Impact of long screens on monitoring of the freshwater-saltwater transition zone in coastal aquifer

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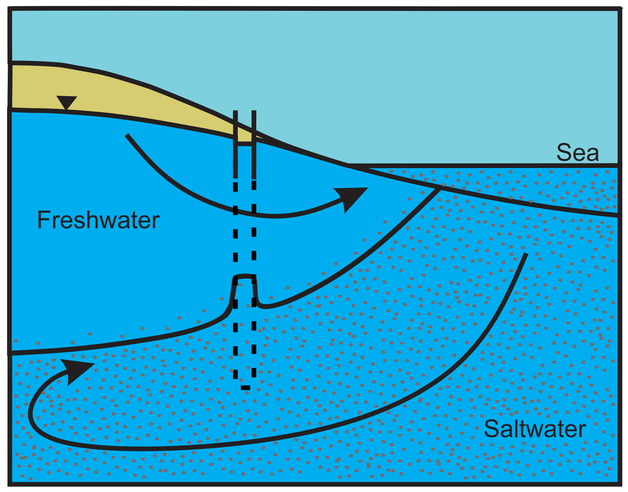
Context

Monitoring wells allow to measure the depth of the freshwater-saltwater transition zone, commonly referred to as the freshwater-saltwater interface, in coastal aquifers.
Studies revealed that long well screens could lead to a biased observation of the freshwater-saltwater transition zone caused by vertical flow within the well that changes the position of the interface from its natural elevation.

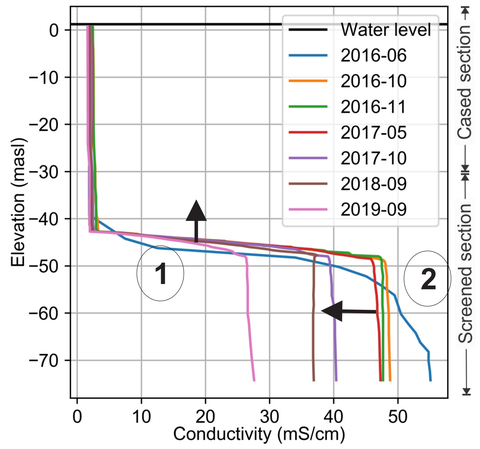


Study area : Magdalen Islands

Long-screened monitoring wells in the Magdalen Islands (Quebec, Canada)

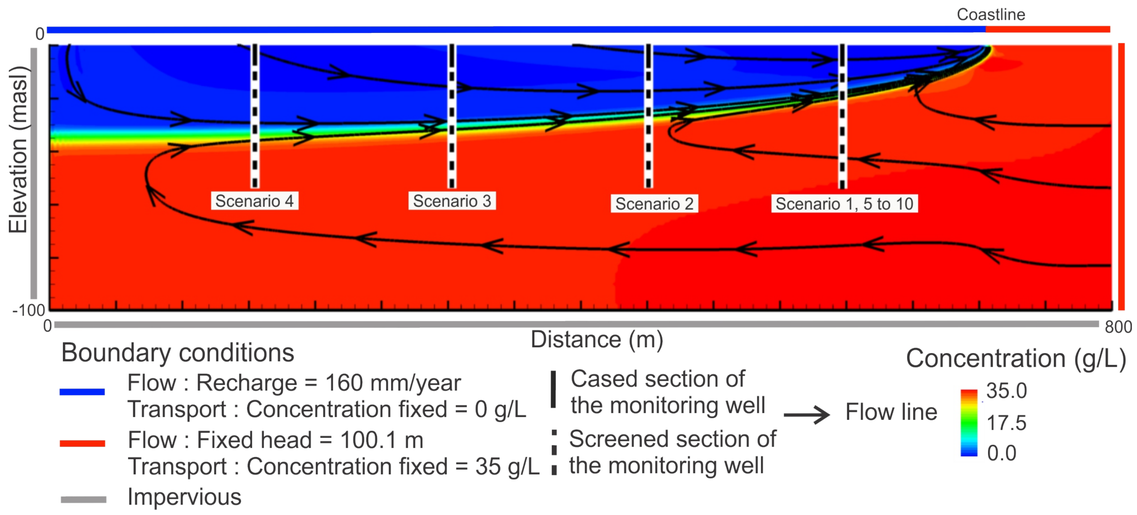
Annual water electrical conductivity profiles show :
1 The interface elevation has increased
2 The saltwater TDS concentration has decreased

Question : Do the long-screend monitoring wells in the network provide biased observations of the transition zone?



