United Nations Educational, Scientific and Cultural Organization

Intergovernmental Hydrological Programme

DRIN CORDA

Global Water Partnership Mediterranean

IW LEARN

Session 4
Monitoring of quantitative status

Dr. Laura del Val Alonso

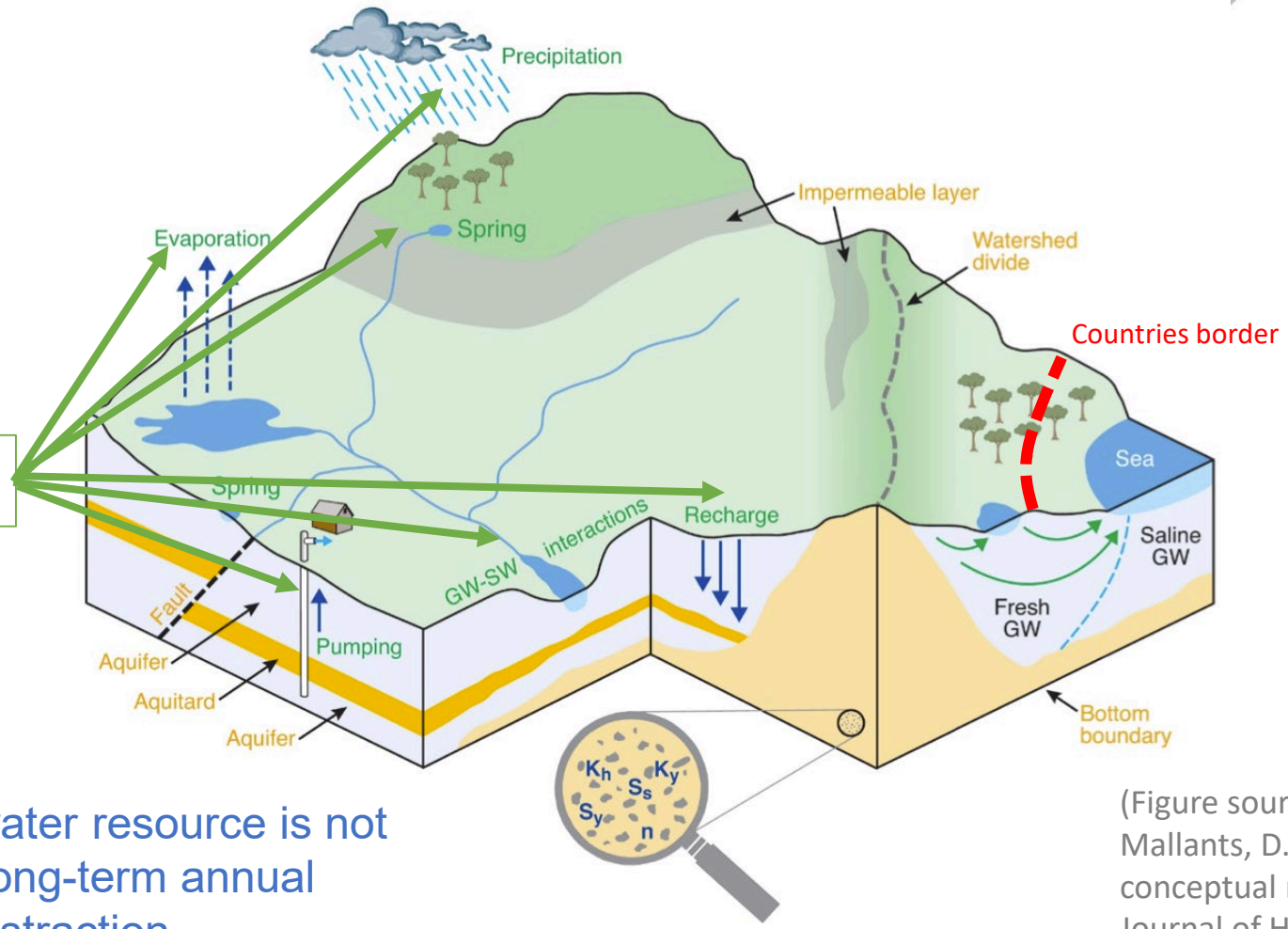
UNESCO Technical Webinar - October 2020
Guidelines for Monitoring Strategies in Transboundary Aquifers: Goals, Methods and Tools.
The Case of the DRIN project (ALB-MTN)

Contents

1. Quantitative status under the EU WFD
2. The concept of groundwater heads
3. Measuring groundwater heads
4. Groundwater head measurements in coastal aquifers
5. Datasheets
6. Additional quantitative information
7. The case of the Skadar/Shkoder - Buna/Bojana transboundary aquifer

