

## Fresh-saline groundwater in deltaic and coastal areas

Salinisation causes problems for farmers, water managers and nature in many coastal areas of the world. Deltares has in-house databases, numerical modelling techniques, monitoring tools and the knowledge to thoroughly investigate salinisation issues and to implement innovative solutions for a robust proof fresh water supply in the coastal zone.

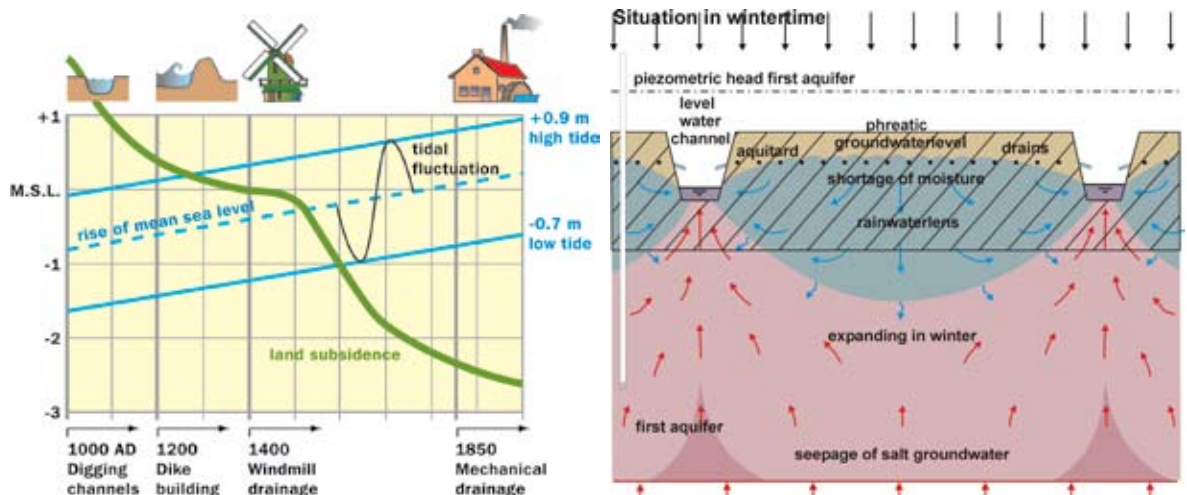
The Netherlands is situated in the deltas of three rivers; the Rhine, the Meuse and the Scheldt. Like in many other deltaic areas, in The Netherlands salinity in groundwater ranges from brackish to saline. This groundwater is mainly old seawater that has been trapped in the ground when the sea transgressed the delta. In a large part of the Netherlands, permanent groundwater drainage keeps the polder areas sustainable. However, this on-going draining resulted in mobilizing and upconing of deeper and more saline groundwater which resulted in salinisation of shallow groundwater and surface water. This may pose problems for drinking water supply, agricultural production (salt damage) and fresh water ecosystem.

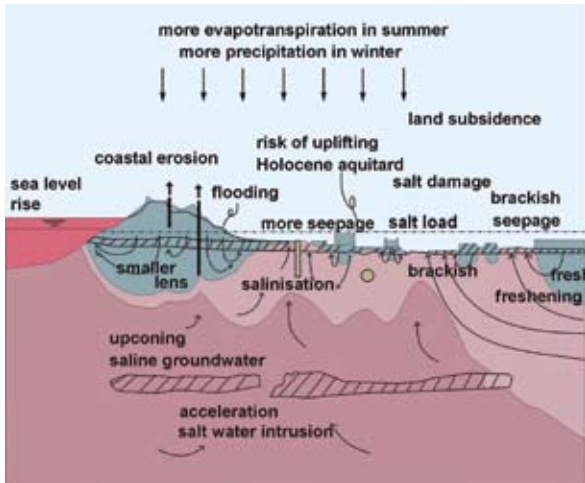
### Threats to the fresh water resources

The process of salinisation will accelerate due to the anticipated sea level rise, climate change, future land subsidence and especially due to human factors like groundwater extraction and lowering of differentiated polder water levels. The processes described here for the Dutch situation prevail in many other deltas and coastal areas. Concluding, not taking any mitigation and/or adaptation measures will lead to a world-wide increase of salinisation.

