Seawater Intrusion

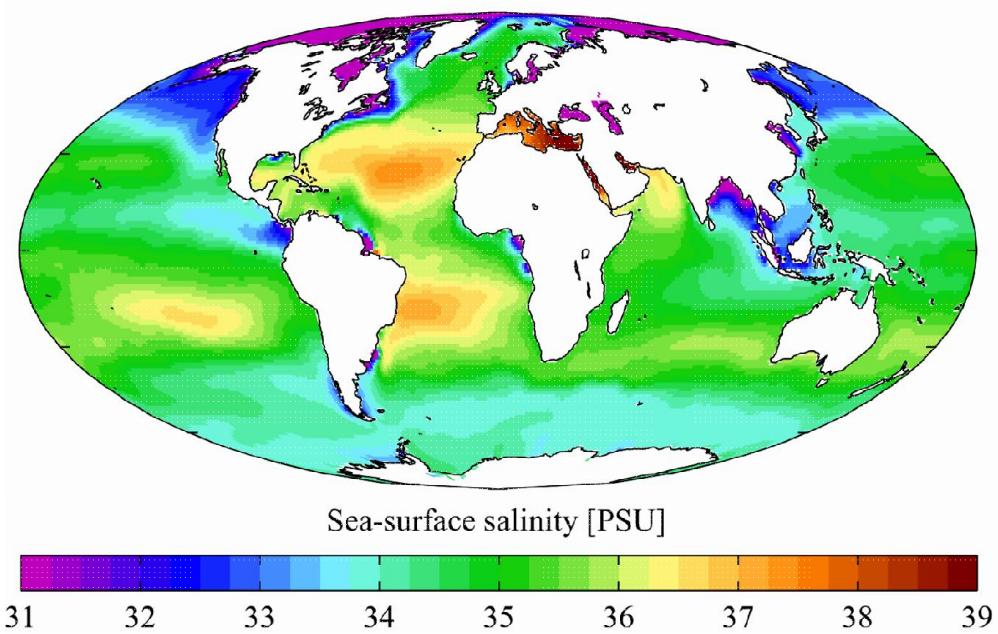
Groundwater Engineering| CE60205 Lecture:20

Learning Objective(s)

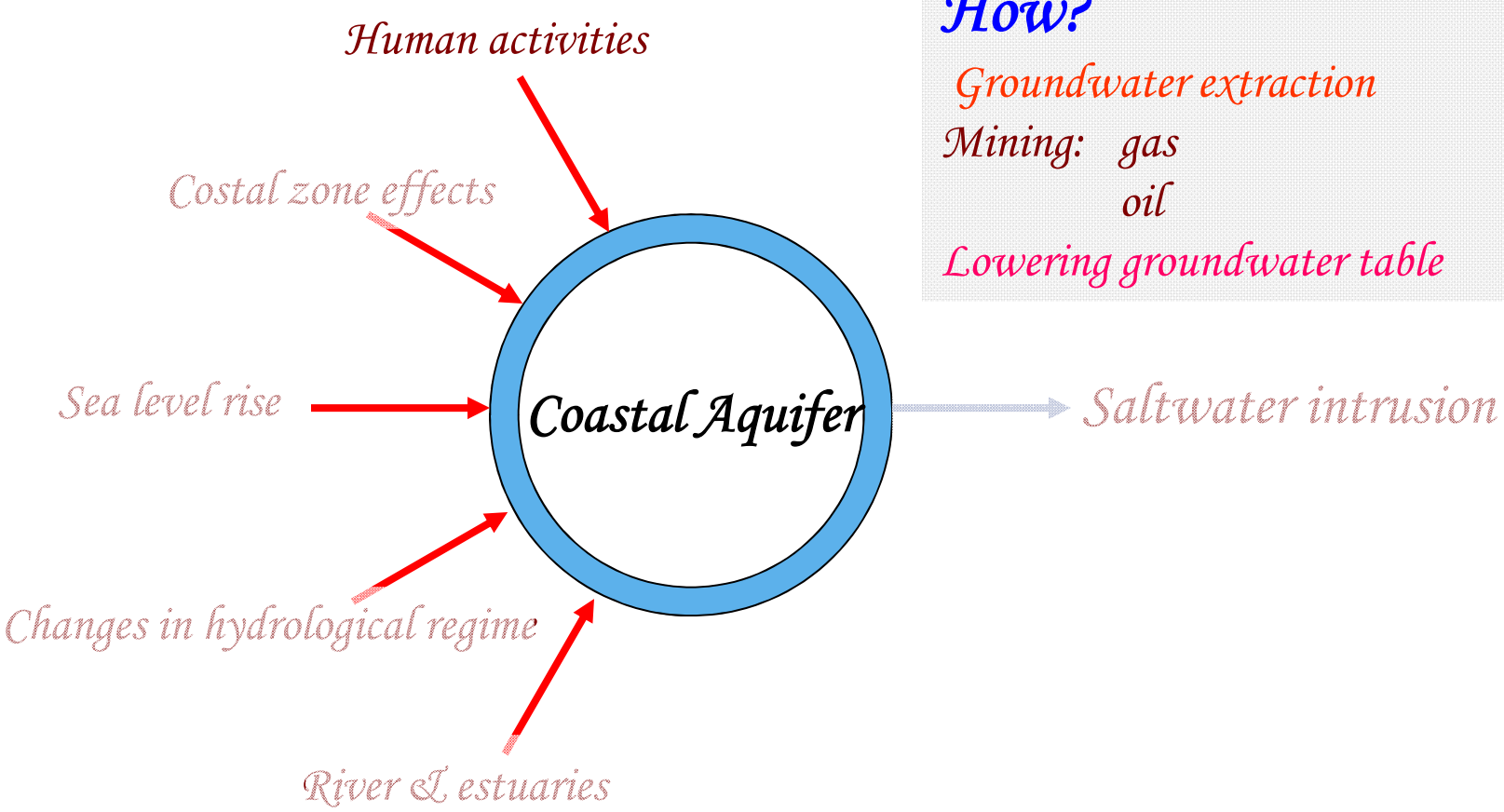
- **To explain saltwater intrusion in the context of flow and transport models.**

Why?

- “More than half the world's population lives within 60 km of the shoreline, and this could rise to three quarters by the year 2020.” (Chapter 17.3, Agenda, 21, The United Nations Conf. on Environment and Development, 1992)



Feature affecting coastal aquifers



How?