1. Quantitative status

Water balance

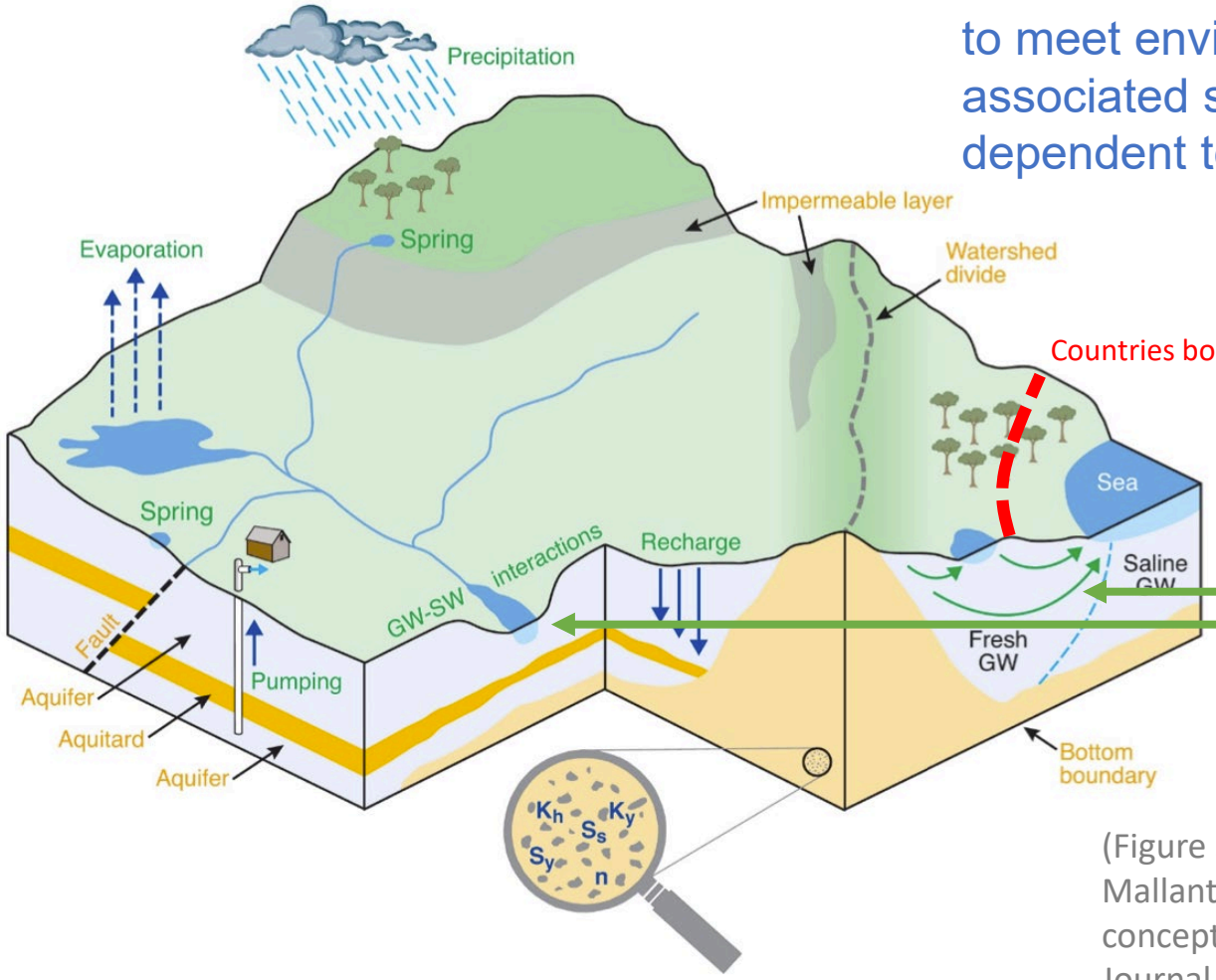


- Available groundwater resource is not exceeded by the long-term annual average rate of abstraction

(Figure source: Enemark, T., Peeters, L.J.M., Mallants, D., Batelaan, O., Hydrogeological conceptual model building and testing: A review, Journal of Hydrology (2018), doi: https://doi.org/10.1016/j.jhydrol. 2018.12.007)

1. Quantitative status

- Groundwater levels and flows are sufficient to meet environmental objectives for associated surface waters and groundwater dependent terrestrial ecosystems

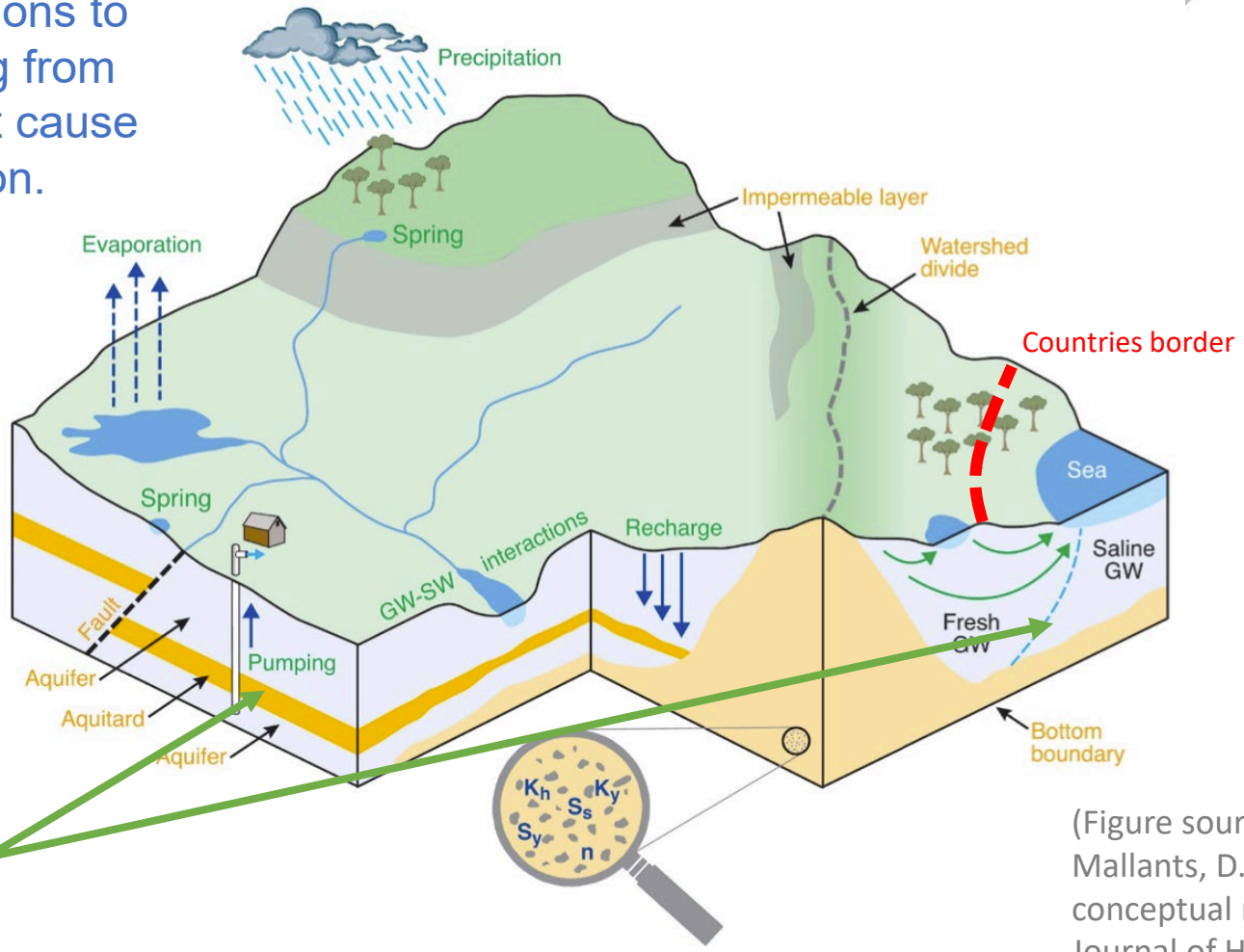


GW-Dependent ecosystems

(Figure source: Enemark, T., Peeters, L.J.M., Mallants, D., Batelaan, O., Hydrogeological conceptual model building and testing: A review, Journal of Hydrology (2018), doi: https://doi.org/10.1016/j.jhydrol. 2018.12.007)

1. Quantitative status

- Anthropogenic alterations to flow direction resulting from level change does not cause saline or other intrusion.



