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Ecohydrogeochemistry of Former Tidal Wetlands

The c. 50 years undisturbed freshwater lens development at Veermansplaat island, a former tidal flat in the southwestern Netherlands

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Introduction

- Veermansplaat: A former tidal flat that transformed into a permanent island (Fig. 1) where, since the Grevelingen estuary closure in 1971 as part of Dutch Delta Works, a fresh groundwater lens started to develop.
- Aim: Quantify spatiotemporal development of this lens related to the water management in the saline lake, being part of the protected Nature 2000 area. This management will probably partly rehabilitate the tide to improve the water quality and anticipate the expected rise in sea water level induced by climate change. Net results must be positive.
- Scope: PhD research into ecohydrogeochemistry of former tidal wetlands.

Veermansplaat

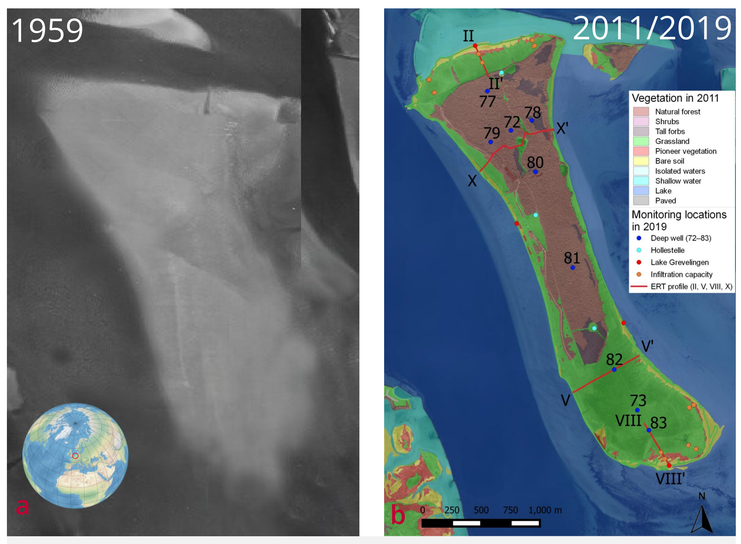

Fig. 1 Veermansplaat, **a.** as bare sand plate in Grevelingen estuary in 1959, **b.** as permanent island in Lake Grevelingen, combined with vegetation map of 2011 and monitoring locations in 2019.

Results monitoring

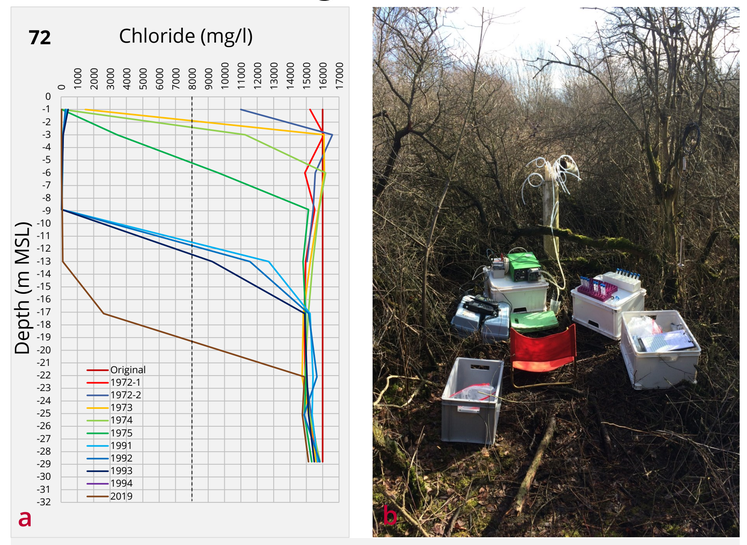

Fig. 2 **a.** Chloride breakthrough curves at well 72 from which infiltration depths were deduced. In 2019, the fresh-saline interface (8,000 mg Cl/l) has reached -19.5 m MSL. **b.** Groundwater sampling at well 72 in 2019.

