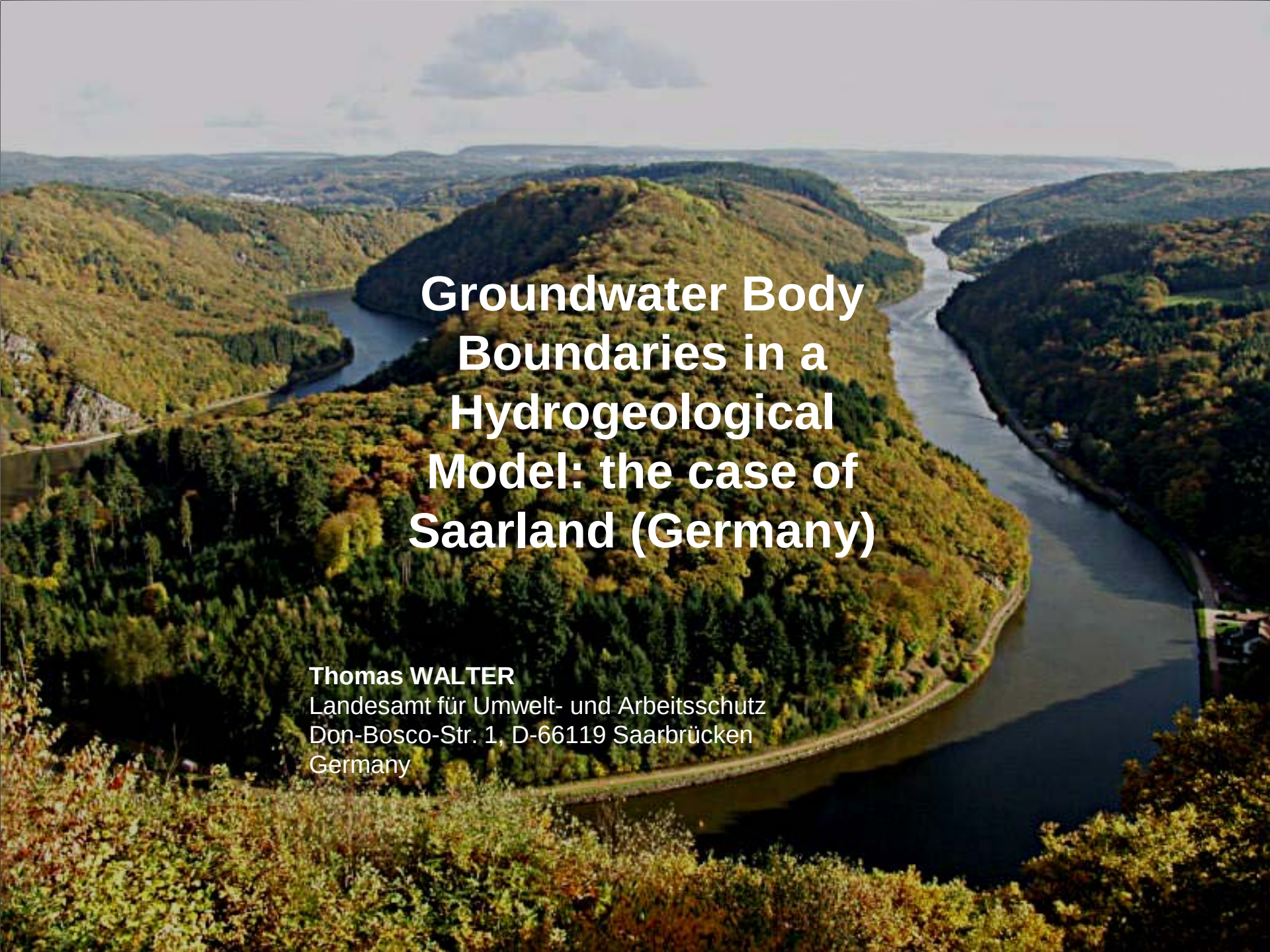
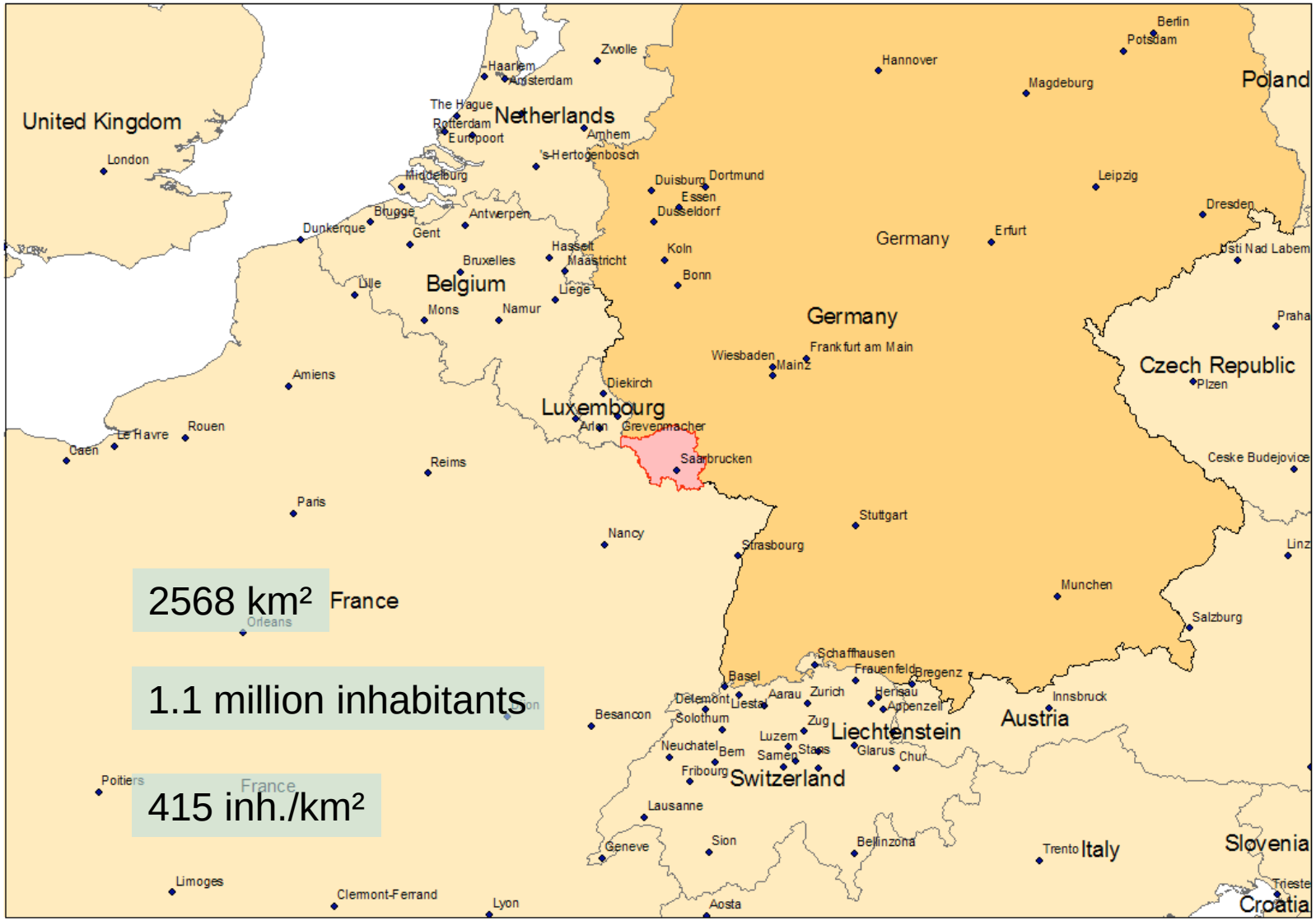


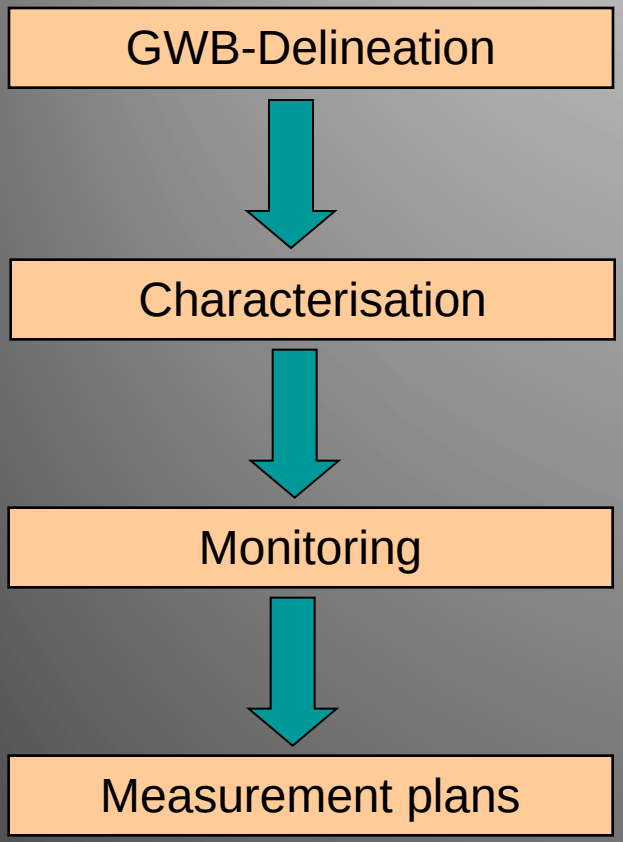
# Groundwater Body Boundaries in a Hydrogeological Model: the case of Saarland (Germany)