Methodology : Numerical modelling

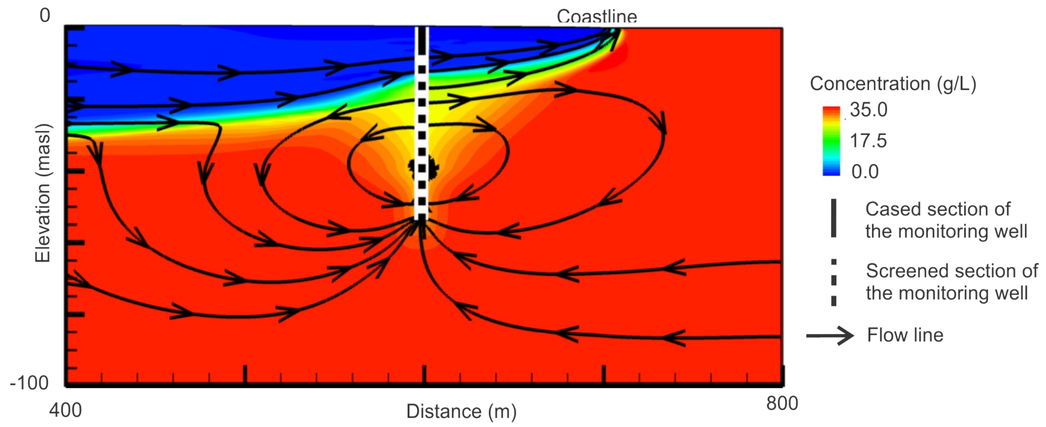
- Steady state obtained in a 3D model of saltwater intrusion (SALTFLOW, Molson & Frind, 2020)
- Monitoring well inserted
- Parametric analysis carried out : which parameters can bias observation?



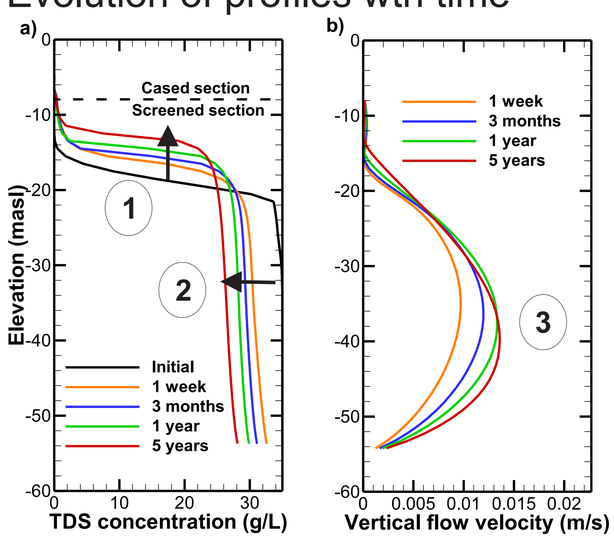
Results & Discussion: Insertion of a long-screened well

New steady state

- The flow lines are now shifted towards the monitoring well
- The inflow of water from the aquifer toward the well only occurs in the saltwater zone until a point of inflection, where there is an outflow from the well towards the aquifer
- This behavior creates a recirculation zone of somewhat diluted salty groundwater
- This leads to a decrease of the saltwater concentration around the well



Evolution of profiles wth time



The construction of a monitoring well is responsible for:

1 - Increase of the interface elevation over time

2 - Decrease of the saltwater concentration over time

3 - An upward flow in in the well

-The construction of a monitoring well instantly changes the equilibrium of the aquifer.