Groundwater extraction

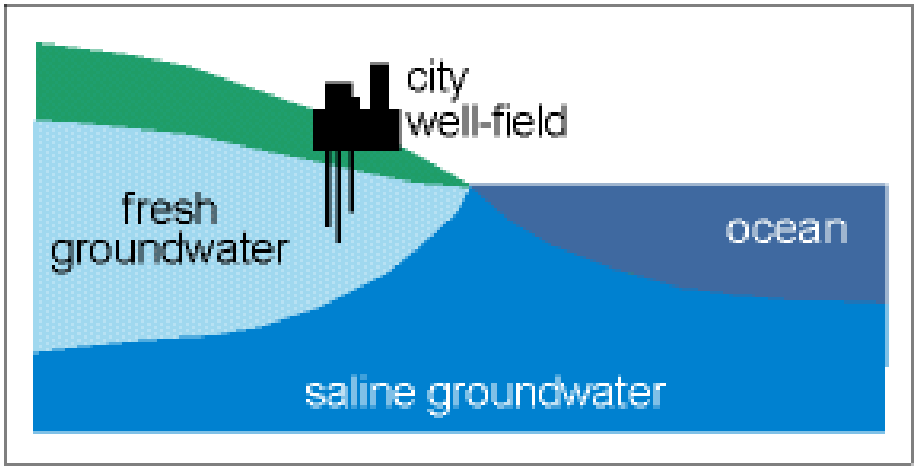
Mining: gas

oil

Lowering groundwater table

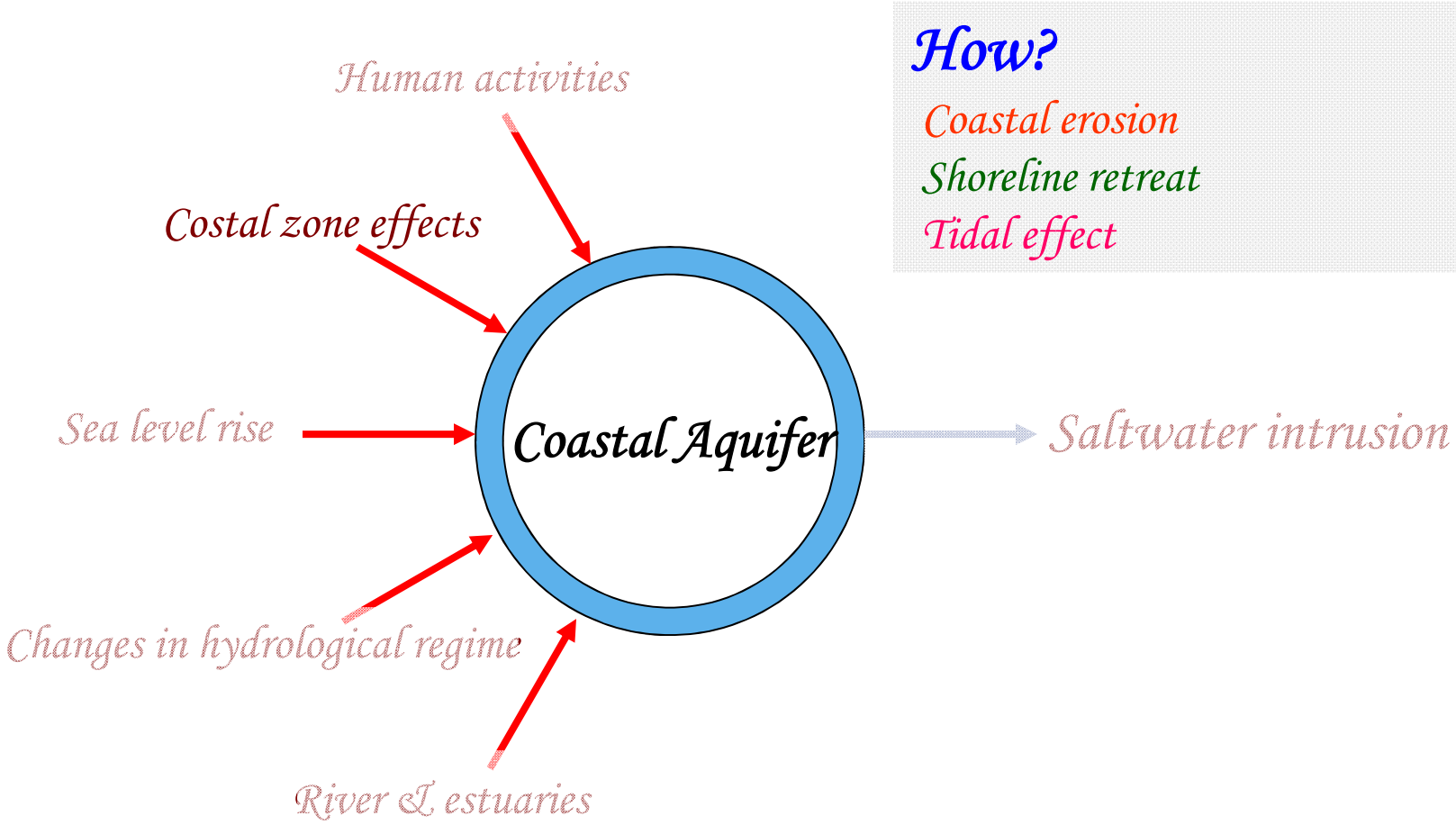
Groundwater extraction

- Saltwater intrusion occurs with coastal wells pump too much water and draw up saltwater below the freshwater lens



Source: http://www.mhhe.com/earthsci/geology/mcconnell/demo/gwsystem.htm

Feature affecting coastal aquifers



How?

Coastal erosion

Shoreline retreat

Tidal effect

Coastal erosion

Erosion of Kappakkal beach (Payyanakkal) at Calicut, Kerala

Site of the Cape Hatteras lighthouse, USA

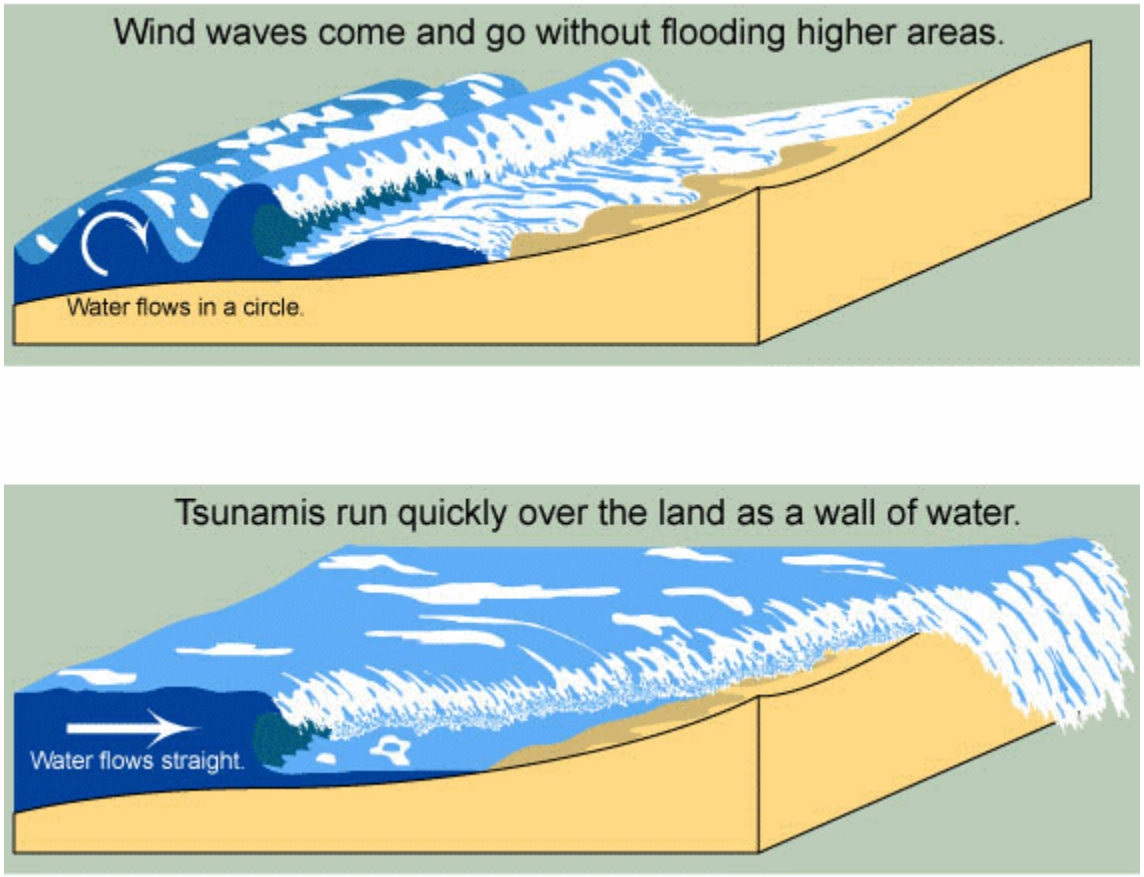

New location

It was moved from its original location at the edge of the ocean to safer ground about 2,870 feet inland.


Old location

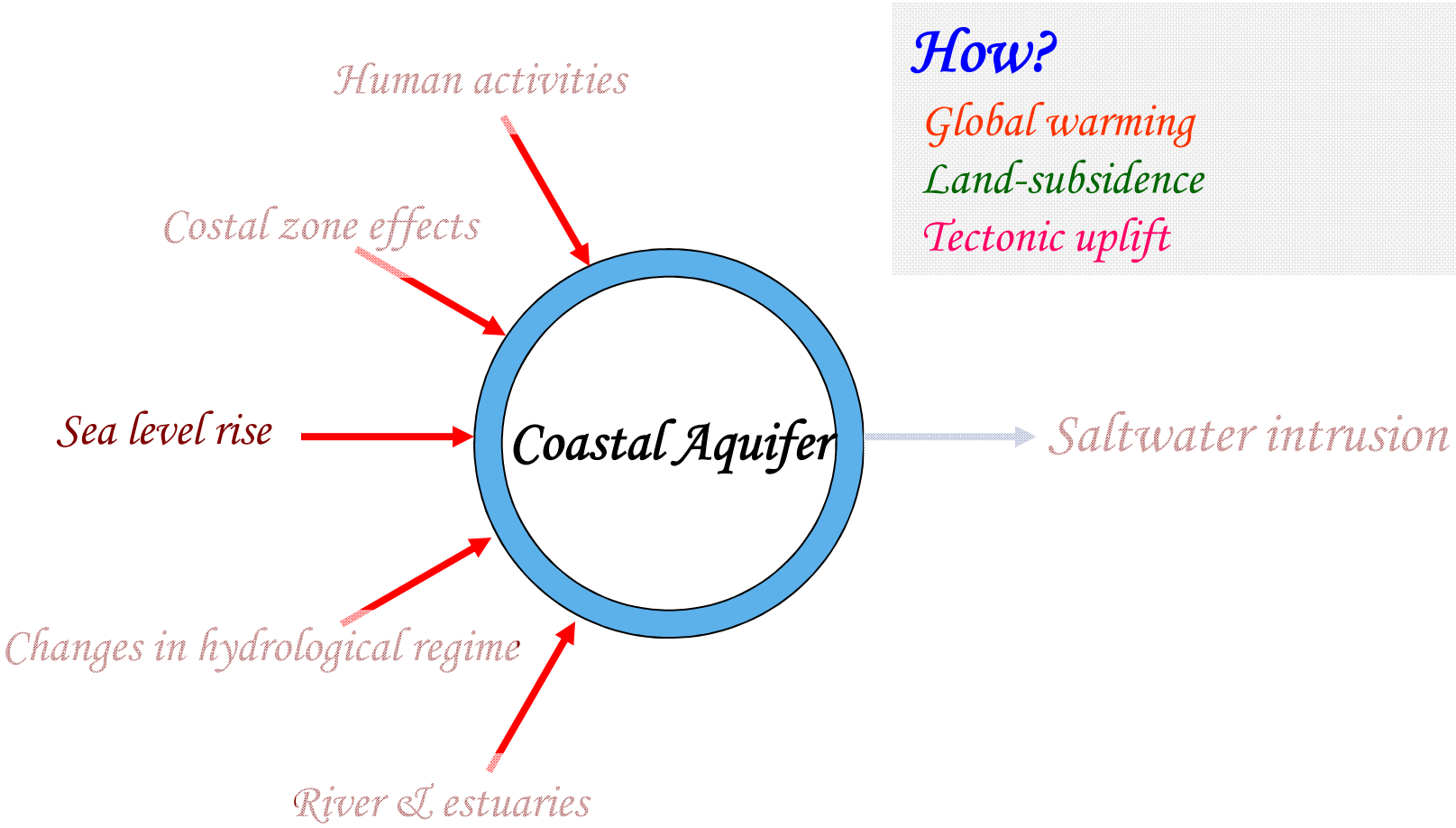
Tallest in the United States, stands 208 feet (63 m) from the bottom of the foundation to the peak of the roof.