**Thomas WALTER**
Landesamt für Umwelt- und Arbeitsschutz
Don-Bosco-Str. 1, D-66119 Saarbrücken
Germany

# Saarland


2568 km² France
1.1 million inhabitants
415 inh./km²
United Kingdom
Netherlands
Belgium
Germany
Luxembourg
France
Switzerland
Liechtenstein
Austria
Czech Republic
Poland
Italy
Slovenia
Croatia
London
Amsterdam
Haarlem
Zwolle
Hannover
Berlin
Potsdam
Magdeburg
Leipzig
Dresden
Erfurt
Dortmund
Duisburg
Essen
Dusseldorf
Koln
Bonn
Frankfurt am Main
Wiesbaden
Mainz
Saarbrucken
Diekirch
Stuttgart
Munchen
Salzburg
Innsbruck
Praha
Plzen
Ceske Budejovice
Linz
Strasbourg
Nancy
Paris
Reims
Amiens
Rouen
Le Havre
Caen
Lille
Bruxelles
Namur
Liege
Maastricht
Hasselt
Antwerpen
Gent
Brugge
Dunkerque
Middelburg
Rotterdam
The Hague
Eurpoort
Arnhem
's-Hertogenbosch
Basel
Zurich
Aarau
Bern
Lausanne
Geneve
Sion
Bellinzona
Chur
Zug
Luzern
Schaffhausen
Bregenz