### Focus on regional and local processes

Deltares researchers investigate the processes of fresh, brackish and saline groundwater in coastal aquifers on different scales. On a regional scale, the effects of climate change, land, and water use change and the combined effects of preventive measures on groundwater salinisation are studied.



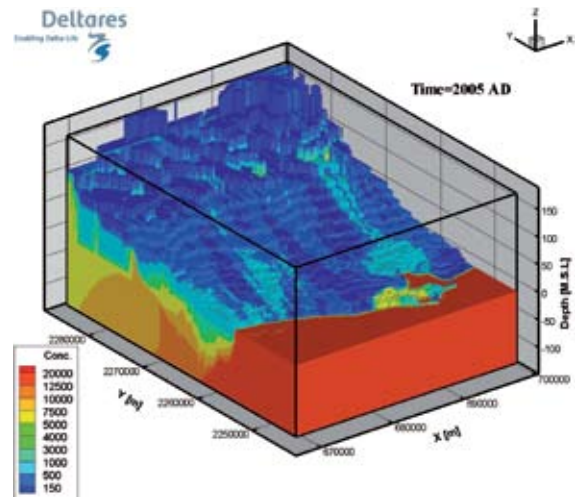


Conceptual salinisation processes in Dutch coastal areas in case of sea level rise and climate change

Other studies give answers on how groundwater concentration changes affect surface water quality. On a local scale, the dynamics of fresh rainwater lenses on saline groundwater as a result of natural or artificial recharge are studied. These lenses allow agriculture in low-lying areas where shallow groundwater is very saline. Other research topics are preferential groundwater flow via sandy layers and boils that connect deep saline aquifers with shallow aquifers and with fresh surface water bodies. These preferential flow paths largely contribute to the salinisation of Dutch low-lying areas. Our knowledge is not specific for the Netherlands and can be applied in similar deltaic areas around the world.

### Solutions of salinisation problems

Deltares has the knowledge and expertise to study processes in combined fresh and saline groundwater systems. We develop and apply monitoring tools and techniques like the T-EC probe, EM-Simflex and other online real-time measurement techniques. Moreover, Deltares has the modelling experience and the numeric compute codes (like MOCDENS3D/SEAWAT) at its disposal to simulate variable-density groundwater flow and coupled solute transport. Deltares is engaged in the design of specific measures needed for salinisation prevention and adaptation and for saline aquifer management. We have a long professional track record on groundwater salinisation studies built up during numerous relevant projects worldwide.



Modelled groundwater salinity distribution in Gujarat, India

### Salinisation projects at Deltares

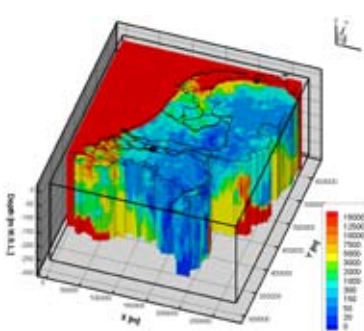
- CLIWAT (Interreg project): assessing the effect of climate change on water quantity and quality in north-west Europe, in collaboration with Danish, German, Belgian and Dutch institutes: [www.cliwat.eu](http://www.cliwat.eu).
- Evaluating salinity prevention measures undertaken in the coastal area of Gujarat, India.
- Crystechsalin (FP5): The development of crystallization technologies for the prevention of salt water intrusion.
- Assessing the impact of the 26-12-04 Tsunami on groundwater systems and fresh resources
- Effects of land subsidence due to salt and gas exploitation on a salinised ground and surface water in Northern-Netherlands
- Fresh-salt National Hydrological Instrument: 3D model to quantify the groundwater with both fresh and saline water. Quantification of the impact of climate change and anthropogenic activities.
- Freshening-salinisation of the phreatic groundwater in Zeeland Province, monitoring and 3D modelling.

### More information

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Modelled groundwater salinity distribution in The Netherlands