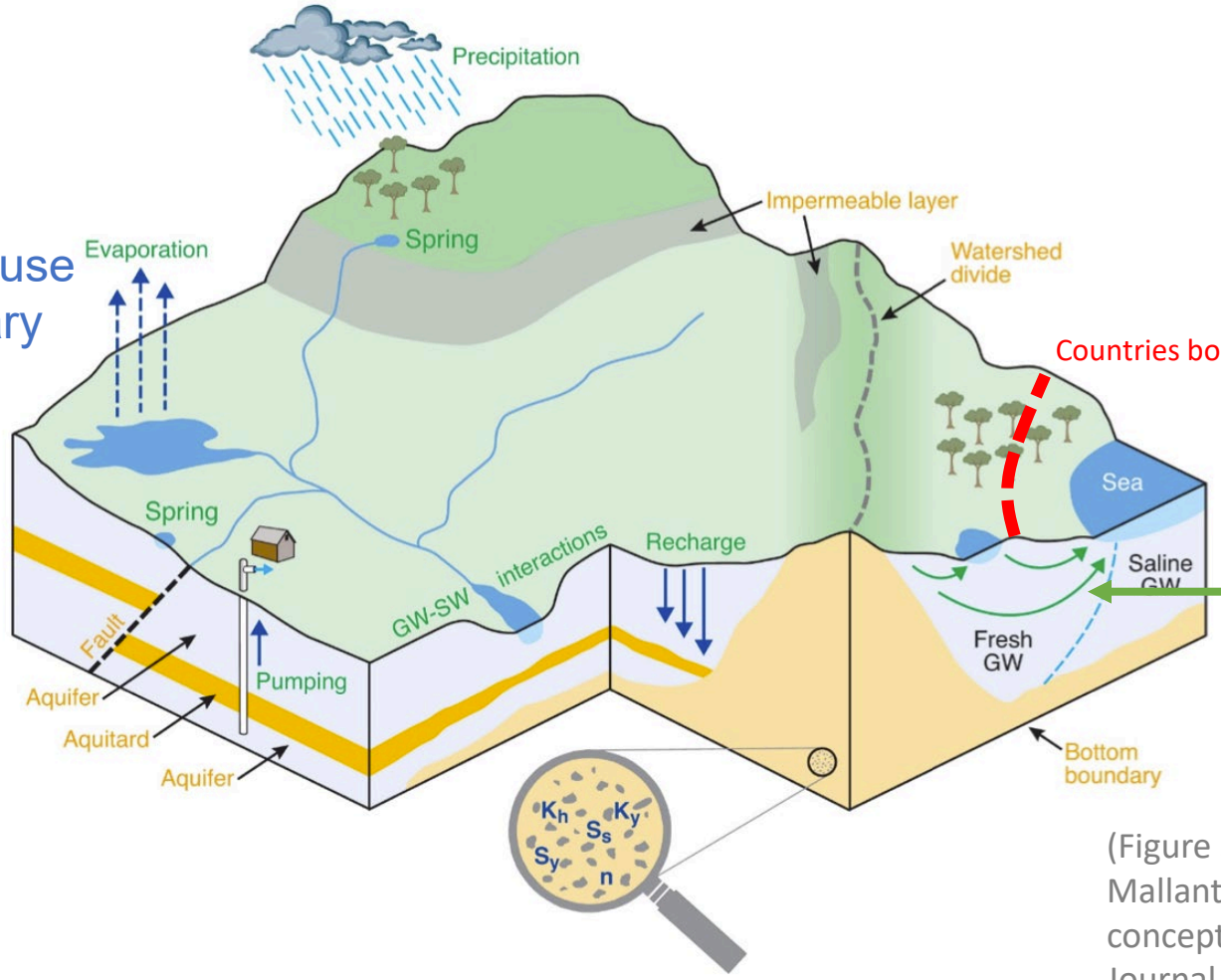
Abstraction rates

(Figure source: Enemark, T., Peeters, L.J.M., Mallants, D., Batelaan, O., Hydrogeological conceptual model building and testing: A review, Journal of Hydrology (2018), doi: https://doi.org/10.1016/j.jhydrol. 2018.12.007)

1. Quantitative status

Additional item:

Activities with respect to monitoring should be coordinated when water use may have a transboundary effect



Flow direction and rate

(Figure source: Enemark, T., Peeters, L.J.M., Mallants, D., Batelaan, O., Hydrogeological conceptual model building and testing: A review, Journal of Hydrology (2018), doi: https://doi.org/10.1016/j.jhydrol. 2018.12.007)

2. Groundwater heads

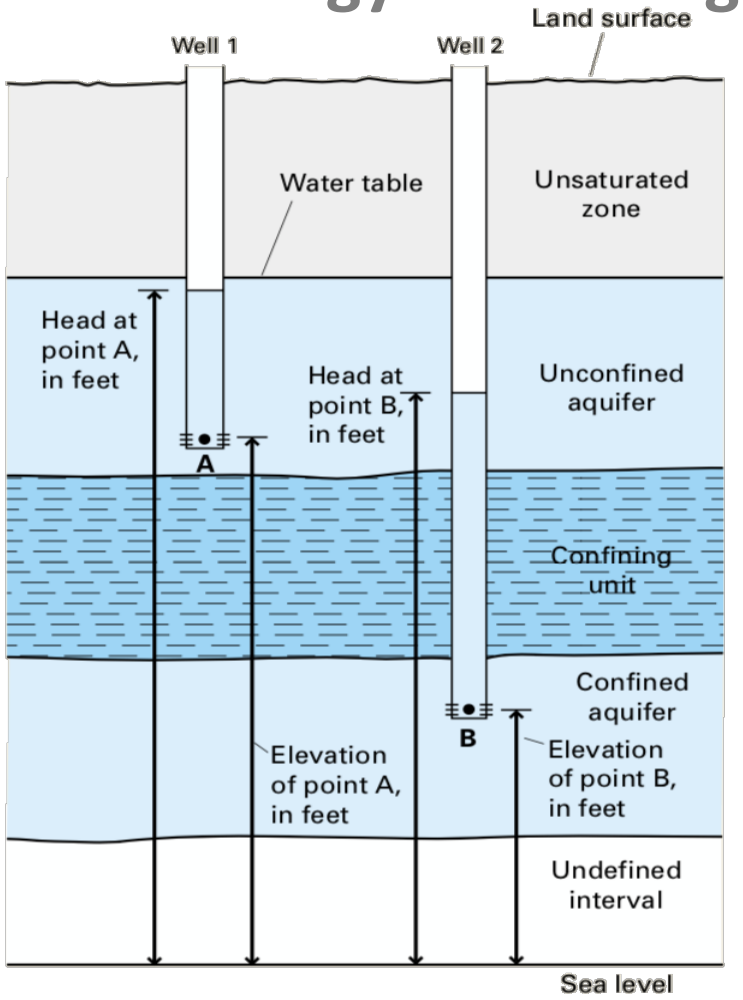
Groundwater head = Potential energy stored in groundwater