Besancon
Poitiers
Limoges
Clermont-Ferrand
Lyon
Aosta
Trento
Trieste

# GWB Identification

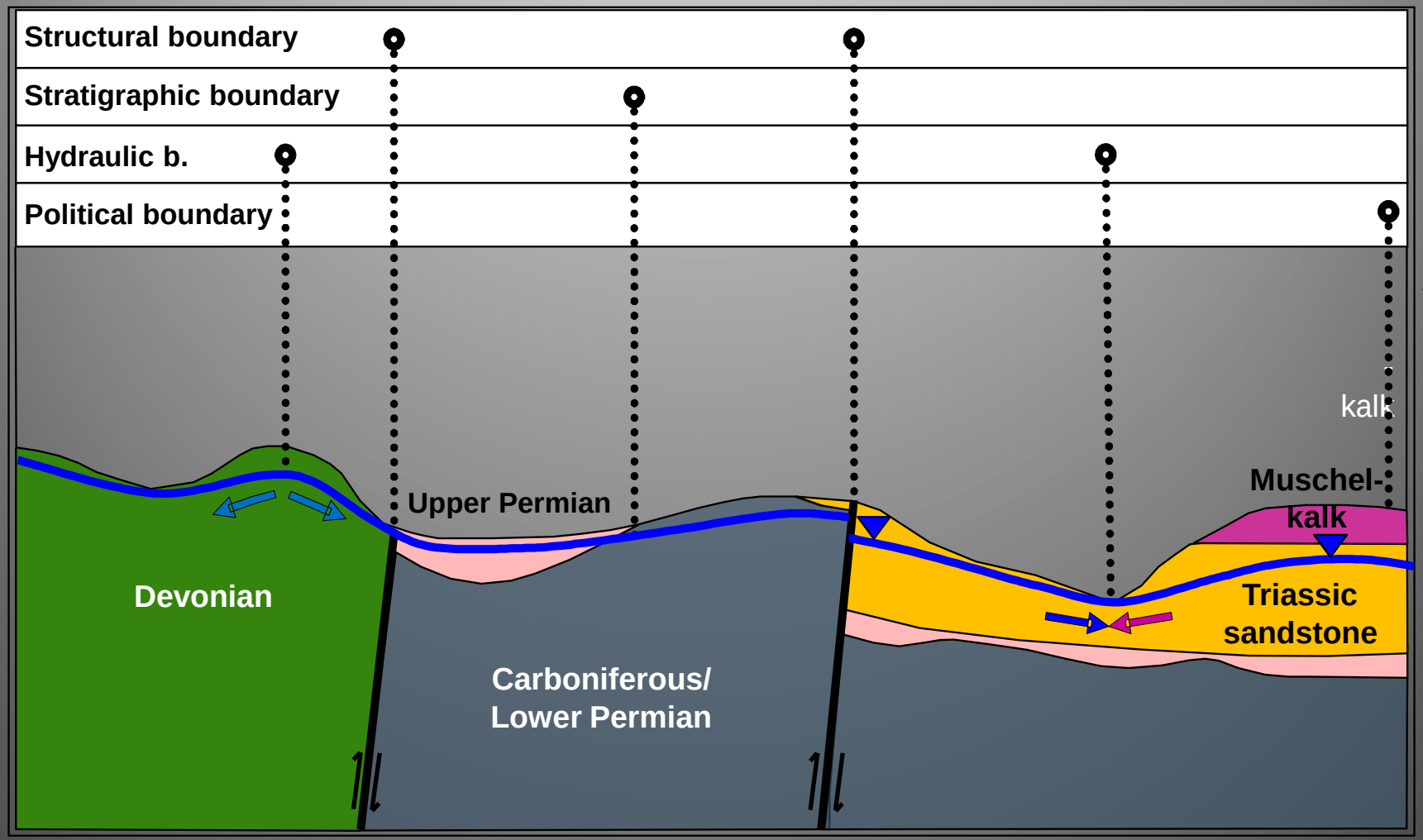



**Groundwater body delineation is the first and most sensitive step!