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Modelling the long-term evolution of groundwater's quality in a flooded iron-ore mine using a reactive transport pipe network model

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Objective of the study

- **Develop a numerical tool being able to forecast flow and quality of groundwater at wells and at overflow adits…**
- **…in order to support water-resource management in mining context.**

Outline of the presentation

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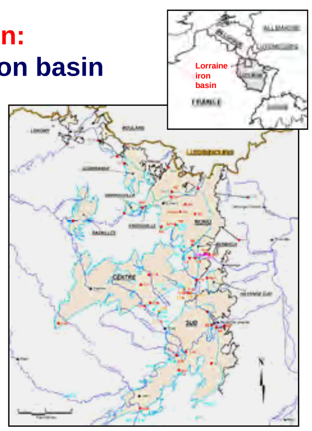
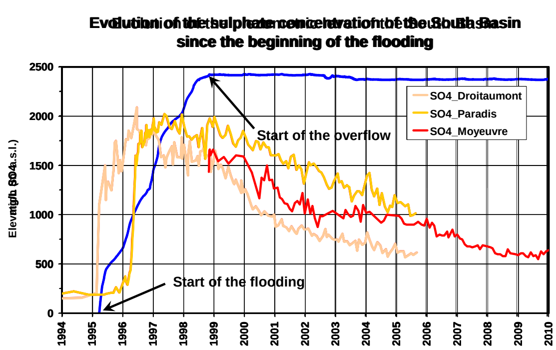
Site description: the Lorraine iron basin

- **11 flooded mines**
  - **430 km² of mine workings**
  - **¾ of workings are flooded**
  - **volume of water > 450 x 10⁶ m³**
- **We are studying the 3 largest flooded mines : South, Centre, and North basin**





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Conceptual model of the South basin

- **A simplified two-step scenario to explain sulphate rise in the flooded mine:**
  - **During the mining:**
    pyrite oxidation + neutralization by carbonates
    → gypsum at the surface of rock fractures
  - **During the flooding:**
    dissolution of the gypsum
    → high sulphate concentration in water
- **An experimental solid sulphate precipitation-dissolution reaction rate :**

$$\frac{d[SO_4^{\ 2-}]}{dt} = k_{pcp}.m(t)^2.(K_{eq} - [SO_4^{\ 2-}])$$

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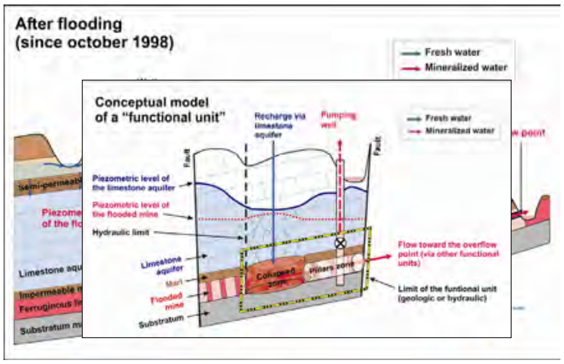
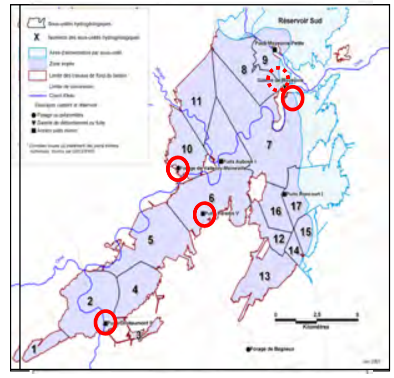
Conceptual model of the South basin

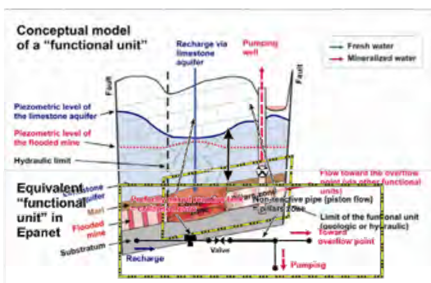


Model development: cartographic analysis

- Cartographic analysis of 75 available mine plans leaded us to…
- …divide the flooded area into 33 functional units
- 4 monitoring points only

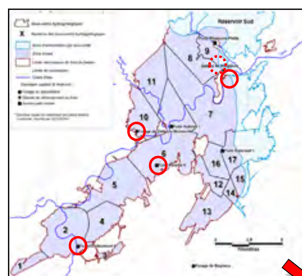


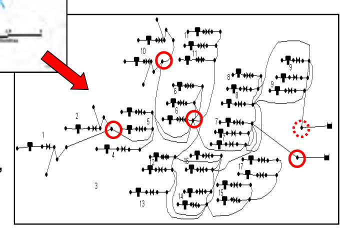
Model development: finding out an Epanet equivalent of the functional unit



Model development: building the network of functional units in Epanet

- In order to build such an equivalent Epanet network, we had to…

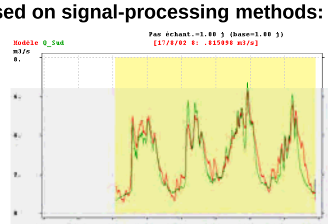




- …deduce geometrical information from cartographic analysis:
  - Volume of functional units,
  - Elevation and length of equivalent pipes…

Calibrating model : calculating the recharge rate of each functional unit

- Total recharge rate (overflow + pumpings) of the flooded mine is modelled using the TEMPO computer code, which is based on signal-processing methods:
  - Calculation of the impulse response of the system…
  - …allow to ajust the observed total recharge rate…
  - …and to simulate future recharge by stochastic methods



- Then, each functional unit receives a part of this total recharge, proportionaly to its relative area

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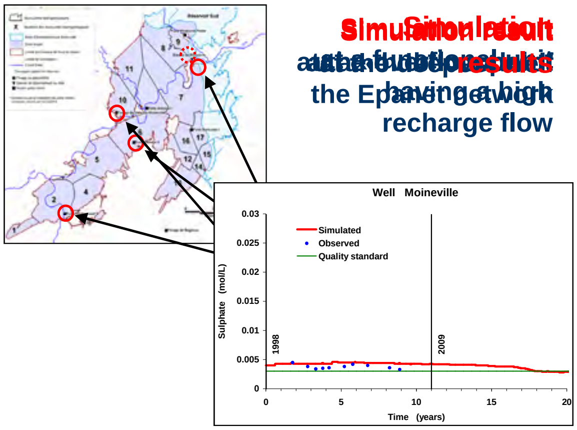
Calibrating model: adjusting chemical parameters

- In a previous work, we added our experimental solid sulphate dissolution–precipitation reaction rate to the Epanet water-quality solver:

$$\frac{d[SO_4^{2-}]}{dt} = k_{pcp}\, m(t)^2 . (K_{eq} - [SO_4^{2-}])$$

At t = 0

- To calibrate the model, we needed to adjust two global parameters:
  - the global apparent kinetic precipitation constant
  - the global initial available mass of solid sulphate
- We also fixed an initial sulphate concentration in water for each tank and pipe



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Conclusion

- **The numerical model gives good agreement between calculated and observed sulphate concentrations… but for few available monitoring points.**
- **Our hydrogeochemical conceptual model as well as our numerical approach seem to be relevant for the South basin…**
- **…but need to be tested for Centre and North basin modelling.**

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