Groundwater head:

$$h = z + \frac{P_i}{\rho_i g}$$

Darcy's Law

$$q = -K\frac{dh}{dx}$$

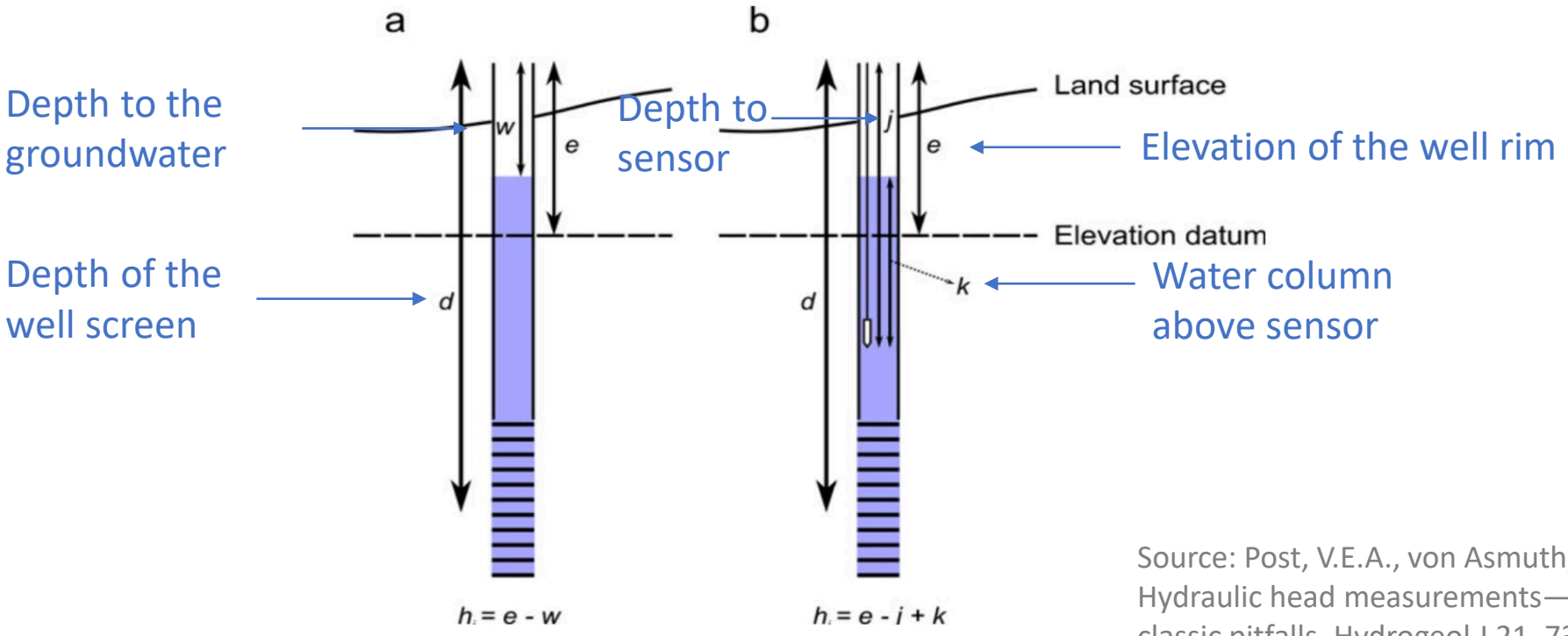


(Figure source: Taylor, C. J., & Alley, W. M. (2001). Ground-water-level monitoring and the importance of long-term water-level data. Geological Survey Circular, 1–76.)

3. Groundwater head measurements

Manual measurements

Measurements with pressure sensor



j = w + k

Source: Post, V.E.A., von Asmuth, J.R. Review: Hydraulic head measurements—new technologies, classic pitfalls. Hydrogeol J 21, 737–750 (2013). https://doi.org/10.1007/s10040-013-0969-0)

3. Groundwater head measurements

Manual measurements

Measurements with pressure sensor

Elevation measurement

3. Groundwater head measurements

Groundwater heads are then used to draw potentiometric maps:

- **Recharge-discharge pathways**
- **Flow rates**
- **Flow directions**
- **Groundwater divides**