Tsunami



Source: http://mail.colonial.net/~hkaiter/earthquakes.html

Feature affecting coastal aquifers



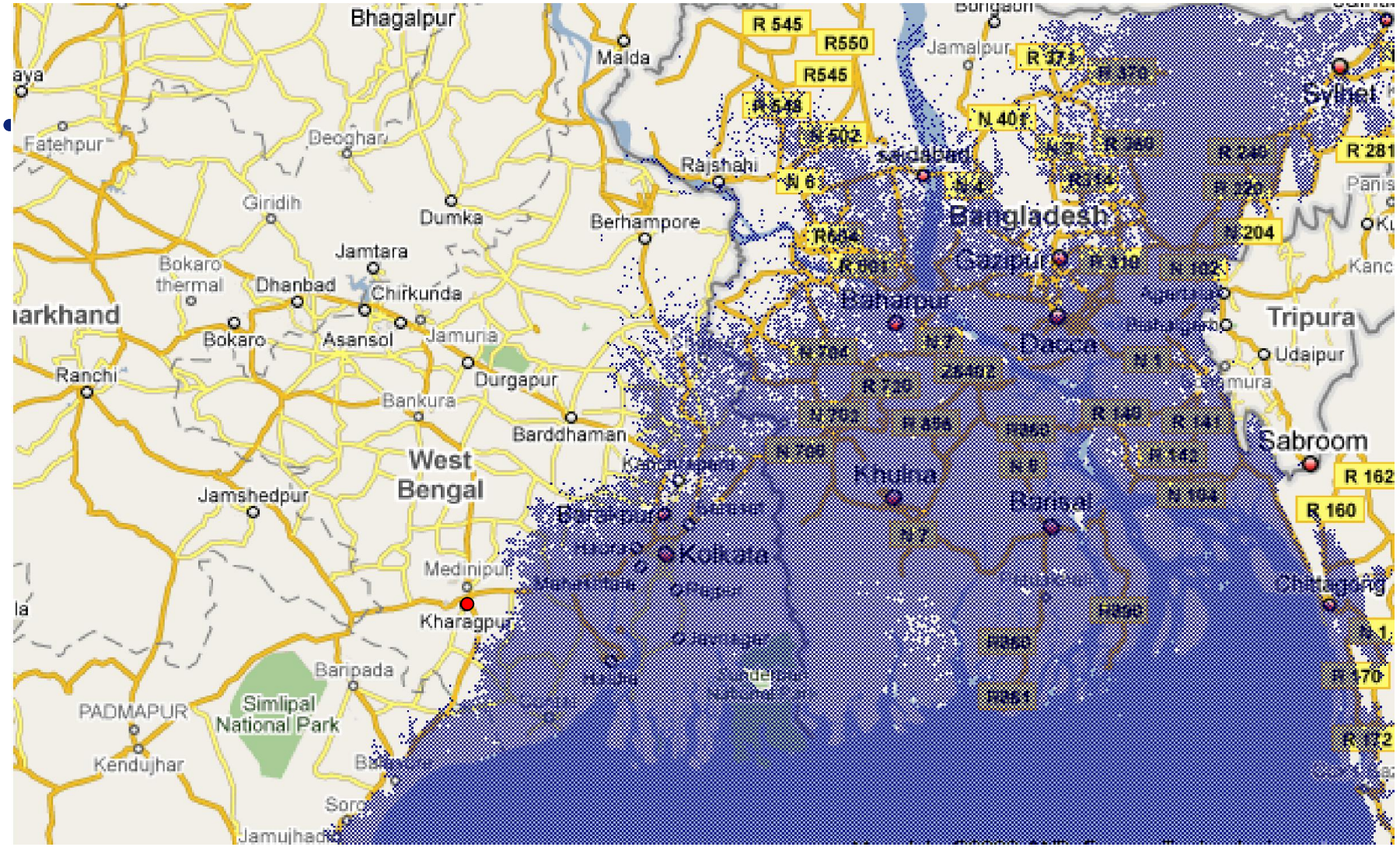
How?

Global warming

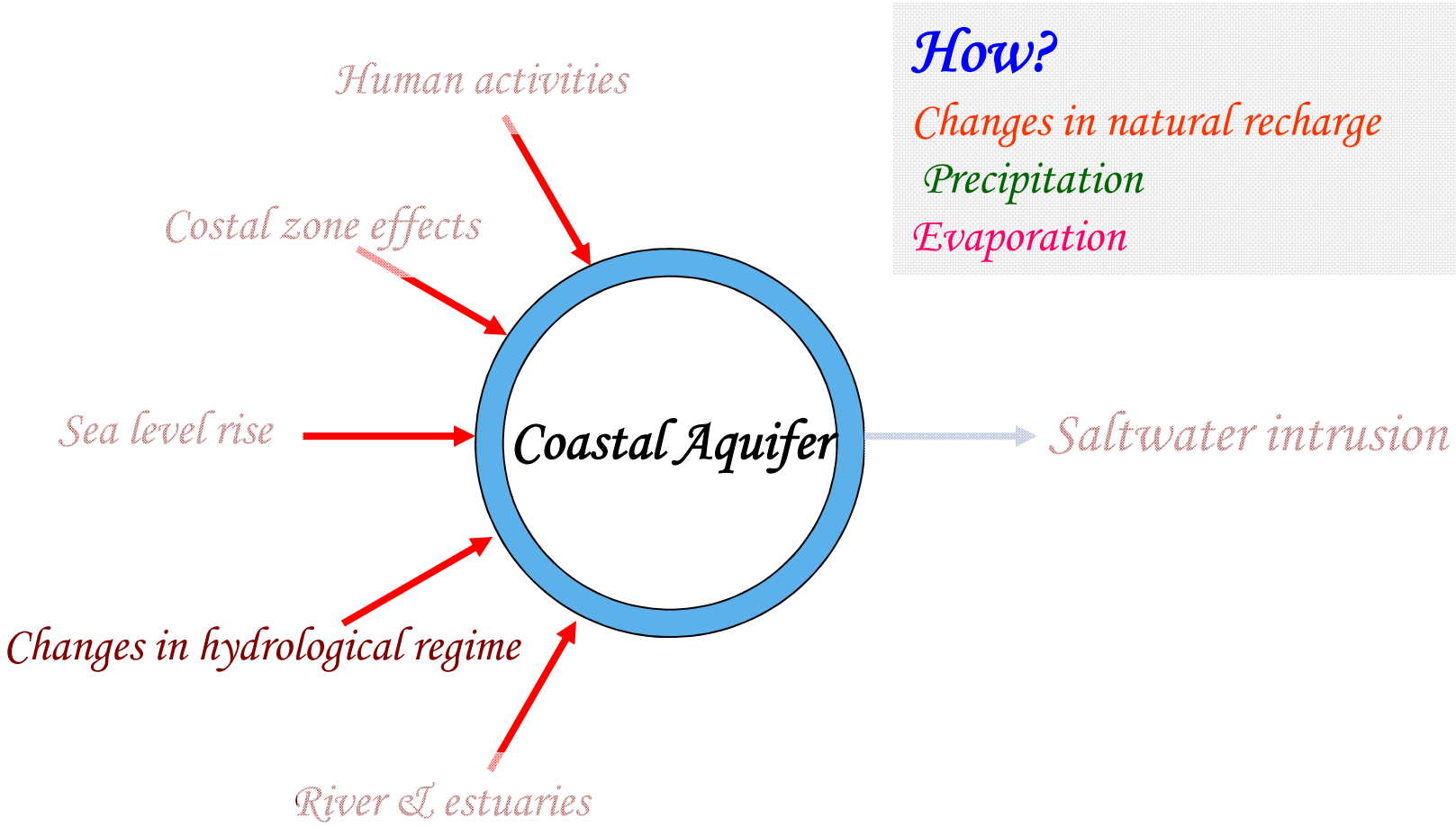
Land-subsidence

Tectonic uplift

Sea level rise (+14 m)