**

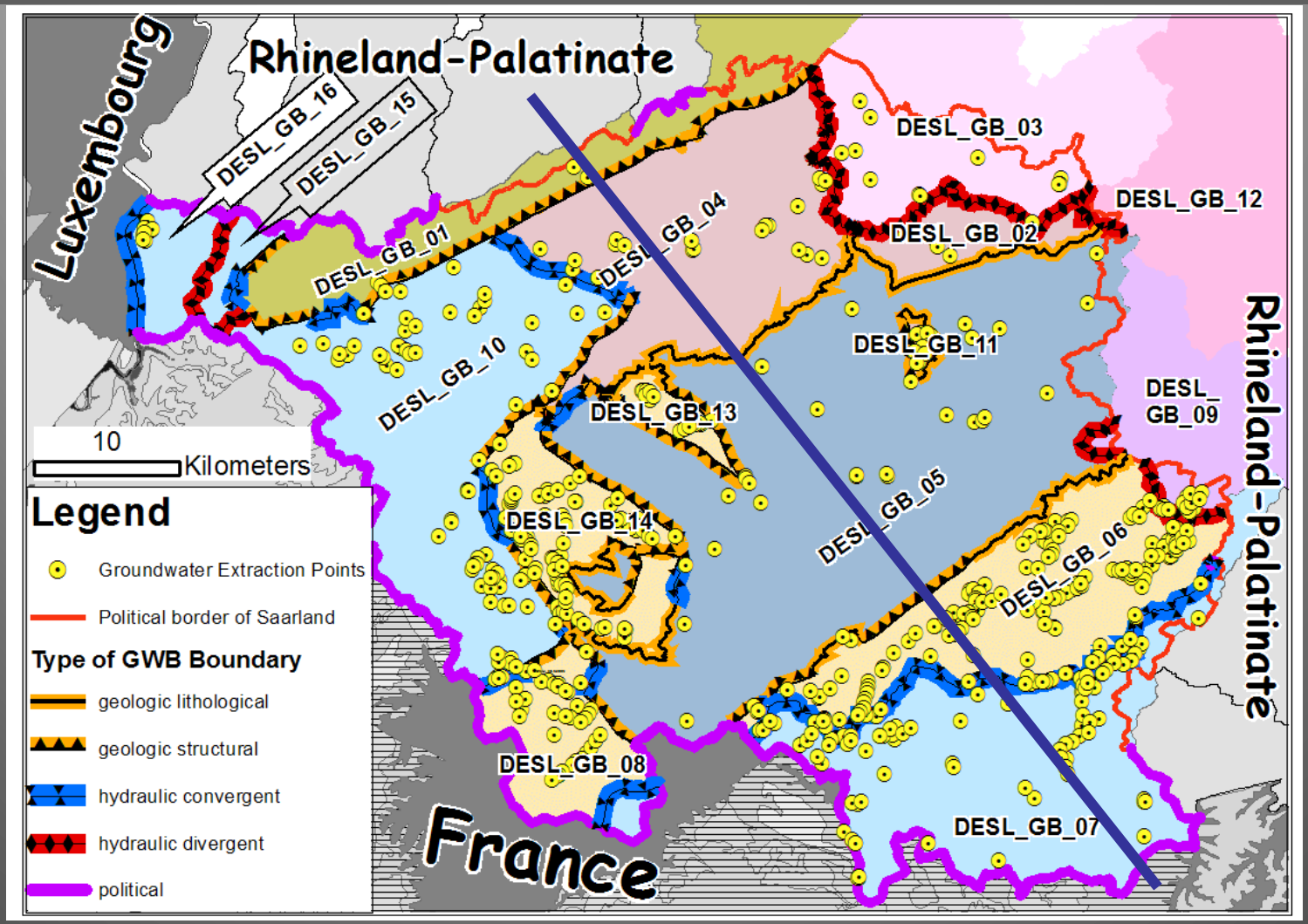
**Therefore, groundwater bodies should be hydraulically and hydrochemically as homogeneous as possible**

***but: Groundwater bodies also should have a reasonable size!