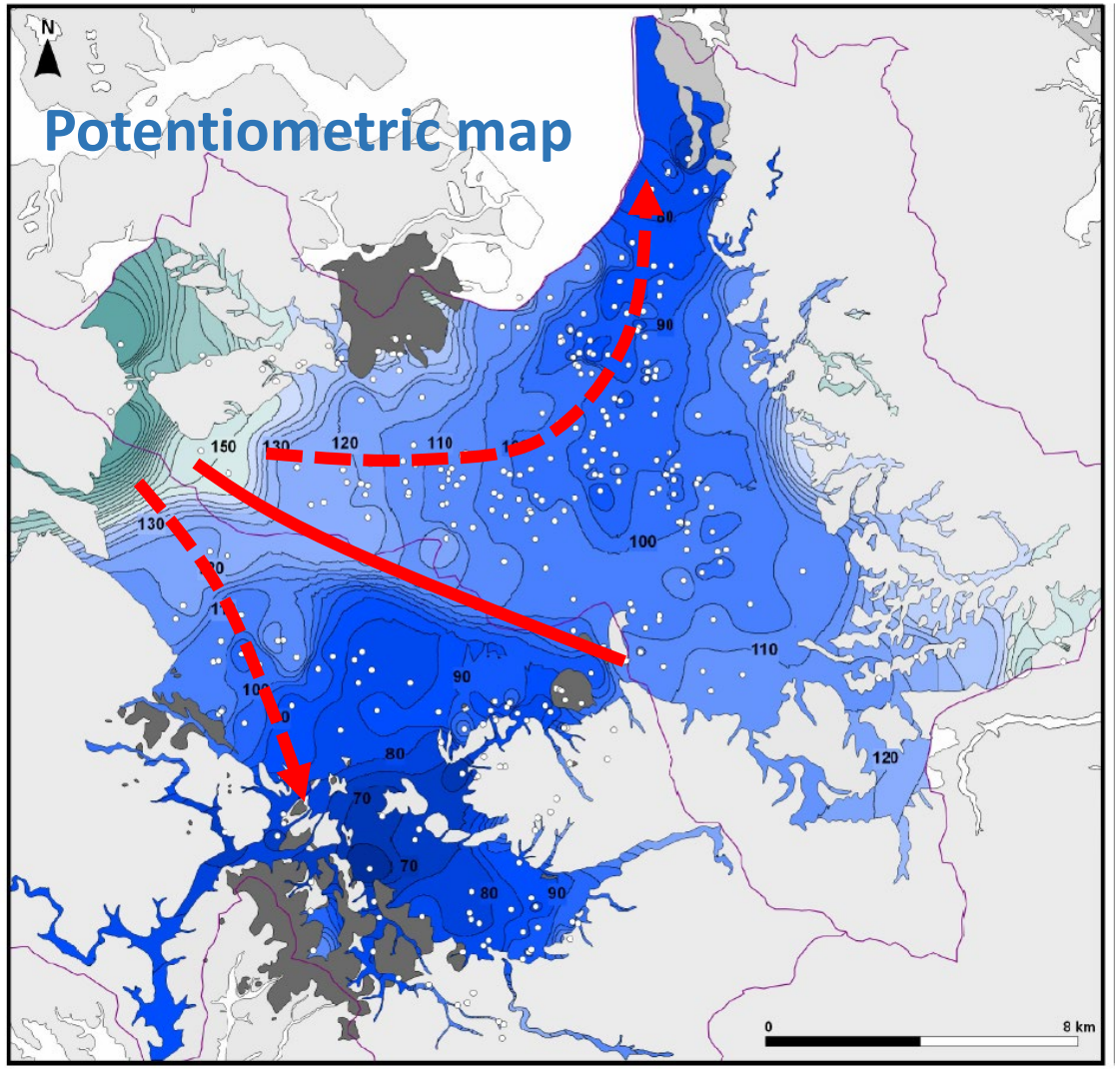
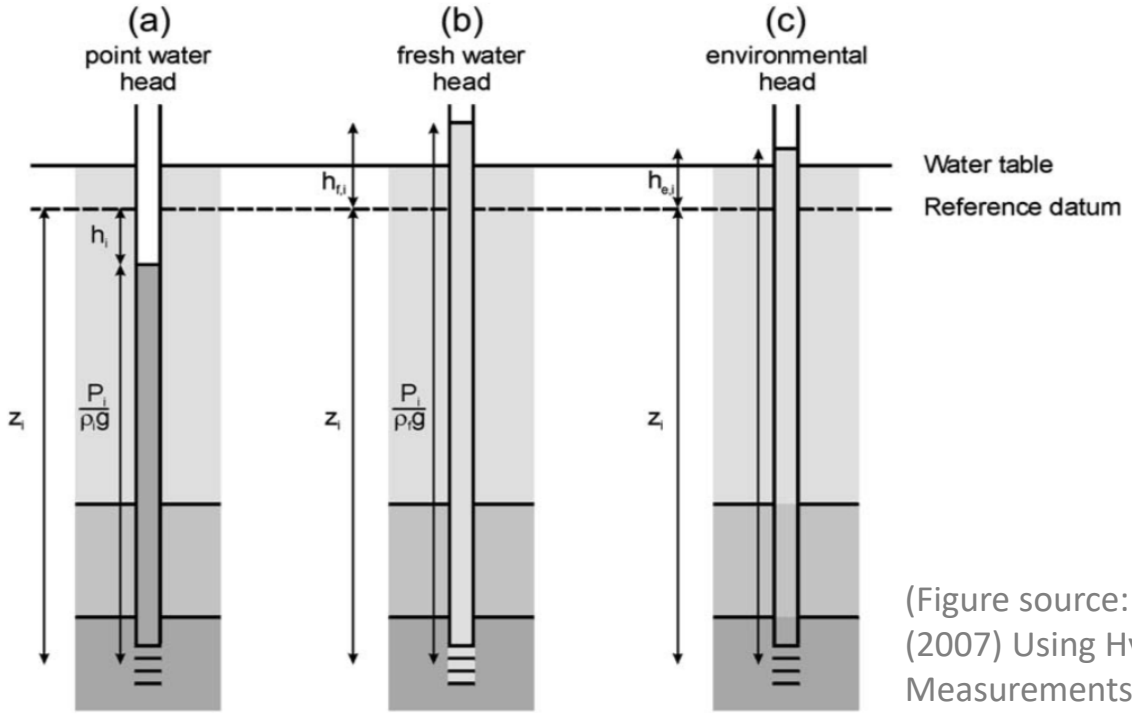


Figure source: Menció A (2005). PhD Dissertation, Universitat Autònoma de Barcelona

4. Groundwater head measurements in coastal aquifers

Groundwater head under variable density conditions:

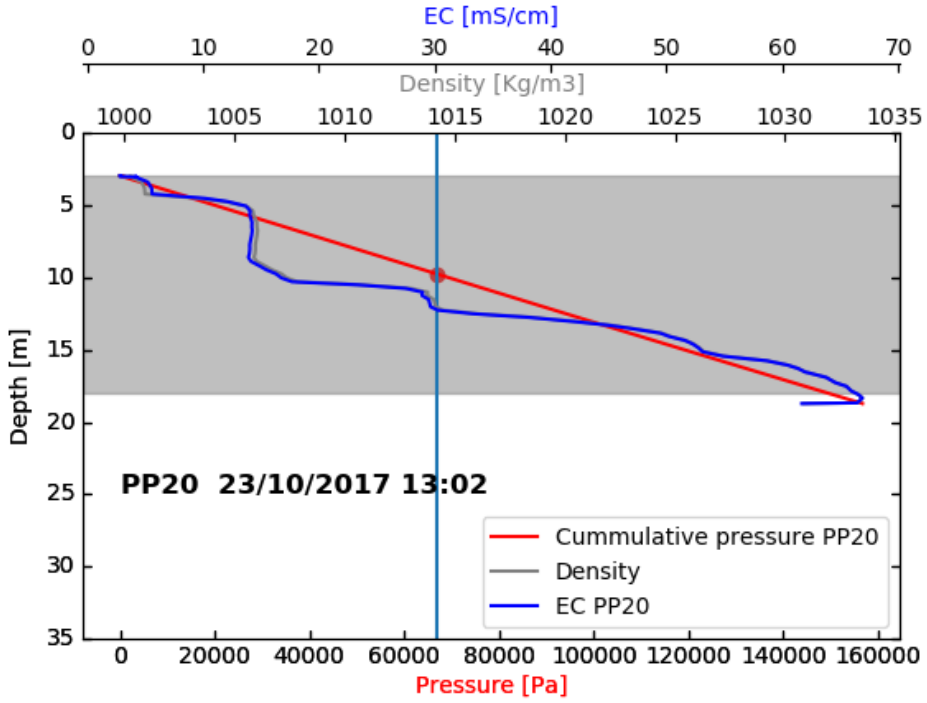
$$h_{f,i} = \frac{\rho_i}{\rho_f} h_i - \frac{\rho_i - \rho_f}{\rho_f} z$$



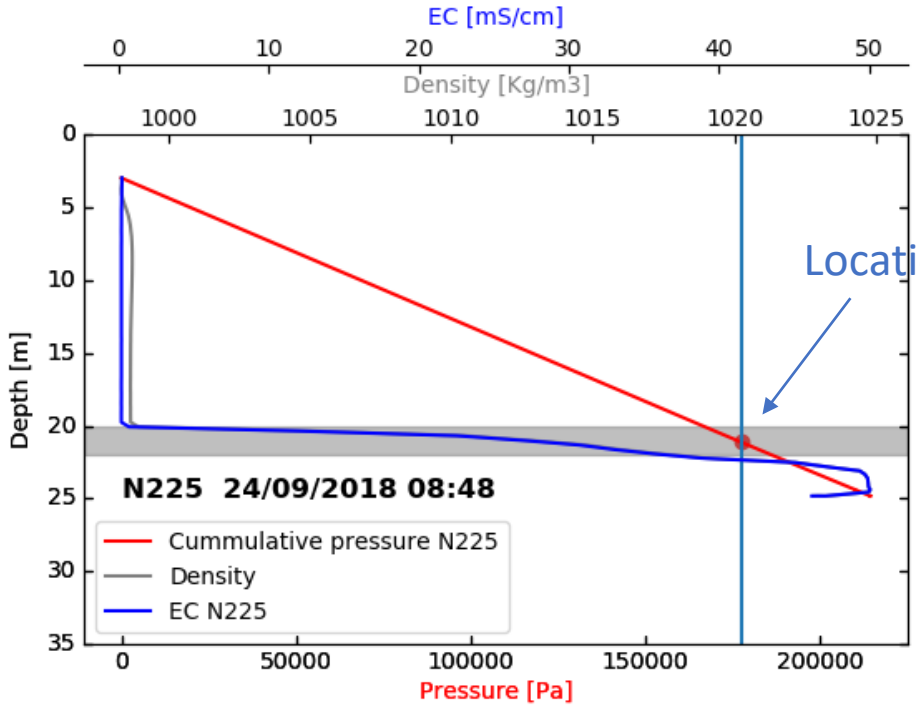
(Figure source: Post, Kooi and Simmons (2007) Using Hydraulic Head Measurements in Variable-Density Ground Water Flow Analyses. Groundwater, Vol. 45, No. 6, 664–671), 10.1111/j.1745-6584.2007.00339.x)

