



# Sustainable use and protection of fresh water resources in delta areas: The fresh keeper

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# Salinization of coastal aquifers: major threat to water supply!

Map 3.1 Saltwater intrusions into groundwater in Europe (1999)



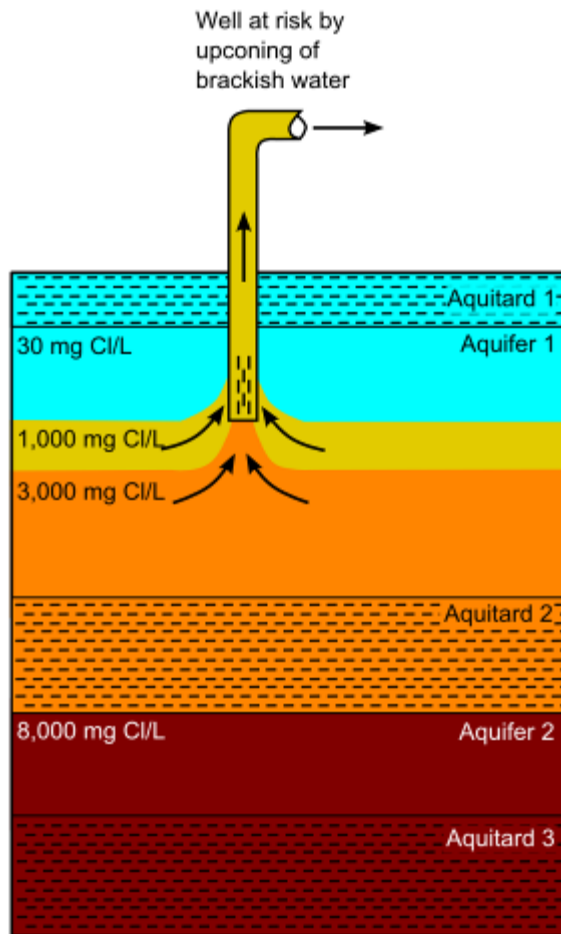
## Driving forces

Sea level rise (CC)

Decreasing river flows (CC)

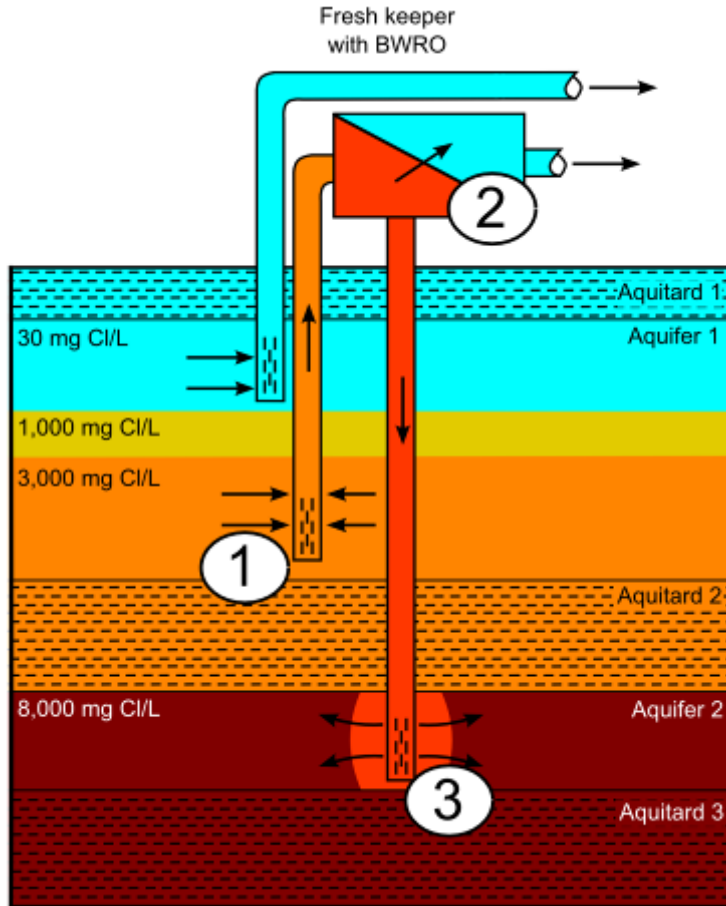
Overexploitation of groundwater

# How to prevent salinization of coastal well fields?



- In coastal areas, fresh water lenses are major fresh water resources, but vulnerable to upconing of brackish water
- If the filter screens are placed too deep, or if the groundwater is overpumped, the well field is at serious risk of salinization.