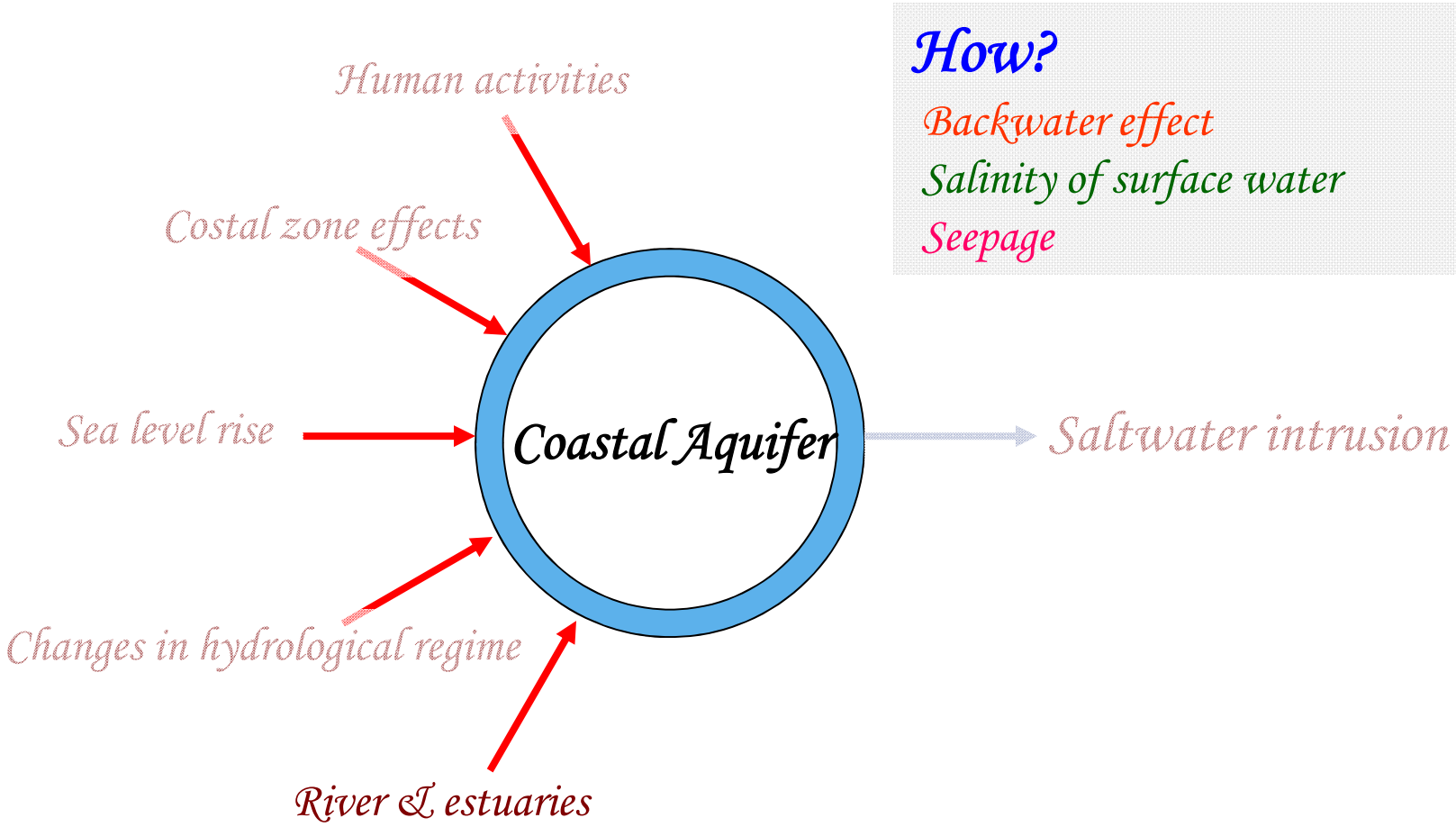


Feature affecting coastal aquifers

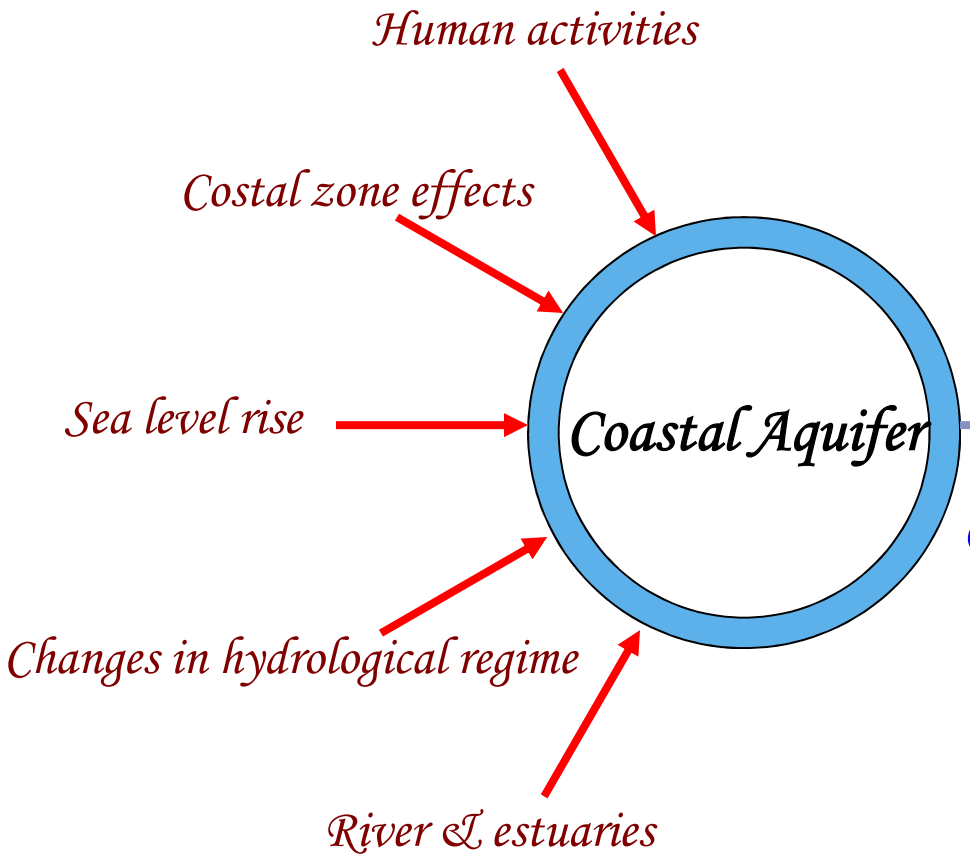


Inundation in Mumbai city in July 2005 (nearly 95 cm of rainfall in 24 hours)

Feature affecting coastal aquifers



Feature affecting coastal aquifers



Saltwater intrusion

Problems..

