Pumping tests and hydrogeological characteristics of the Cambrian aquifer in the Belgian Brabant provinces for geothermal potential

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1. Introduction

- Hydrogeological characterization is essential not only for effective groundwater management but also for evaluating the shallow geothermal energy potential.
- Hydraulic conductivity K and transmissivity T directly influence heat exchange and the efficiency of geothermal energy extraction.
- Specific well capacity (SWC), a simple yet informative parameter, can be easily obtained from pumping wells.

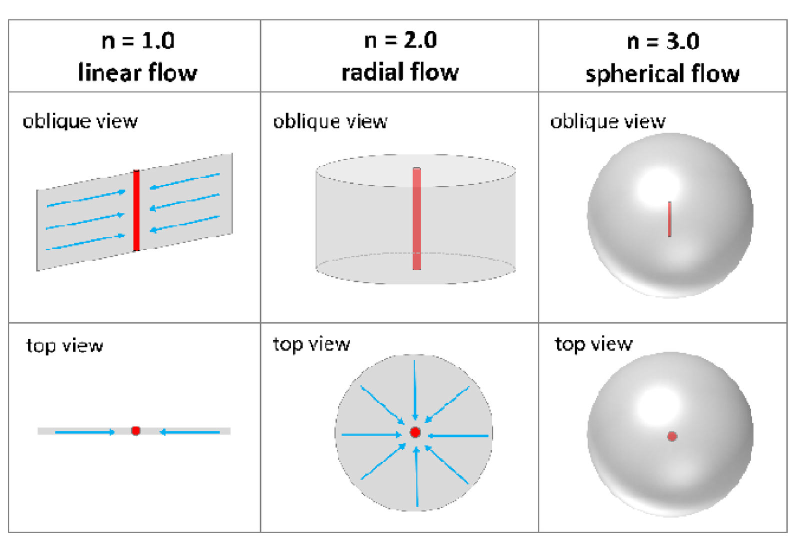
2. Methods

2.1. Specific well capacity (SWC)

✓Maximum drawdown s during pumping at rate Q: data from 82 wells (consulted all archives, mostly old).
✓**Q/s (firsthand proxy for transmissivity)**

2.2. Interpretation of pumping tests

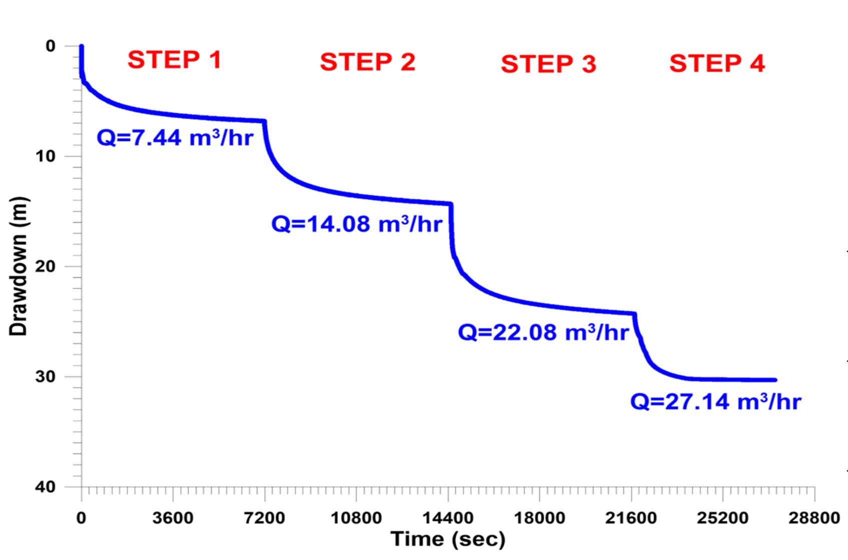
✓**Development of interpretation model** (program) taking into account **"fractional dimension"** of groundwater flow, based on an analytical solution from John Barker (1988).
✓**Barker solution (1988) = THEIS solution but for fractional dimension n (ranging from 1 to 3)**
✓A generalized radial flow model for hydraulic tests in fractured rock (Water Resources Research, 1988).