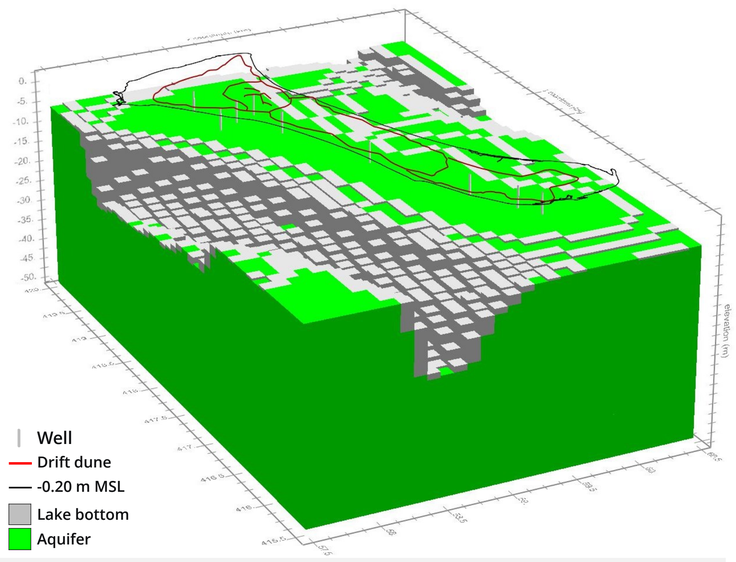

Fig. 3 Conceptual transient 3D groundwater model of Veermansplaat as unconfined aquifer with hydraulic heads influenced by surface elevation (including drift dune and Lake Grevelingen bottom), lake water levels, flooding (storms), surface runoff, precipitation, evapotranspiration (dependant on vegetation types), dispersion, and variable densities. Hydrological base is at c. -55 m MSL. No flow at model borders (sides and base).

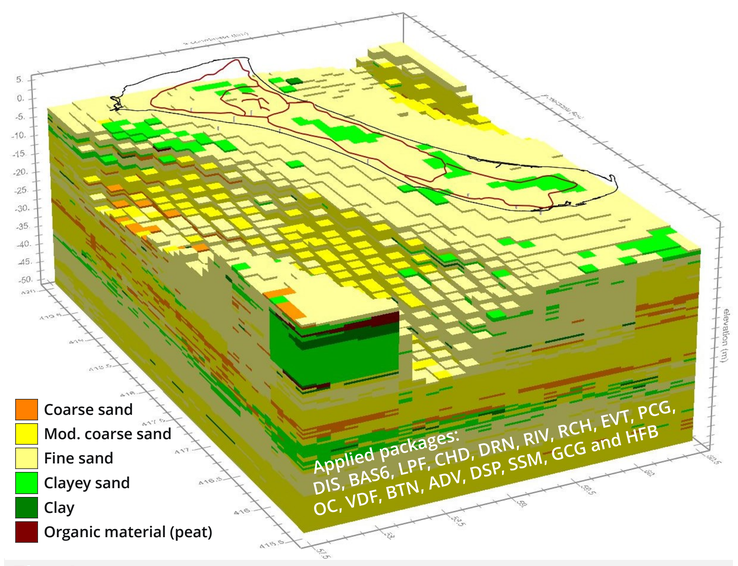

Fig. 4 3D model with lithologies and applied program packages for flow and transport. The GeoTOP 1.6 lithologies combined with stratigraphy were linked to permeability and porosity values. Between -50 and -55 m MSL permeability and porosity values are from REGIS II v2.2.1.

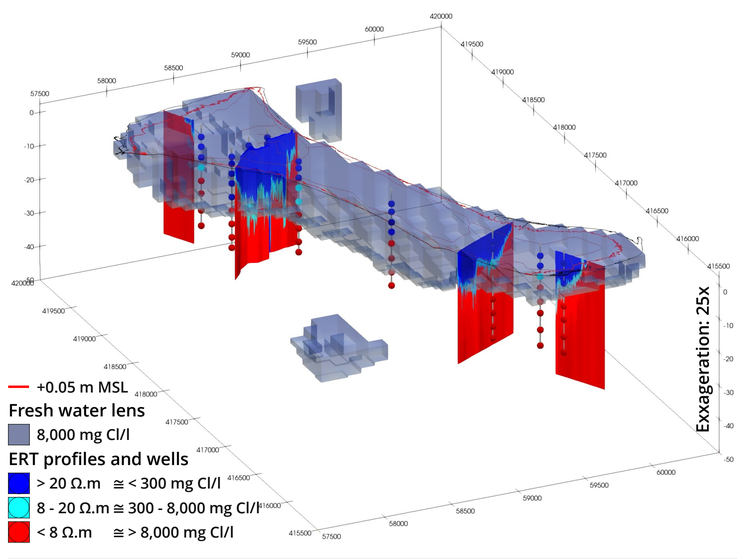

Fig. 5 3D model with the fresh water lens in 2021, delineated by the fresh-saline interface, combined with the four ERT profiles and nine wells for validation. ERT resistivities were transformed to chloride concentrations per profile. At the surface, the interface coincides with the elevation contour of +0.05 m MSL, probably being the maximum extent of floodings.