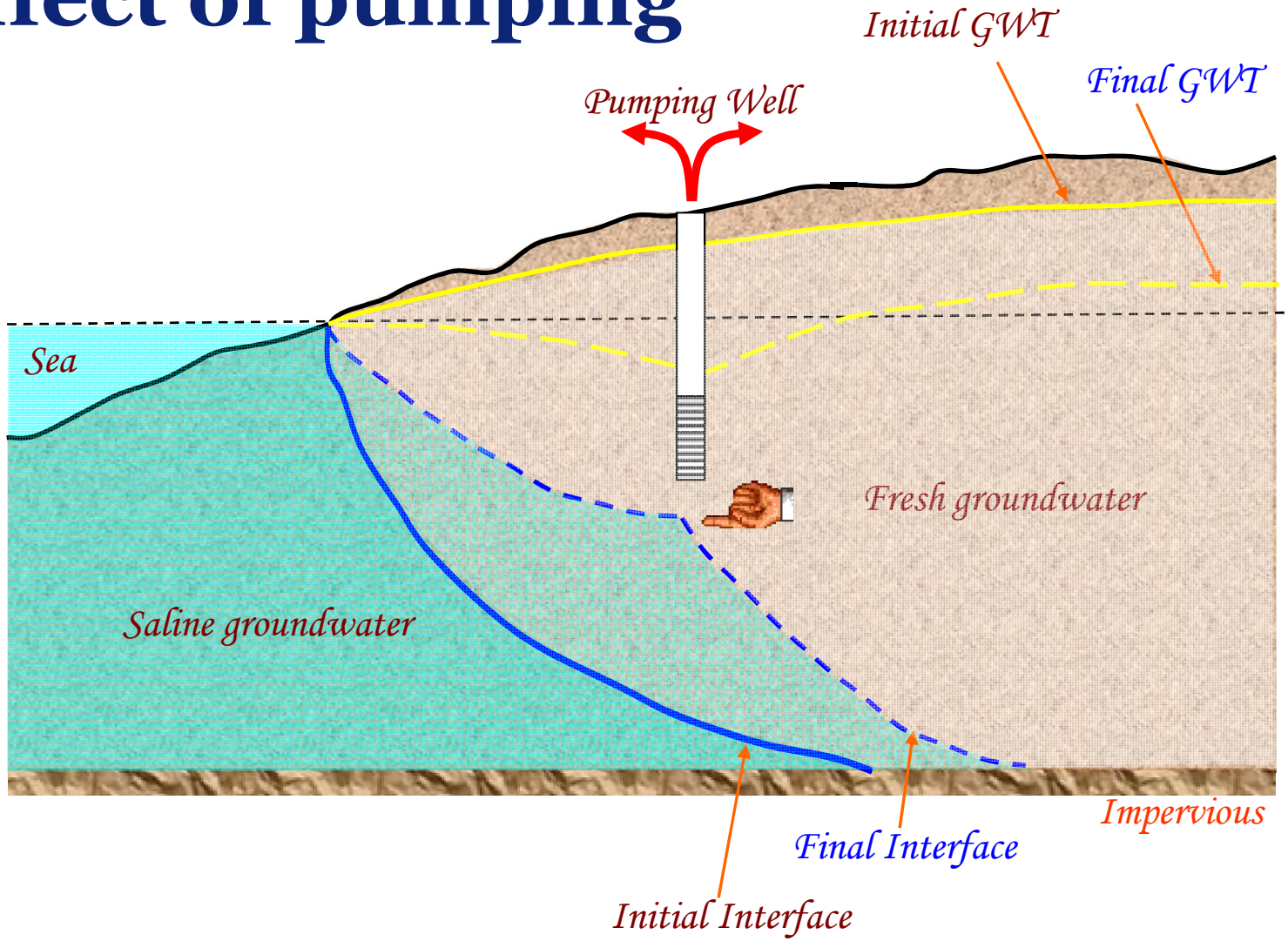
Loss of drinking water

Increase in soil salinity

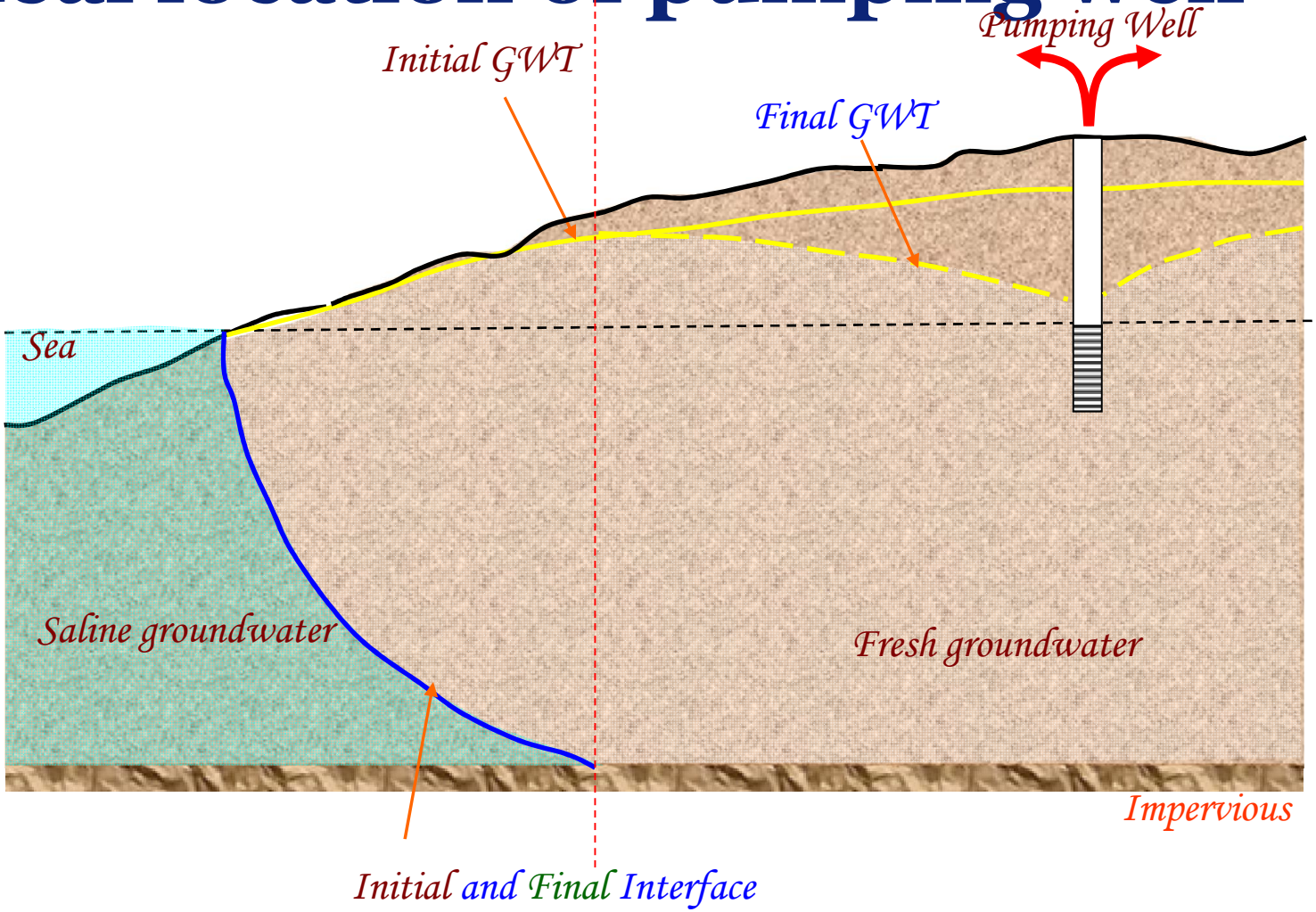
Possible relocation of habitants

…on the whole serious consequences on environment, ecology and economy of that region.