$$h(r,t) = \frac{Q_0 r^{2\nu}}{4\pi^{1-\nu} K_f b^{3-n}} \Gamma(-\nu, u) \qquad \nu < 1$$

$$\nu = 1 - n/2$$

✓**Step-drawdown test in Molenbeek**

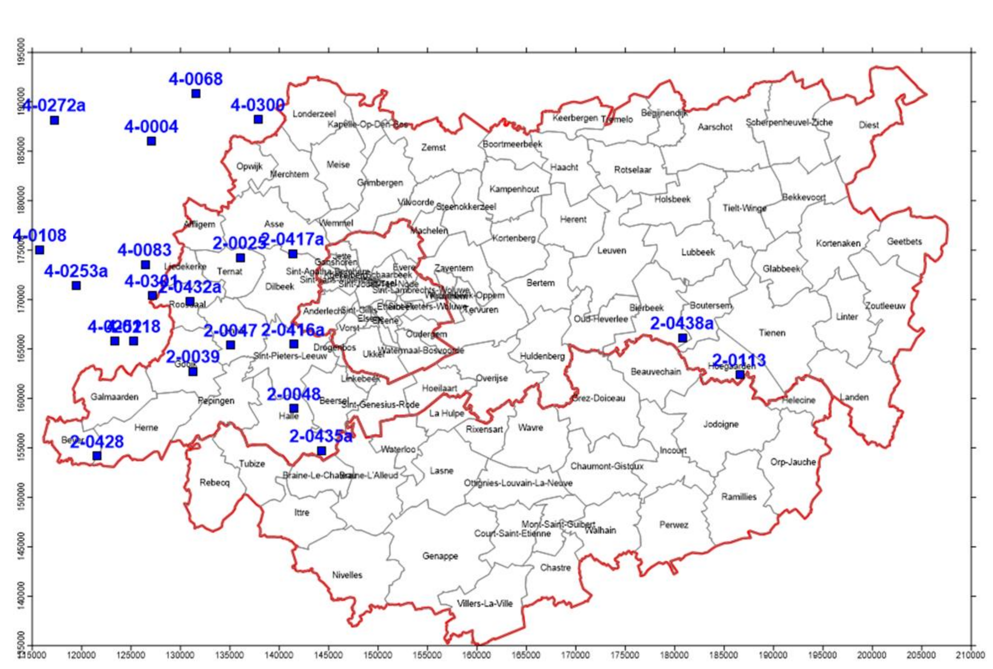


Steps: 4 steps, each 2 hours

✓Interpretation of step-drawdown test with **STEPMASTER Method of Eden-Hazel**.
✓The first phase is interpreted as regular pumping test with **Barker (1988)**.
✓Estimated values compared.

2.3. Interpretation of water level monitoring wells VMM (DOV)

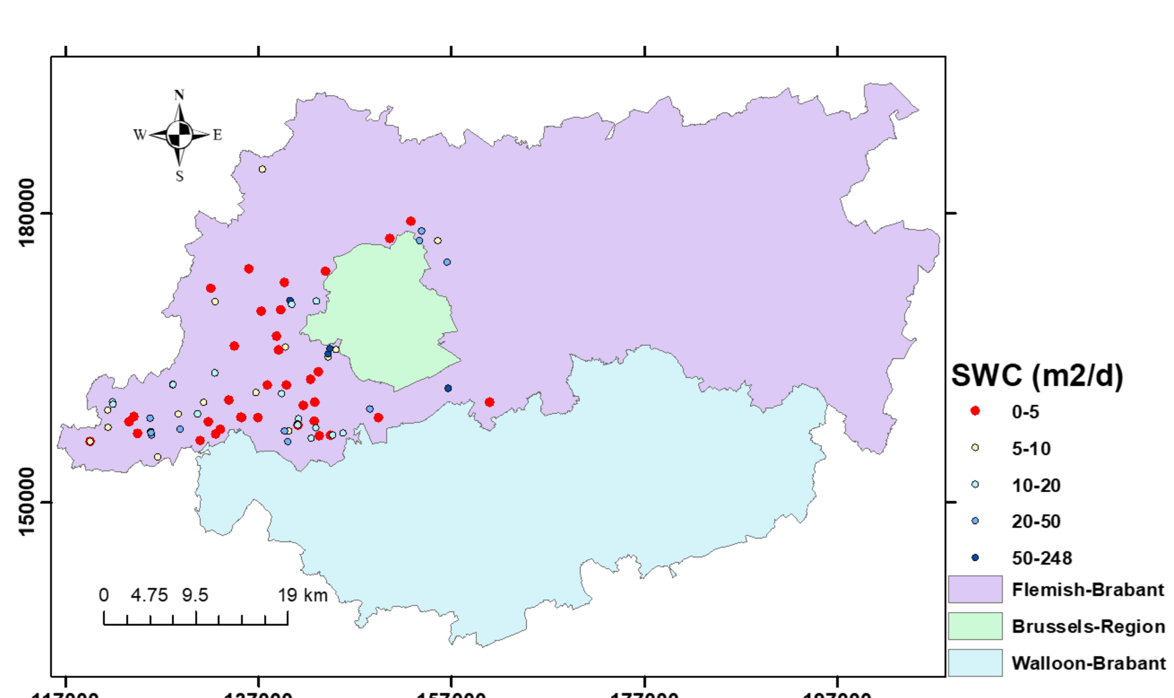
✓**12 monitoring wells inside study area**
✓Some start in the 1990s but most since 2005/2006
✓Measured mostly at monthly interval