-The upward flow within the well (3), can be responsible for the displacement of the interface (1).

-The decrease of the TDS concentration (2) is important since electrical conductivity profiles are often used to derive saltwater properties such as salinity or density.

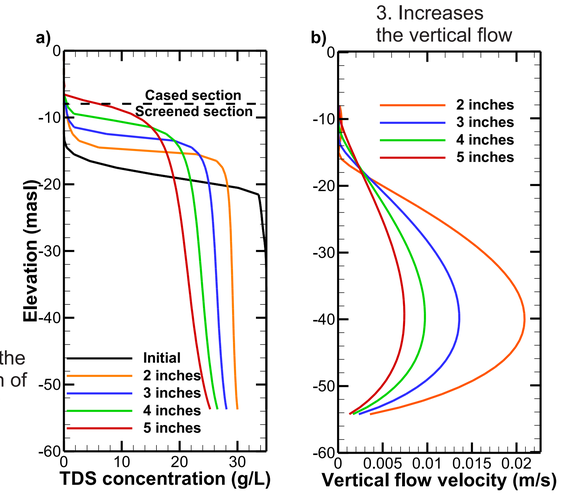
Results & Discussion: Parametric analysis

Increasing well diameter

1. Increases the interface elevation

2. Decrease the concentration of the saltwater

3. Increases the vertical flow

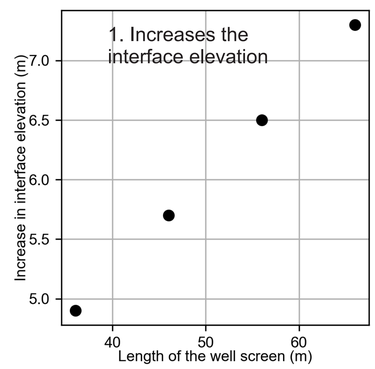


Which can be explained by:

-The increased vertical flow

-A larger radius provides a greater surface area available for radial diffusion.

Increasing well length



And (not shown):

2. Increases the vertical flow

3. Has no impact on the saltwater concentration

Which can be explained by:

-Connecting zones with greater hydraulic heads leads to a greater vertical flow.

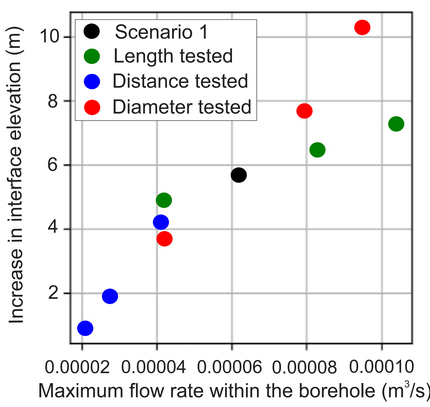
-The level of the vertical flow is not important for this decrease.

Increasing the well distance

First results seemed to present a amplified bias closer to the coast, but recent results contradicted it.

Flow rate analysis

- There is an important correlation between vertical volumetric flow within the well and the increase of the interface elevation
- It was demonstrated that the maximum vertical flow rates within the well result in a more significant increase of the interface elevation.



Conclusion

- The introduction of a well screen led to an increase of the interface elevation which means that the measured position of the interface elevation within the monitoring well does not give an accurate representation of the true interface elevation within the aquifer.
- There is a decrease of the saltwater TDS concentration within the monitoring well that happens instantly after the installation of the well.
- An upward flow within the well is responsible for the increase of the interface elevation and higher vertical flow rates leads to a more important increase of the interface elevation.
- The parameters studied revealed that larger well radius and longer well leads to a more important increase of the interface elevation. The larger radius also showed to create a more important decrease of the saltwater TDS concentration. Those parameters should then be minimized to allow a better monitoring of freshwater-saltwater interface