4. Groundwater head measurements in coastal aquifers

Fully screened borehole



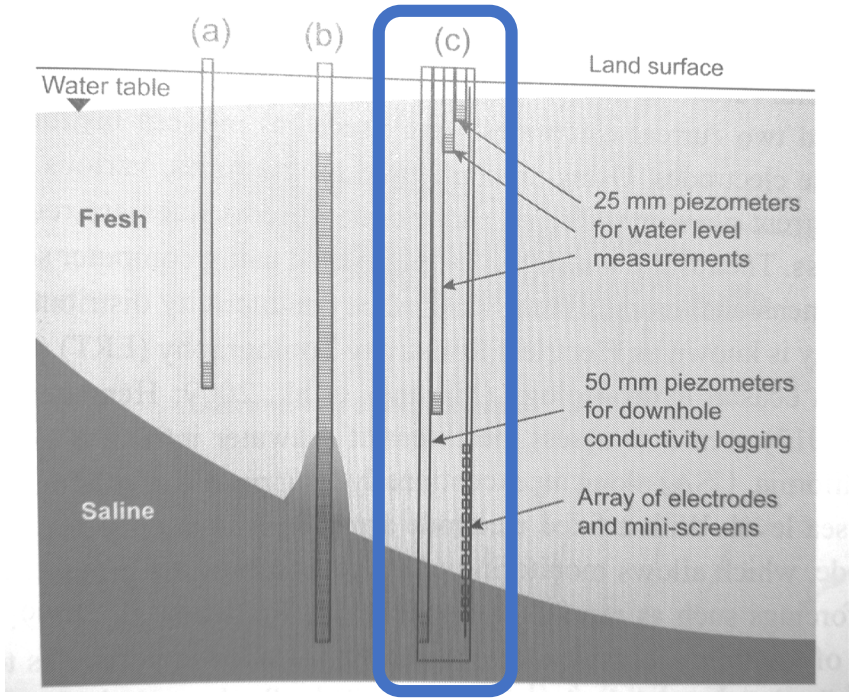
2 m screen interval



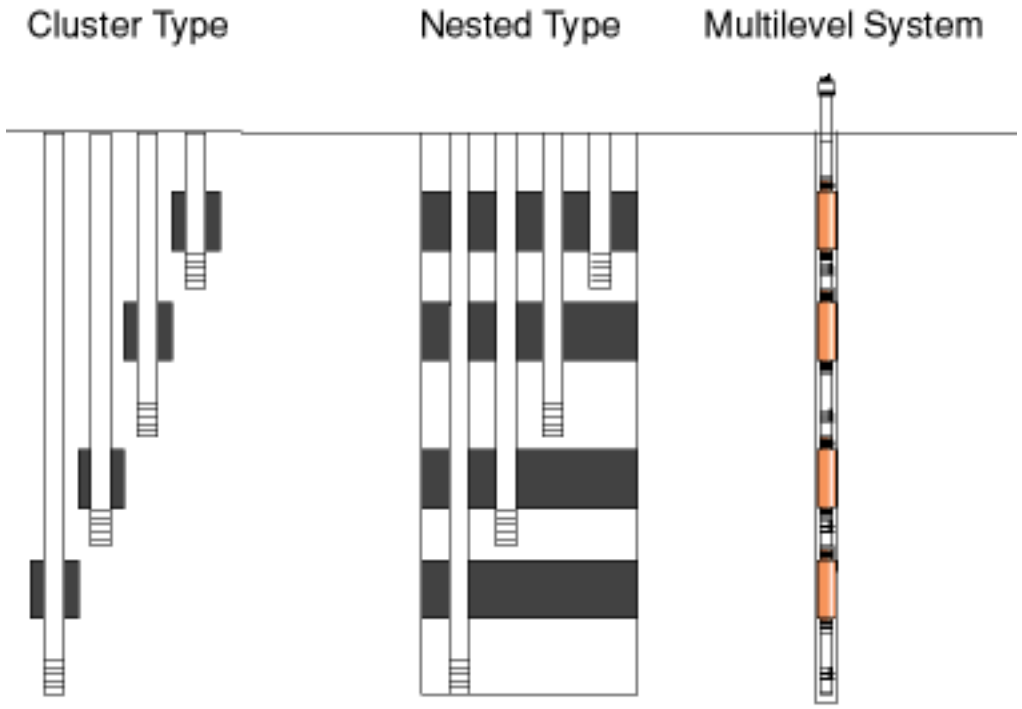
Location sensor

(Source: del Val Alonso, 2020. PhD Thesis. Advancing in the Characterization of Coastal Aquifers. Unpublished data MEDISTRAES project.)

4. Groundwater head measurements in coastal aquifers



(Source: Jiao & Post, 2019. Coastal Hydrogeology. Cambridge university press.)



(Source: Solinst. https://www.solinst.com/resources/papers/401k.php)

4. Groundwater head measurements in coastal aquifers

Electrical conductivity sensors

Pumps

5. Data sheets

Information about monitoring point:

- Site name
- Date and time
- Coordinates of the well
- Contact information
- Measuring-point elevation
- Access to location

Information to collect, formats and units to be agreed between riparian States

Construction details:

- Drilling method
- Lithology description (if available)
- Materials of casing and annulus
- Type of cap
- Total depth
- Measuring point
- Diameter of borehole
- Height/depth of the borehole rim
- Screen interval
- ***Status/maintenance***

Hydrological information

- Aquifer monitored
- Groundwater body
- Type of monitoring point
- Operating interval
- Pump status
- Pump status time
- ***Depth to groundwater***
- Depth to sensor (if any)

For coastal aquifers:

- ***EC profile or equivalent***

6. Additional quantitative information

Water balance also needs…

Groundwater:

- Spring flows
- Groundwater abstraction (and artificial recharge)

Surface water:

- Stage levels of surface water courses
- Stage levels in significant groundwater dependent wetlands and lakes

Recharge:

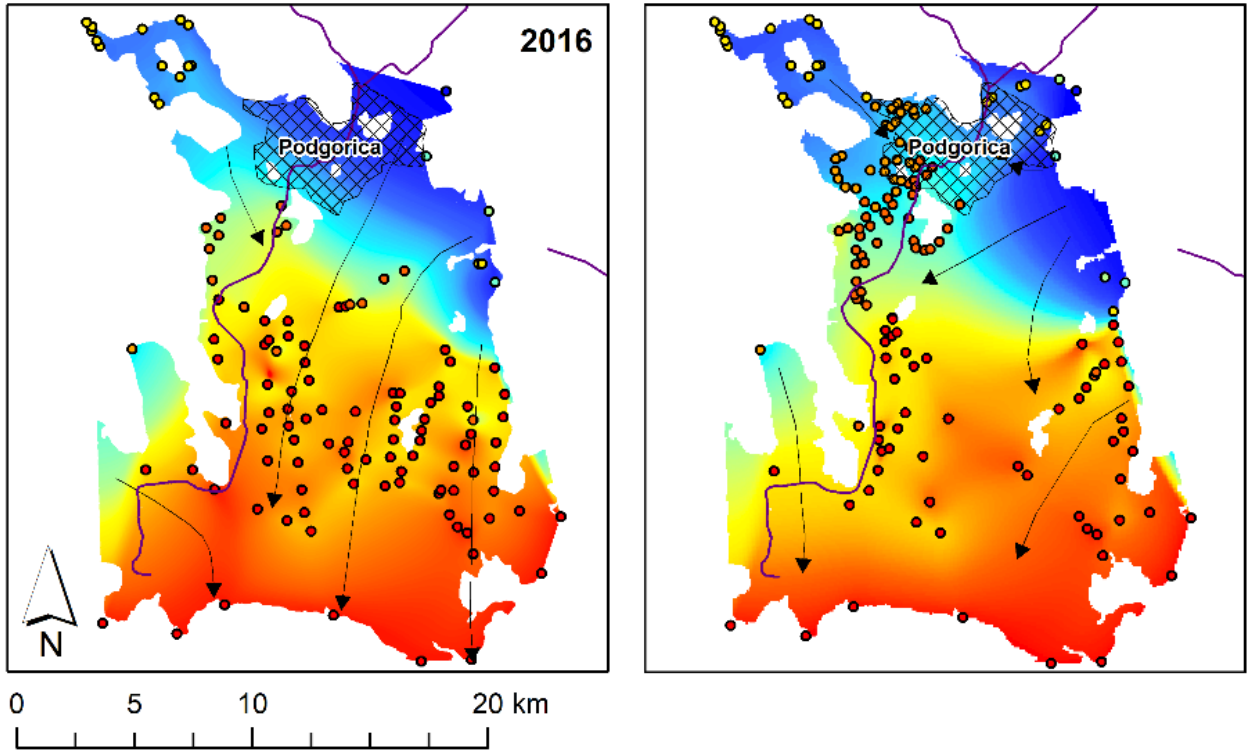
- Rainfall and the components required to calculate evapo-transpiration