3. Results and Discussion

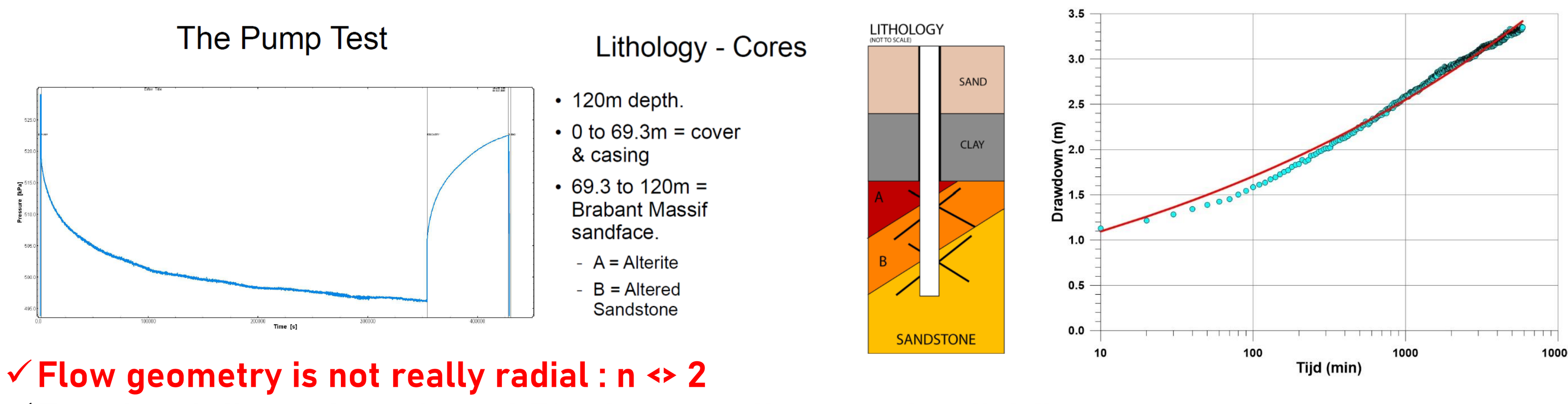
3.1. Specific well capacity

- ✓ **West side of Flemish Brabant**
- ✓ **SWC ranges from 0.51 m²/d to 248.3 m²/d**
- ✓ **Not normally distributed**
- ✓ **Geometric mean = 7.41 m²/d**
- ✓ **High variability of SWC ⟹ high T variation, high variation in productivity potential**



3.2. Interpretation of pumping tests

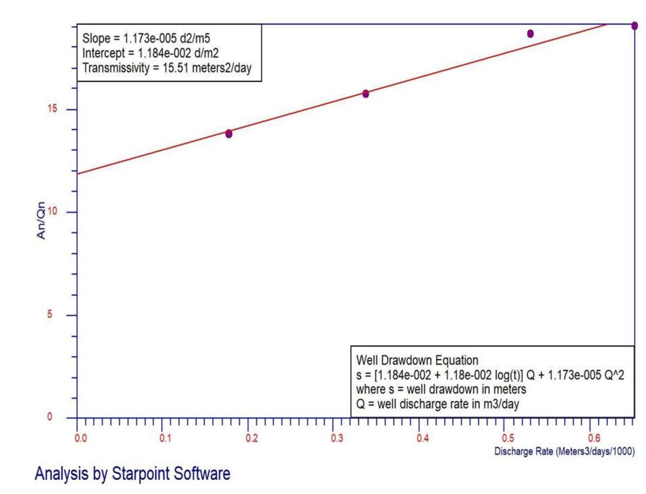
- **Anderlecht pumping test (March 2018)**