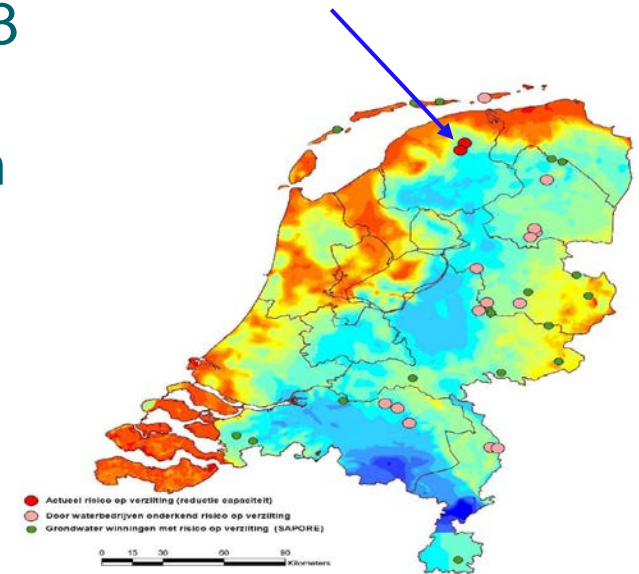
# The solution: 3-way approach



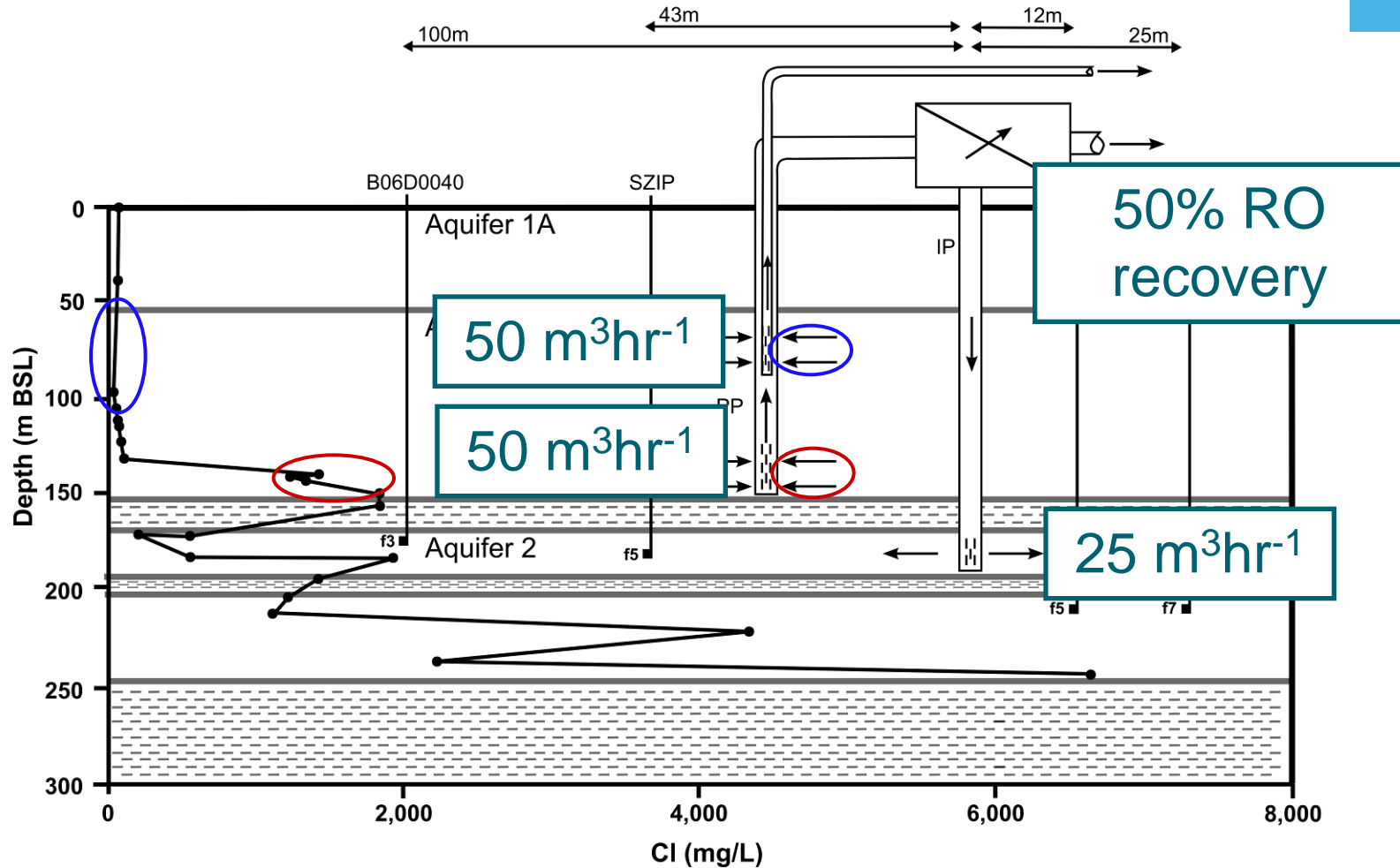
1. Pump (intercept) brackish water ('Fresh keeper')
2. Use brackish water as additional fresh water source (desalination by reversed osmosis)
3. Dispose RO concentrate in deep (more saline) aquifer through well injection

