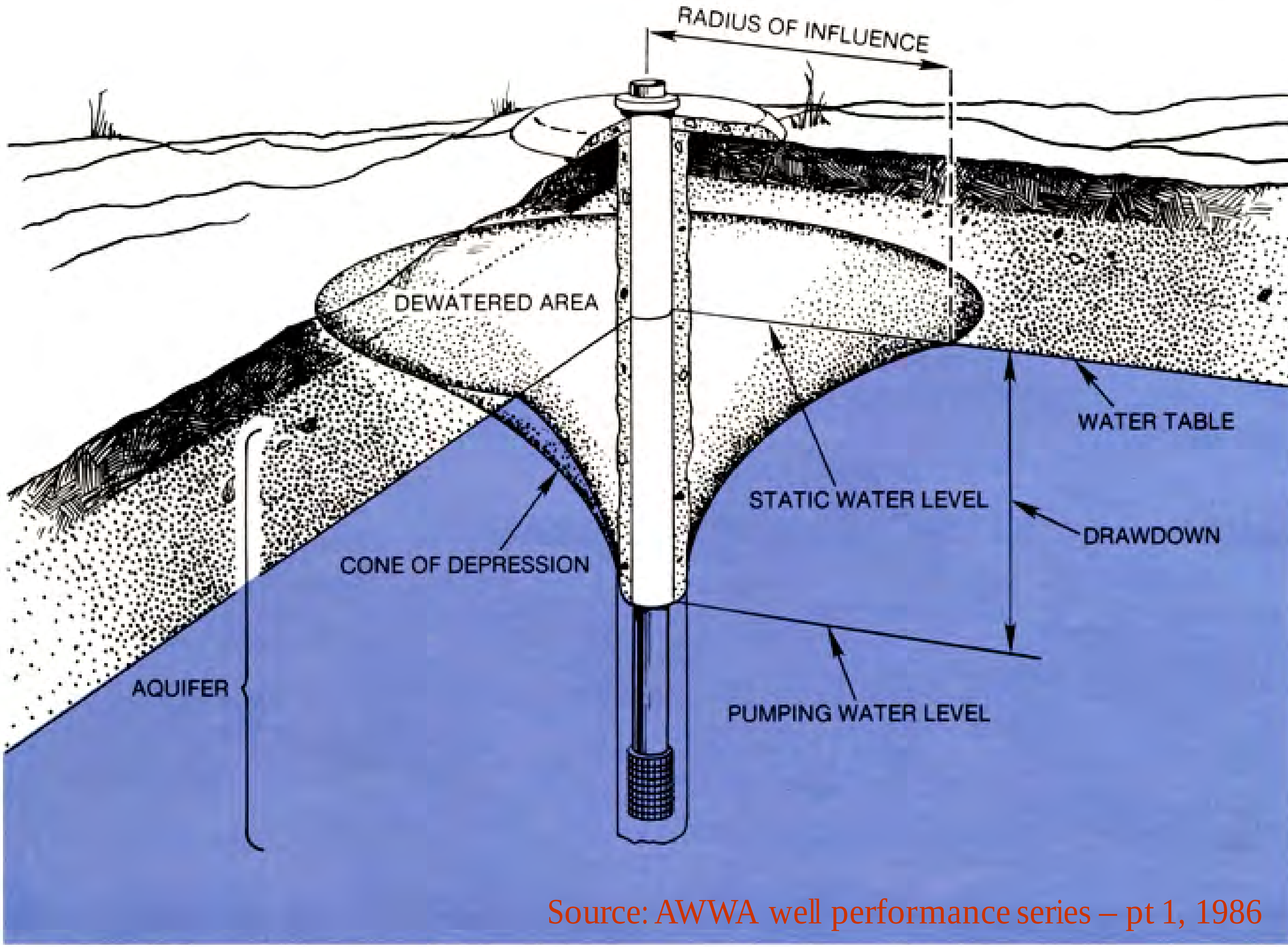


Figure 5 Common Water Well Terms and Measurements

Is it the well, pump, or aquifer?

Problem	Issue
Static water level stays the same but the pumping level has dropped several feet:	Clogged Screens - Sand Bridging - Iron Bacteria - Lime Scaling
Static water level is the same but pumping water level has risen several feet, pump production has also decreased:	Pump related problems - Impeller clearance - Line shaft stretch

Questions???

Comments???

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Providing technical assistance and training to water systems across New Mexico since 1978