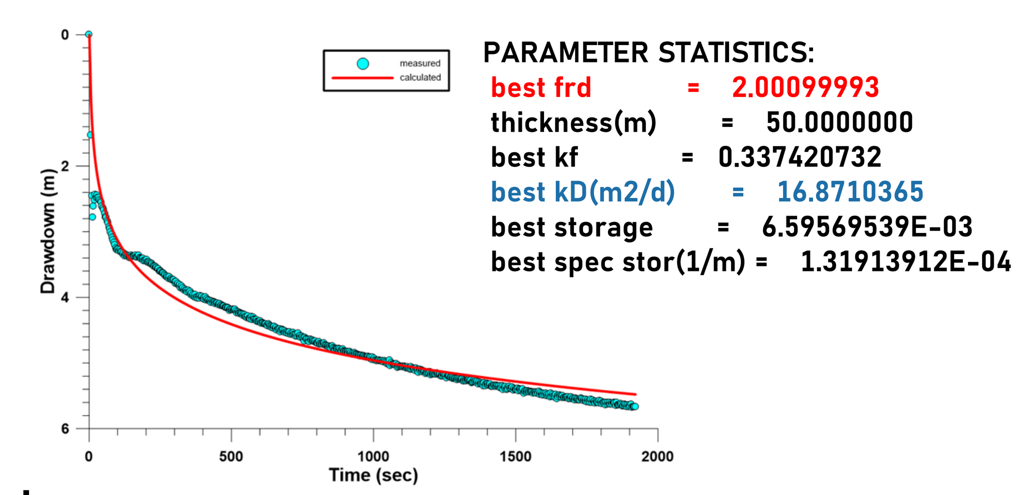
✓**Flow geometry is not really radial : n <> 2**
✓**Fractional dimension n is ca 1.72 = between linear and radial flow**
✓**Transmissivity is about 60 m²/d.**
✓**Specific elastic storage is around 4.4 10⁻⁵ 1/m**
✓**Aquifer thickness = depth of well into basement = 50.7 m**
✓**K = 1.18 m/d**

- **Molenbeek pumping test (March 2023)**

✓**Interpretation step-drawdown test with STEPMASTER Method of Eden-Hazel**



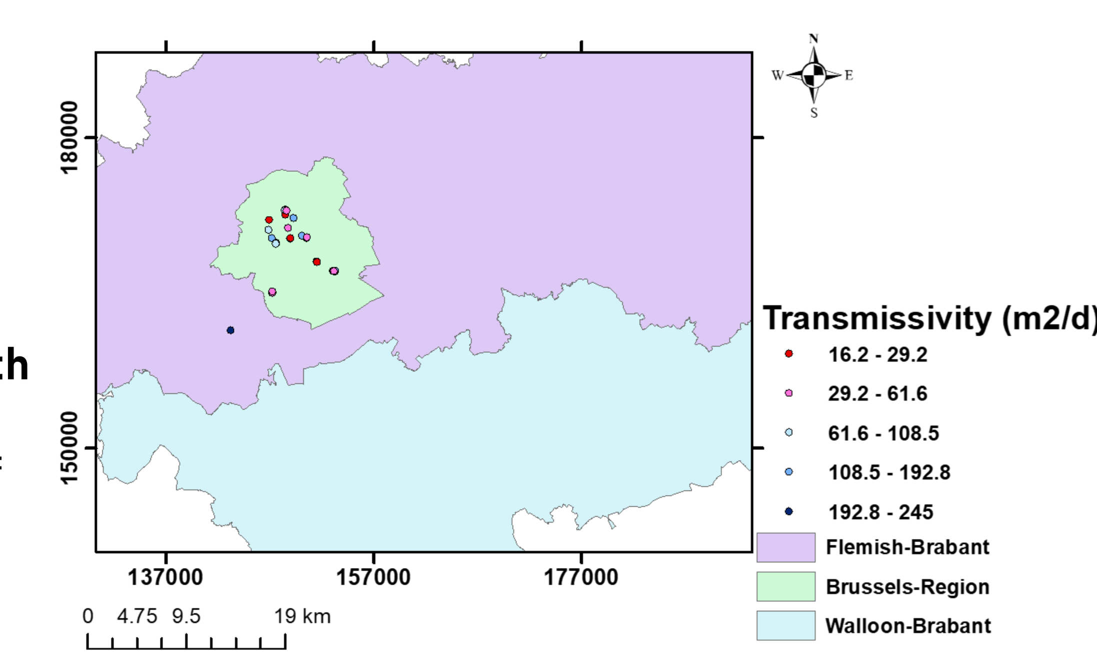
✓**Interpretation with Barker (1988) solution of first pumping phase of step-drawdown test**