Methods

Based on our conceptual model (Fig. 3), we:

- compiled available spatiotemporal data:
  - Precipitation and evapotranspiration (KNMI);
  - Water levels and compositions Lake Grevelingen (RWS);
  - Groundwater heads and compositions (RWS);
  - Digital surface elevation map (RWS);
  - Lithology and stratigraphy (TNO-GSN).
- additionally monitored:
  - Water compositions Lake Grevelingen;
  - Groundwater heads and comp. (Fig. 2);
  - Electrical resistivity with electrical resistivity tomography (ERT);
  - Soil infiltration capacities.
- created a 3D groundwater model with these data and the program iMOD-WQ (SEAWAT+MT3DMS) to simulate variable density flow and transport (Fig. 4).
- validated this model (Fig. 5, Fig. 6) and simulated scenarios (Fig. 7).

Results modelling

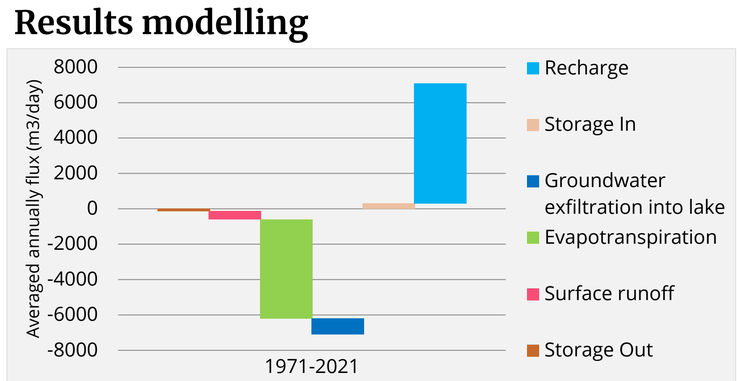

Fig. 6 Water balance from 3D model with averaged annually flux per source and sink term. Bars are spread to emphasize individual terms.

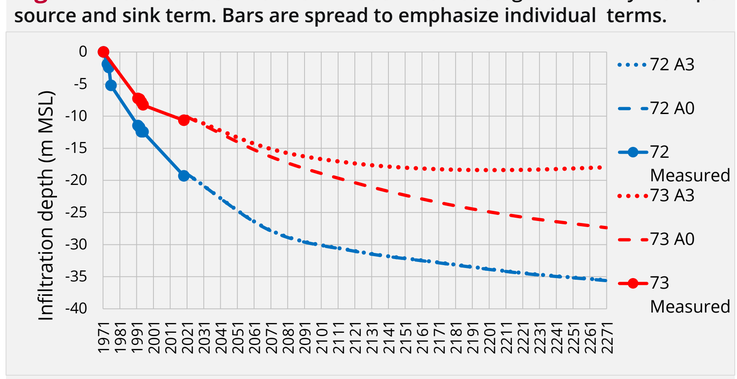

Fig. 7 Measured and modelled infiltration depths of fresh-saline interface at wells 72 and 73. Scenario A0 (present conditions continued): the depths increase but with a decreasing velocity, even after 300 years. Scenario A3 (water level in lake maximal 0.2 m MSL): Fresh water lens shrinks at well 73.

Conclusions

1. The fresh water lens of Veermansplaat is unique because it is developing undisturbed, already for c. 50 years.
2. The groundwater model quantifies the growth of the freshwater lens rather well using the available and additionally acquired spatiotemporal data.
3. The fresh water lens increasingly raises the groundwater table (Δh = Lens thickness/40).
4. The modelling could also quantify surface runoff. Runoff occurs only between the narrow drift dune and the coast because the drift dune blocks the runoff. Consequently, less water infiltrates in that part, leading to a twice thinner freshwater lens and less seepage, thus impacting vegetation types.
5. The simulated future development of the fresh water lens with a climate adapted water level in Lake Grevelingen of maximal 0.2 m MSL after 2080 shows a development towards locally a thinner fresh water lens.

References

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