# Field pilot Noardburgum (Fryslan)

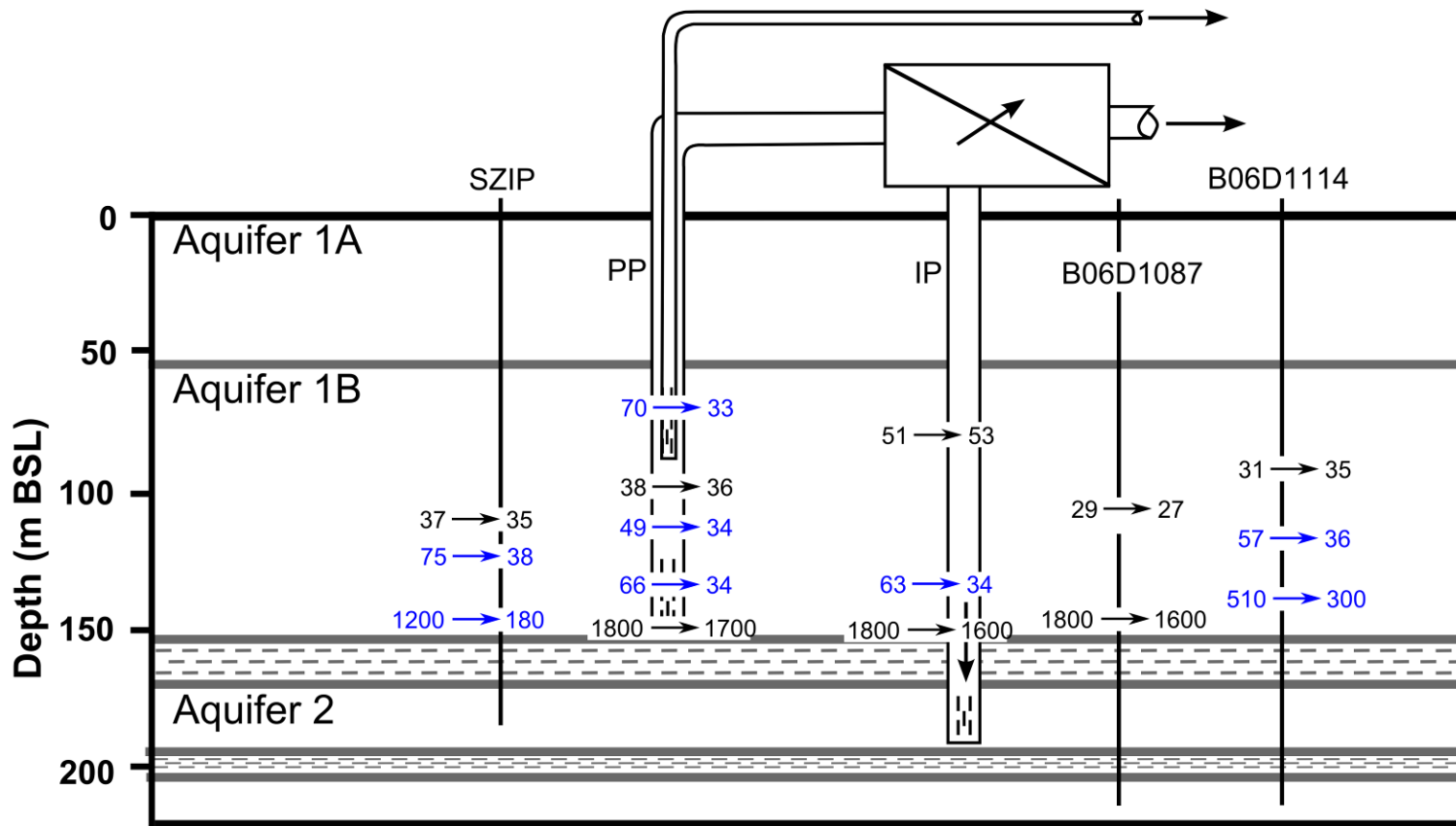
- Salinized well field, shut down in 1993
- Simultaneous pumping of upper fresh and lower brackish water, using a single well with two separate filters
- Fresh water and RO permeate used for drinking water production
- Deep well injection of RO concentrate



# Field pilot Noardburgum: operational design



# Fresh keeper in practice: Sustainable abstraction!



Change in chloride, 8 months after start abstraction