- **with STEPMASTER: method of Eden-Hazel**
  - ✓**T is ca 15.5 m²/d**
  - ✓**Aquifer loss = 0.8664** m/(m³/day)
  - ✓**Well loss = 0.0101** m/(m³/day)
- **first pumping phase with BARKER (1988) solution:**
  - ✓**Fractional dimension n = 2 : radial flow**
  - ✓**T is ca 16.9 m²/d**
  - ✓**Storage is 0.00659**

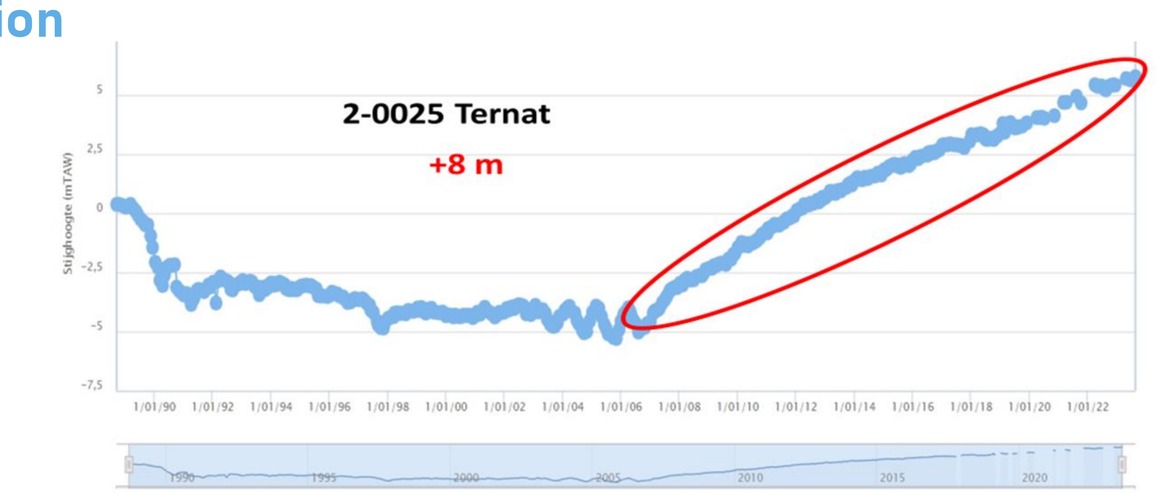
3.3. Compilation of existing pumping test results

- **109** wells, among which **29** have T values analyzed
  - ✓ **High variability of T**
  - ✓ **High variability of aquifer potential**
- **GW inflow in wells comes mainly from only a limited productive depth interval** (from **Flow loggings**)
  - ✓correlated with the occurrence of fractures
  - • **high vertical variability**



3.4. Water level interpretation

- Most wells show a rising trend in recent years
  - ✓ recovery due to restrictions to exploitation from the Palaeozoic basement (Cambrian) in Flanders
  - ✓ positive for the aquifer potential and sustainability



4. Conclusions

✓Data set of SWC and T shows the **lateral variation of aquifer transmissivity is large**
✓GW inflow in wells comes mainly from only a limited productive depth interval (from Flow loggings)
❖ **High vertical variation in transmissivity**
✓High variability of the Cambrian aquifer potential ⟹ **Geothermal potential is highly variable**
✓**Water level** in the Palaeozoic aquifer : **rising trend = recovery** in recent years

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