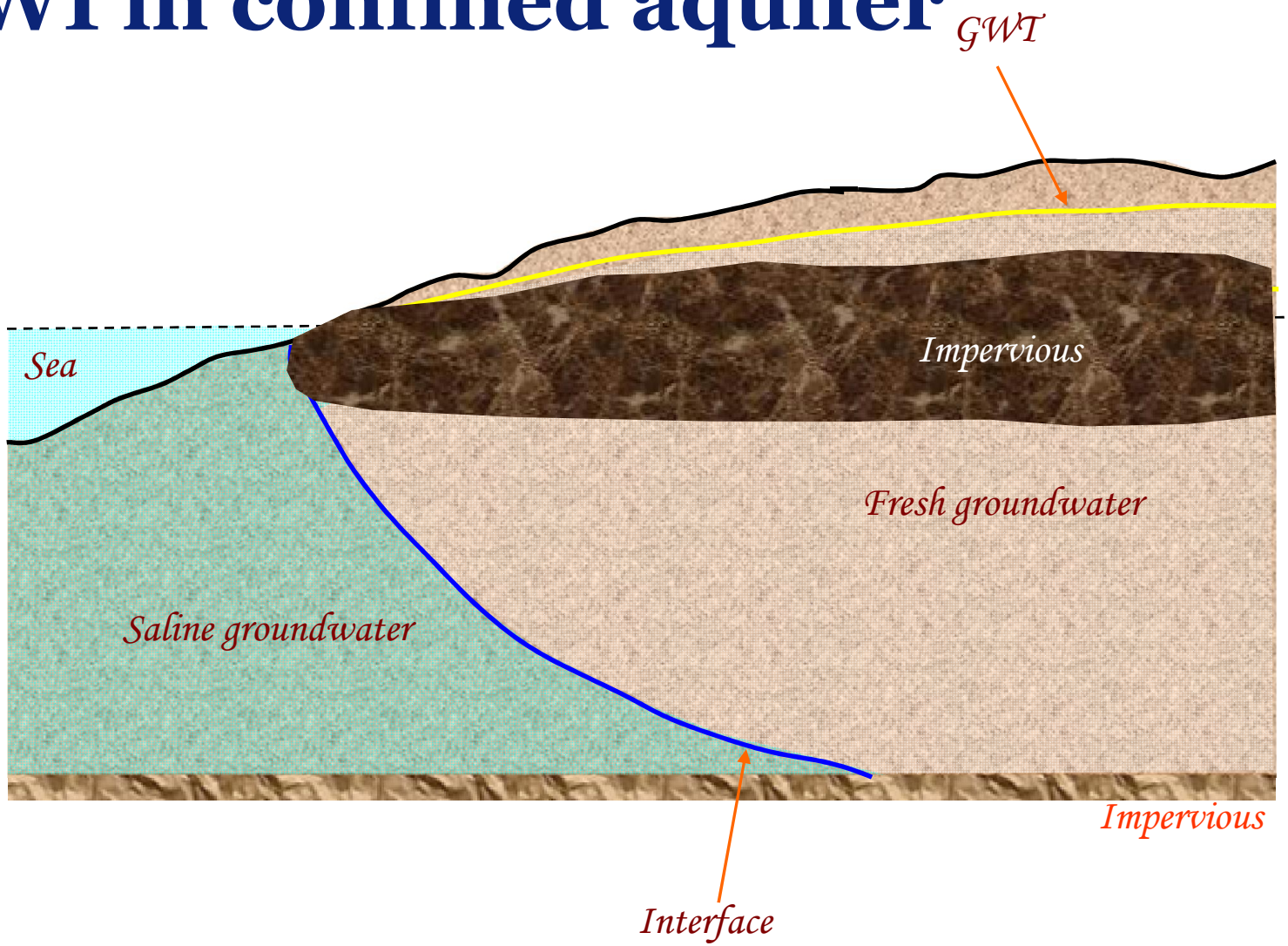
Effect of pumping



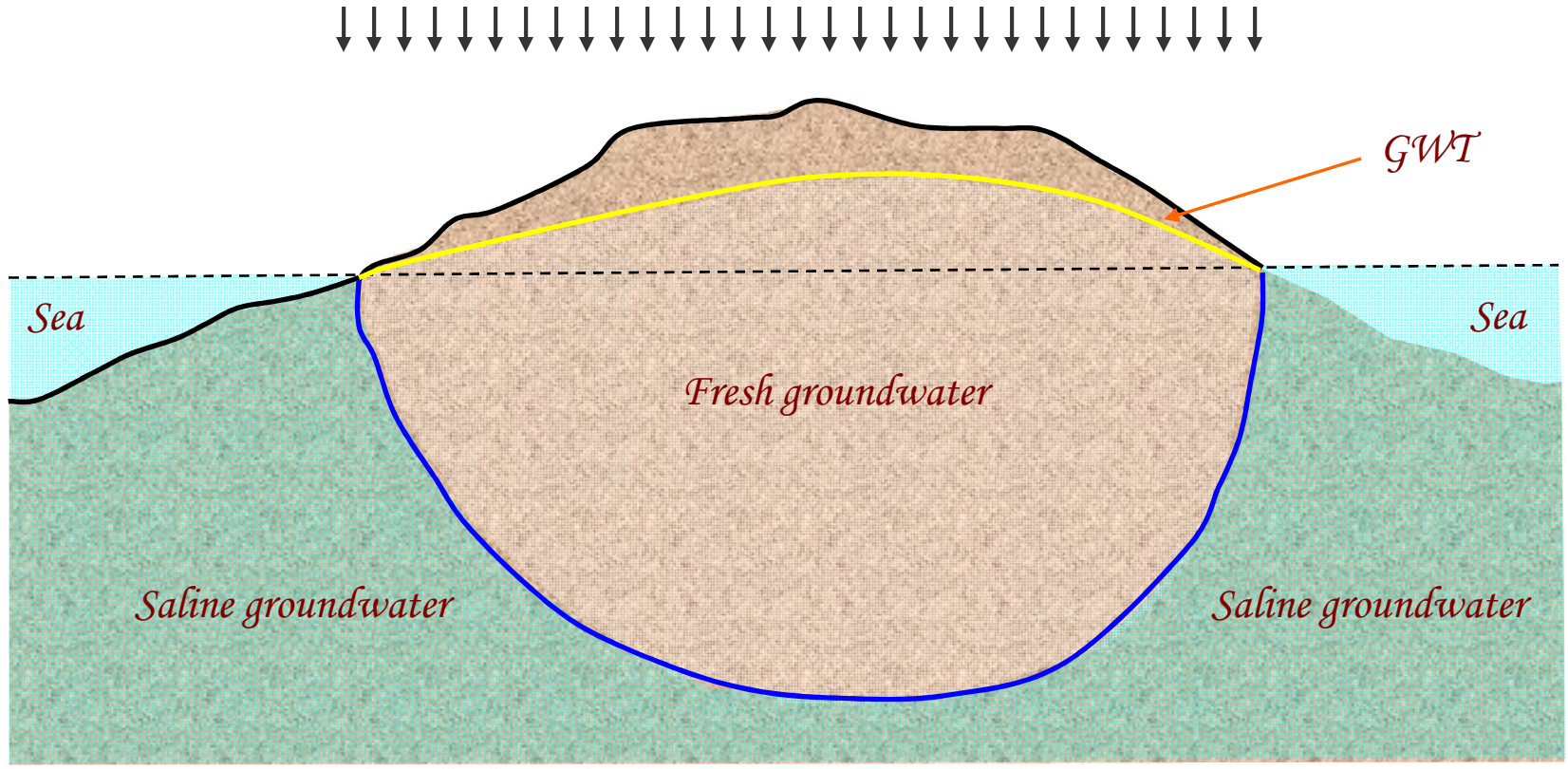
Ideal location of pumping well



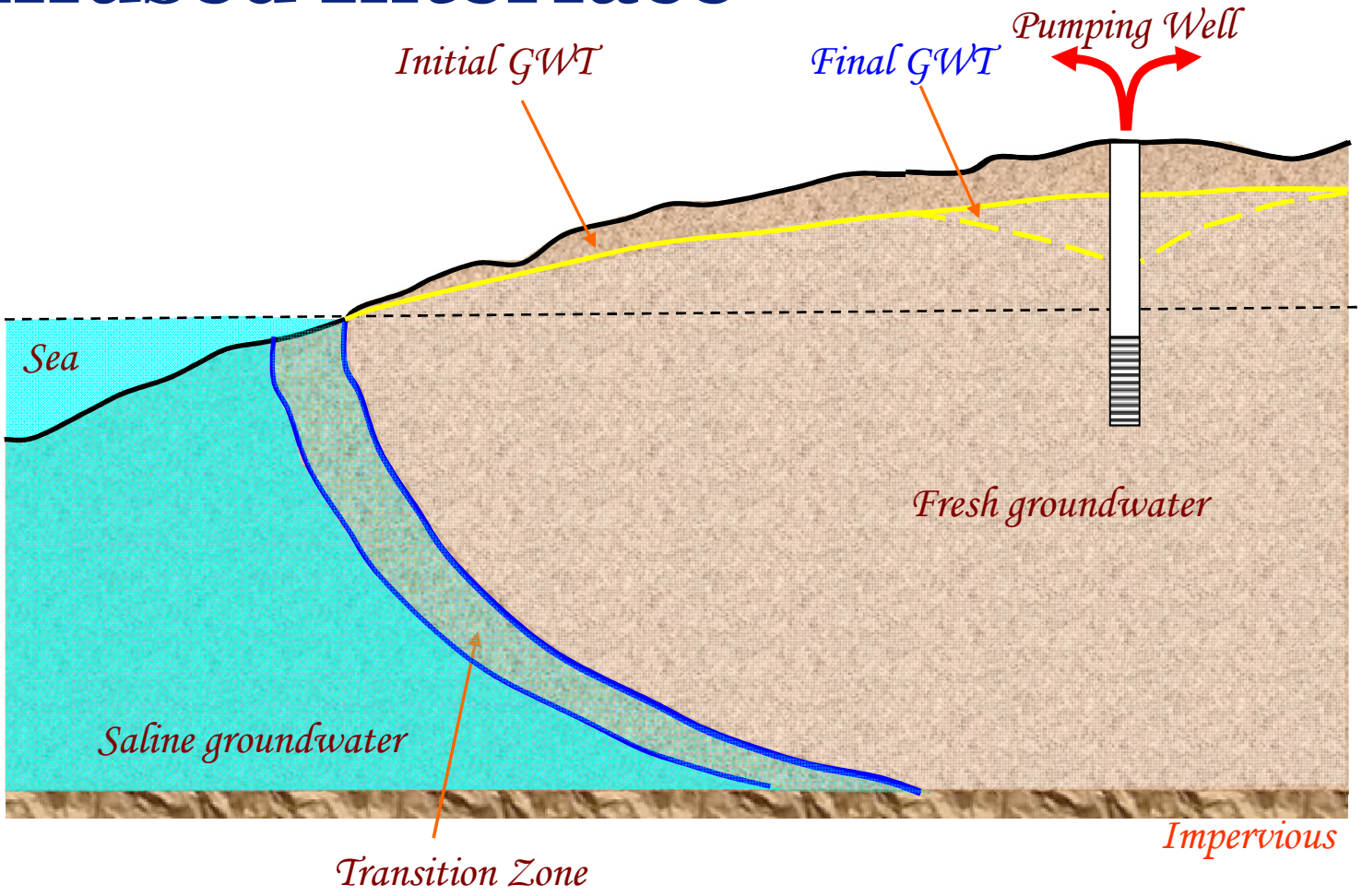
SWI in confined aquifer



Elongated island



Diffused Interface



Composition of seawater (Younos, 2005)

- TDS level: 500 mg/l to 50,000 mg/l
- Lower range values indicate brackish water while upper range represents seawater.

Element	% Weight/ Gram of Water	Concentration (mg/l)
Chloride (Cl)	55.04	19,400
Sulfate (SO_4)	7.68	940
Calcium (Ca)	1.16	411
Sodium (Na)	30.61	10,800
Magnesium (Mg)	3.69	1290
Potassium (K)	1.10	392