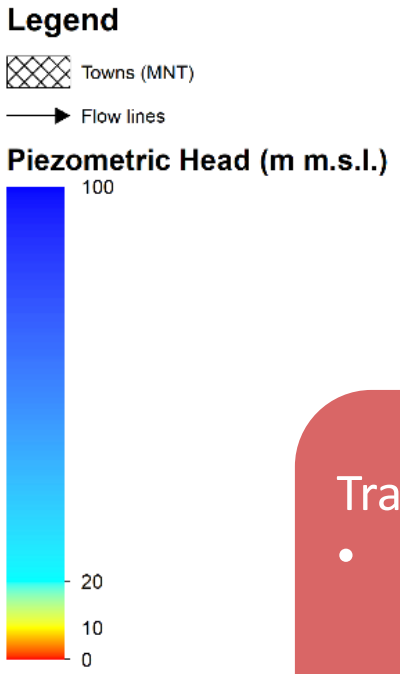
10. Real case

The case of the Skadar/Shkoder - Buna/Bojana transboundary aquifer

MNT – Groundwater levels

Zeta Plain





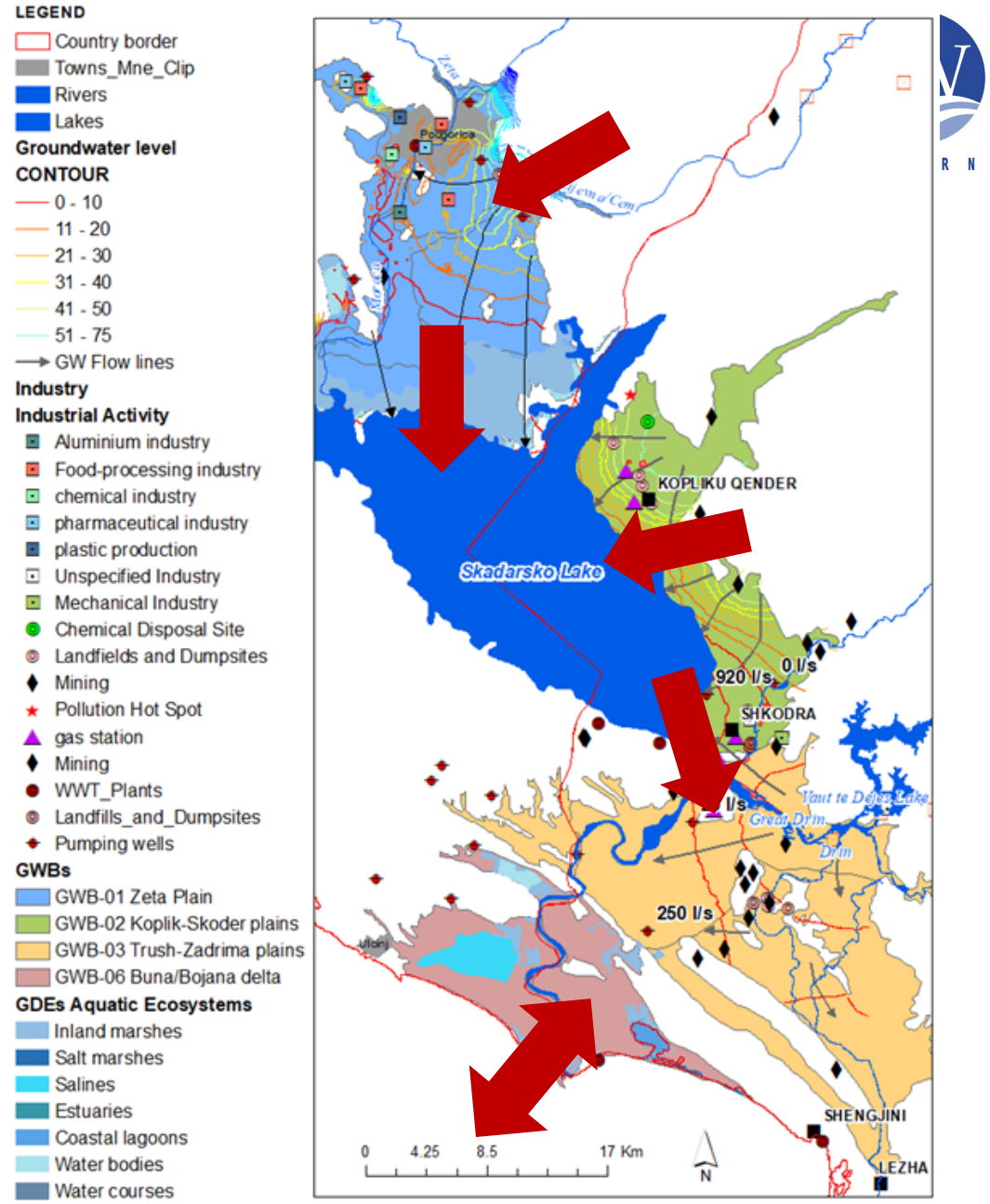
Lateral recharges occurs mainly through the north right part of the catchment, that is the Cijevna river upper catchment

Transboundary features:

- Recharge arriving to the Zeta Plain
- Discharge to Transboundary lake

Groundwater levels to monitor transboundary features

- Recharge to Zeta Plain
- Discharge from Zeta Plain to Lake
- Discharge from Koplik-Shkodra plain to Lake
- Discharge from lake to Trush-Zadrima plain
- Saline intrusion



Further reading

EU-WFD guidance documents:

- European Commission (2007). Guidance Document No. 15. Guidance on Groundwater Monitoring. Common Implementation Strategy for the water framework directive (2000/60/EC). ISBN 92-79-04558-X

Other relevant documents:

- Taylor, C. J., & Alley, W. M. (2001). Ground-water-level monitoring and the importance of long-term water-level data. Geological Survey Circular, 1–76.
- Post, V.E.A., von Asmuth, J.R. (2013) Review: Hydraulic head measurements—new technologies, classic pitfalls. Hydrogeol J 21, 737–750. https://doi.org/10.1007/s10040-013-0969-0
- ISO (2005) Manual methods for the measurement of a groundwater level in a well. ISO 21413:2005, ISO, Geneva
- USGS. A National Framework for Ground-Water Monitoring in the United States. (2013).

Thank you!

Contact details:

Dr. Laura del Val Alonso
Dpt. Earth and Ocean Dynamics
University of Barcelona
lauradelvalalonso@gmail.com
lauradelvalalonso@ub.edu