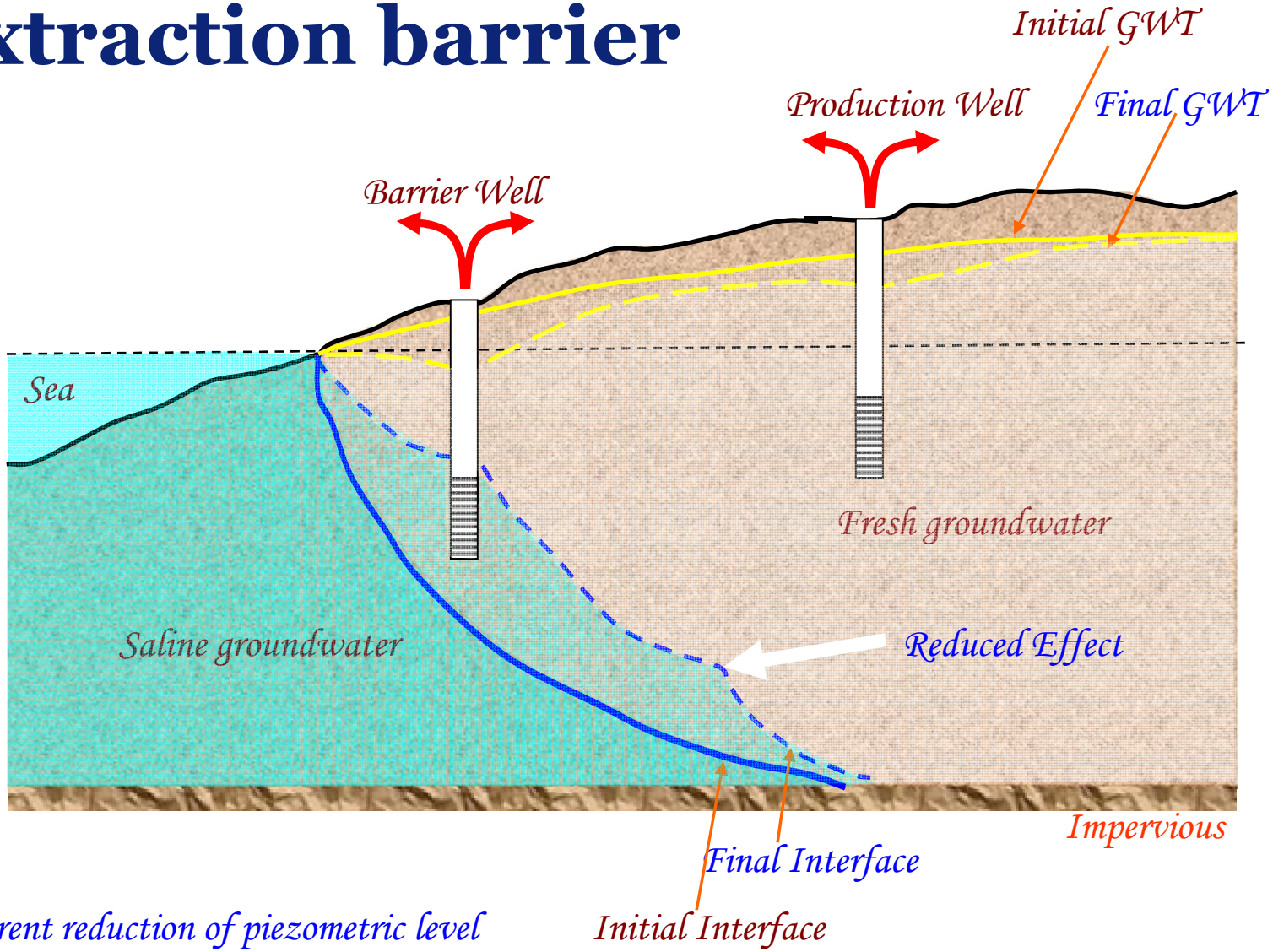
Classification of groundwater on the basis of chloride concentration, after Stuyfzand (1993).

Type of groundwater	Chloride Concentration (mg Cl^-/l)
Oligohaline	0-5
Oligohaline-fresh	5-30
Fresh	30-150
Fresh-brackish	150-300
Brackish	300-1000
Brackish-saline	1000-10,000
Saline	10,000-20,000
Hypersaline or brine	$\geq$ 20,000

Counter measures

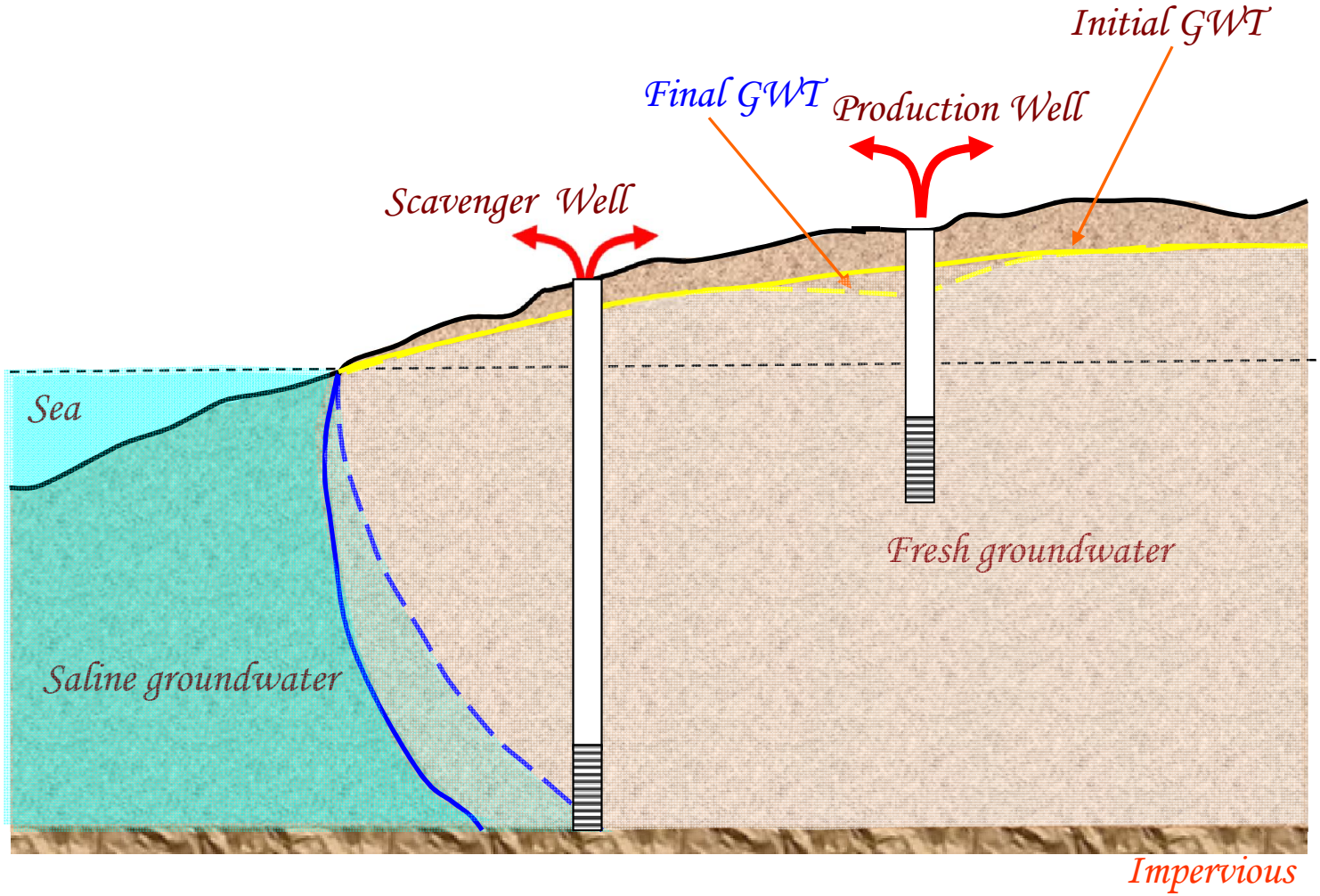
- *Demand Management*
- *Non-potable Water Reuse*
- *Modified Pumping Rates*
- *Pumping Caps*
- *Well Relocation*
- *Conjunctive Use*
- *Aquifer Storage and Recovery*

Extraction barrier

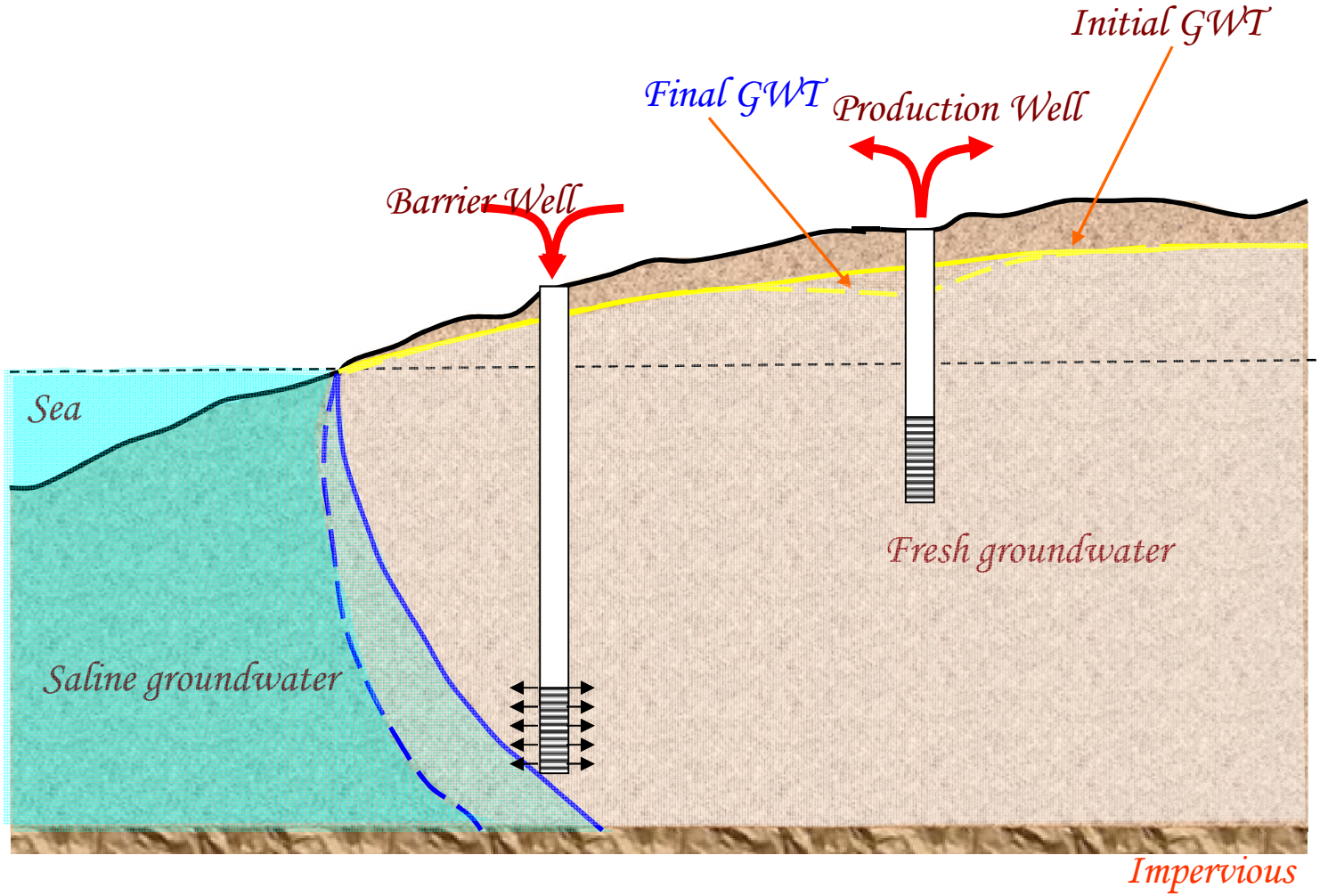


Apparent reduction of piezometric level

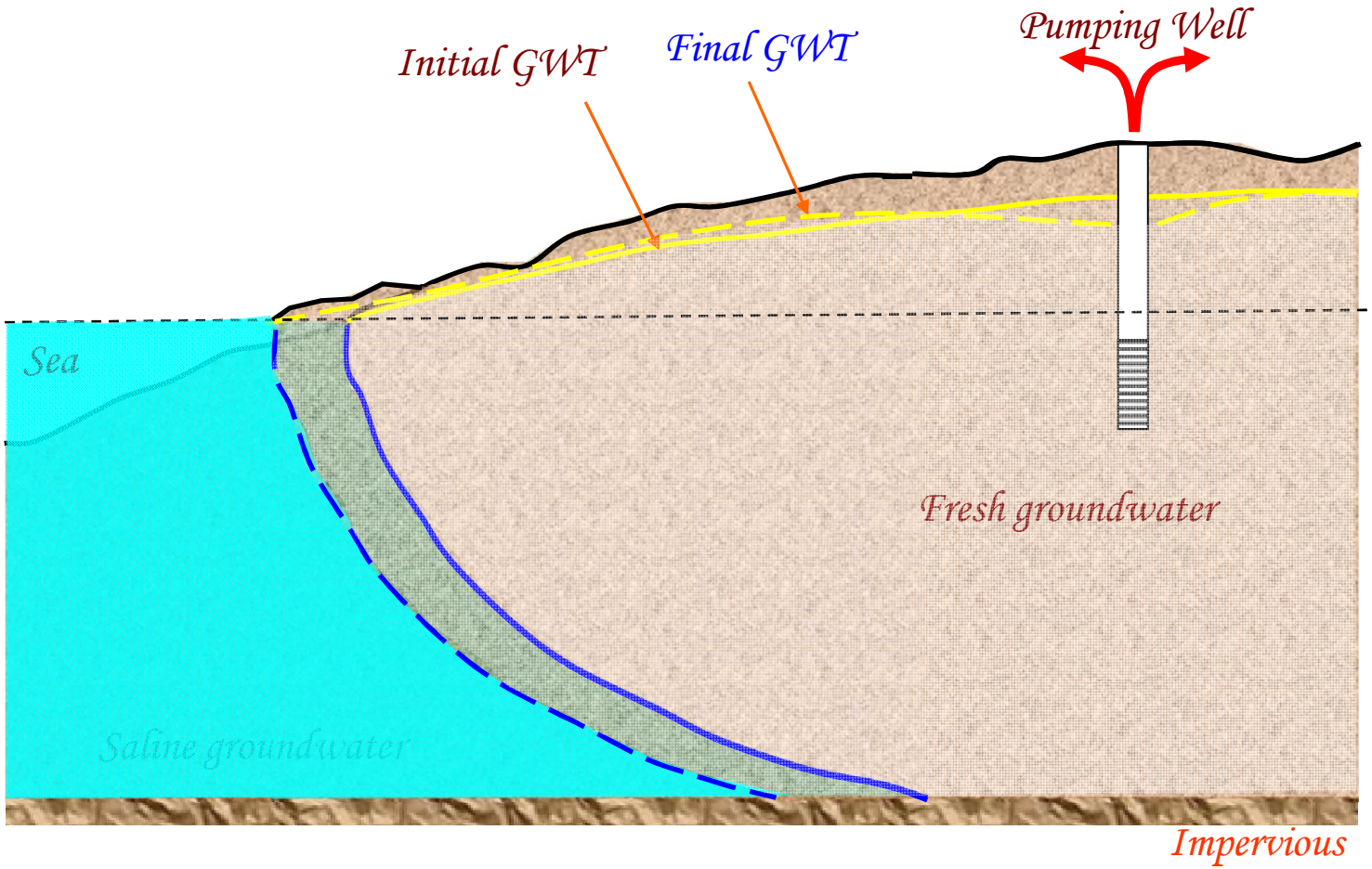
Scavenger Well



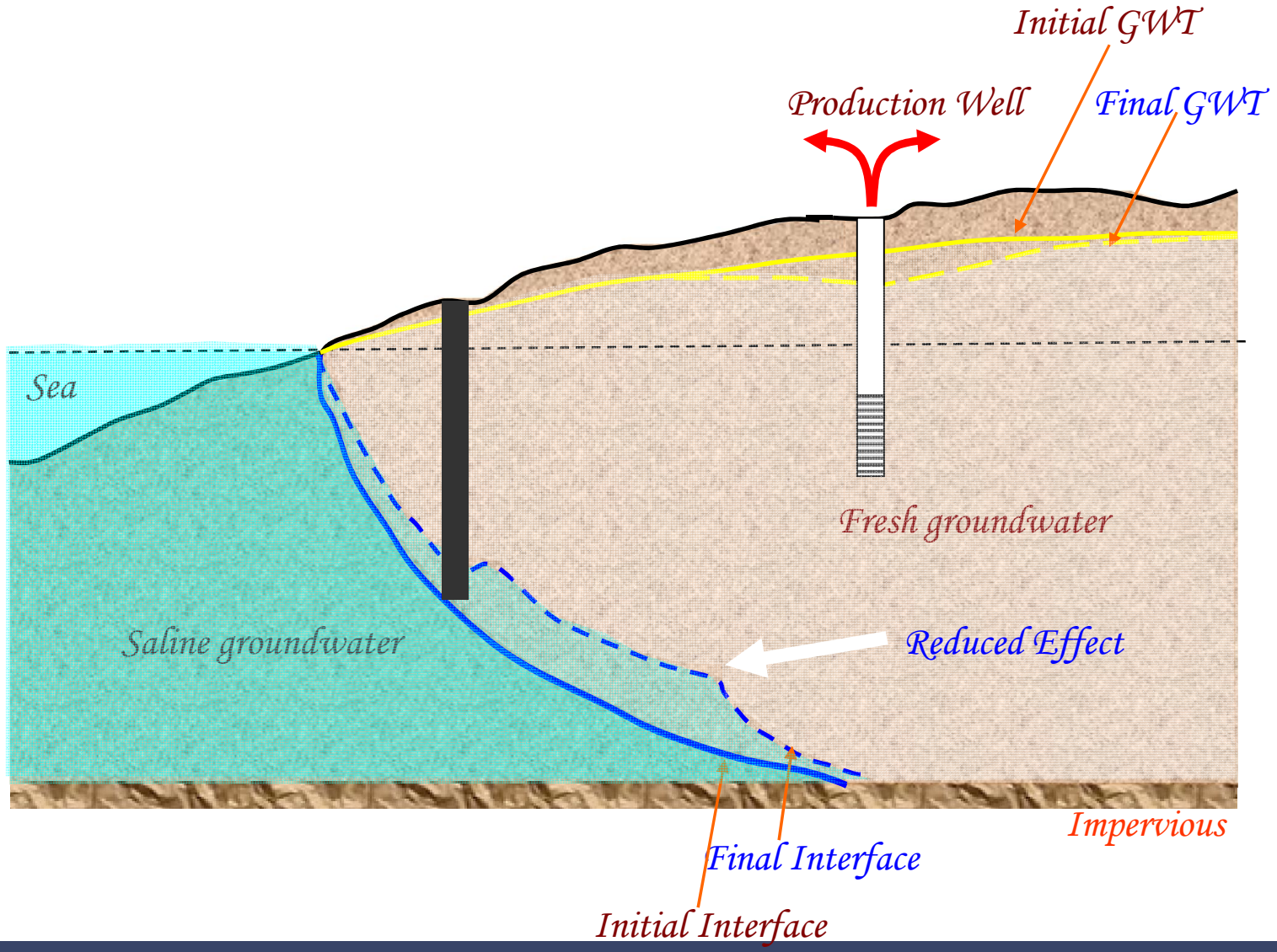
Injection barrier



Land Reclamation



Impermeable barrier



Our Goal

- Maintaining of quantity and quality is essential.

- Careful planning of withdrawal strategies for control and remediation of saltwater intrusion in coastal aquifers.

Descriptive modeling of saltwater intrusion

- Simple approximation based solution.
- Sharp interface simulation.
- Density dependent flow simulation

Thank you