***

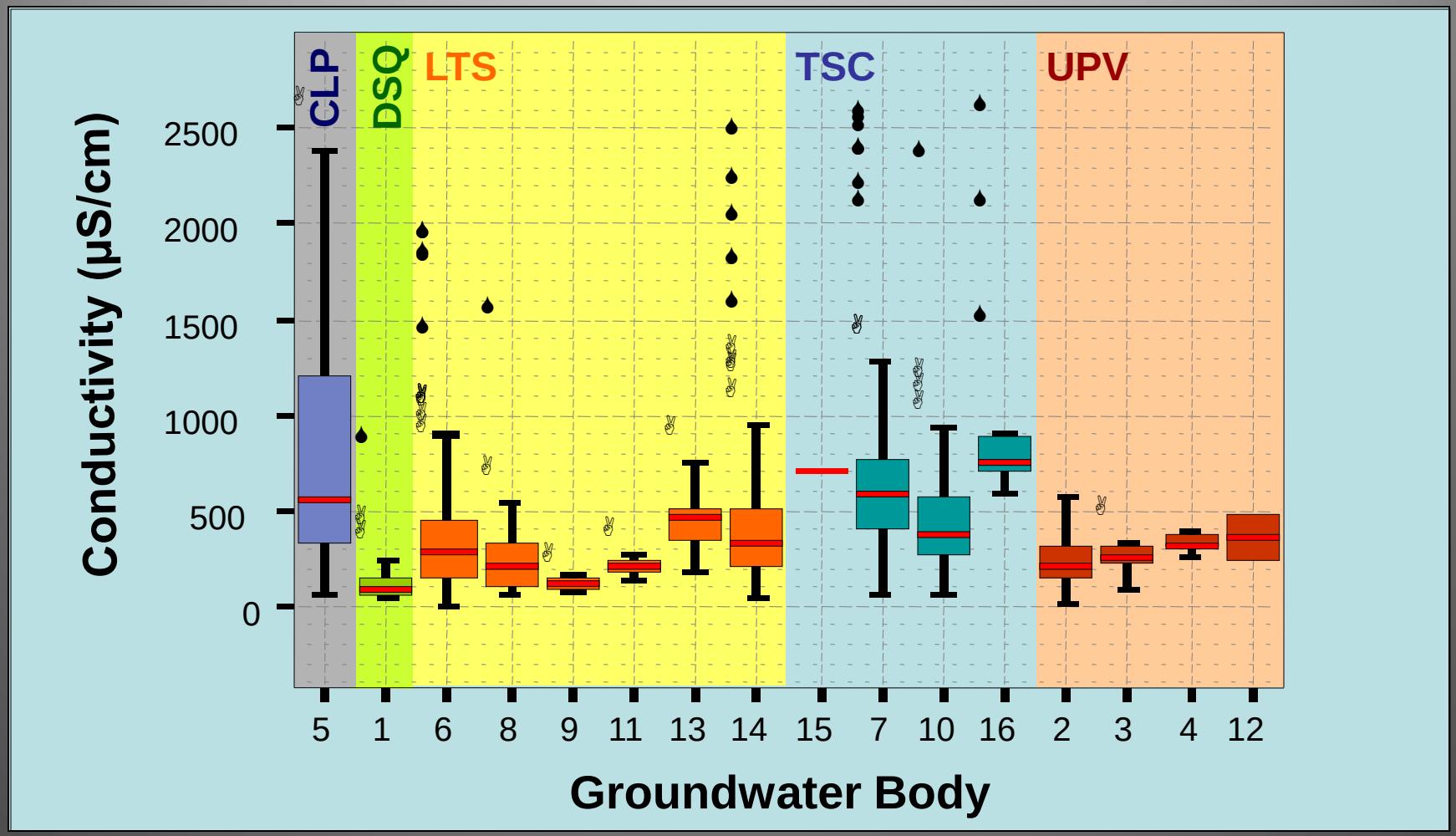
# Schematic Vertical Section



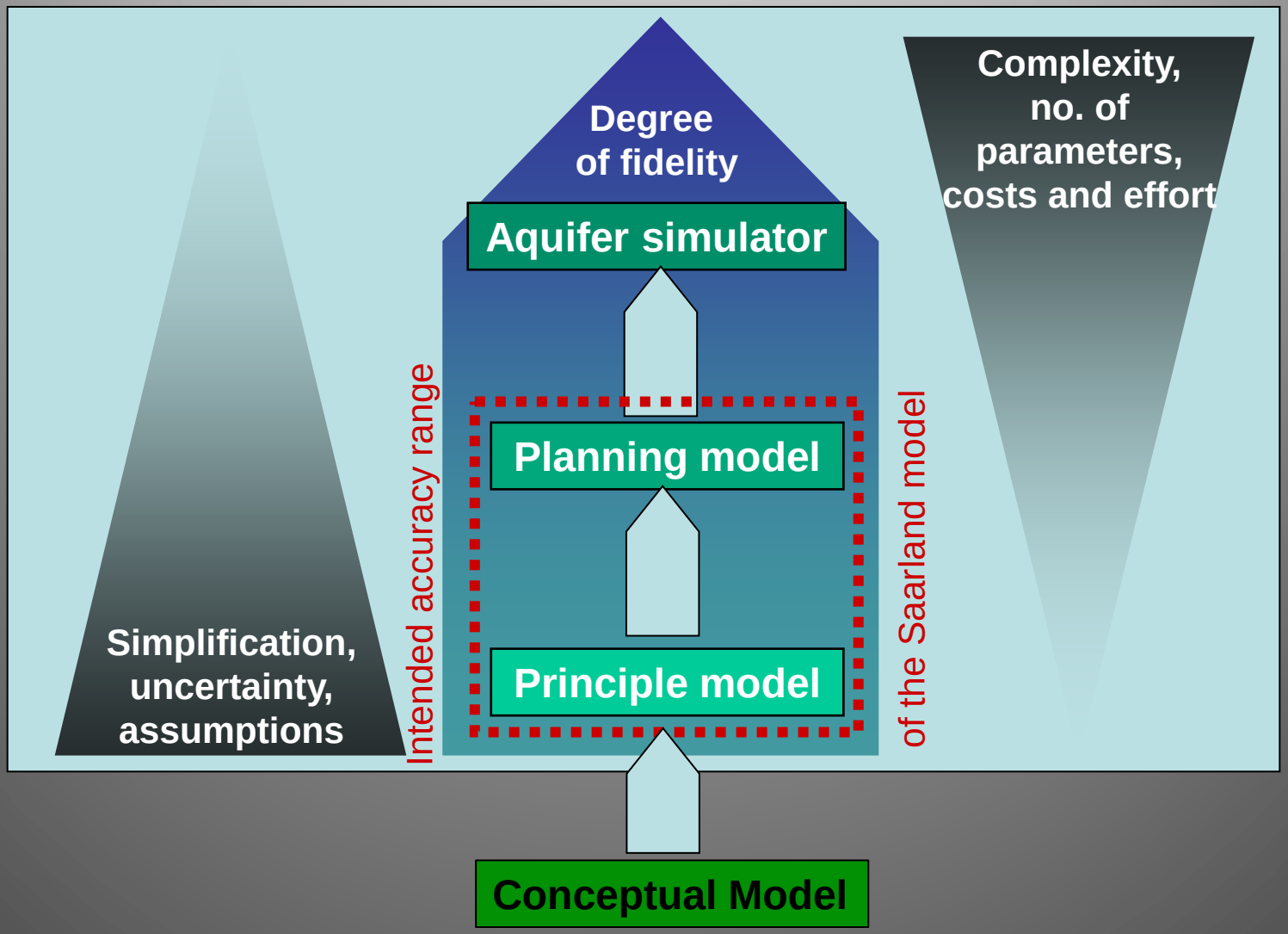
# Groundwater Bodies



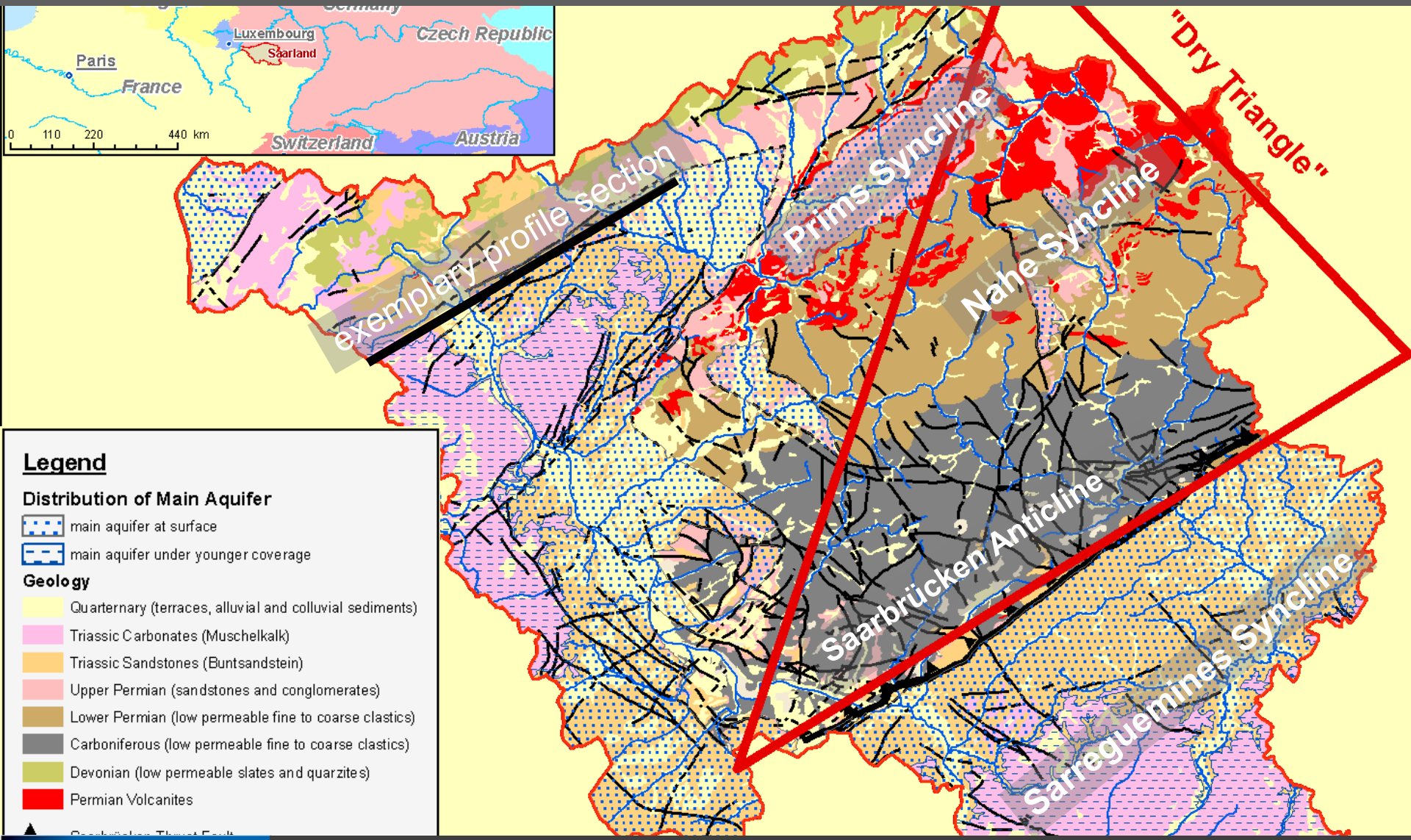
# Overall Groundwater Mineralisation



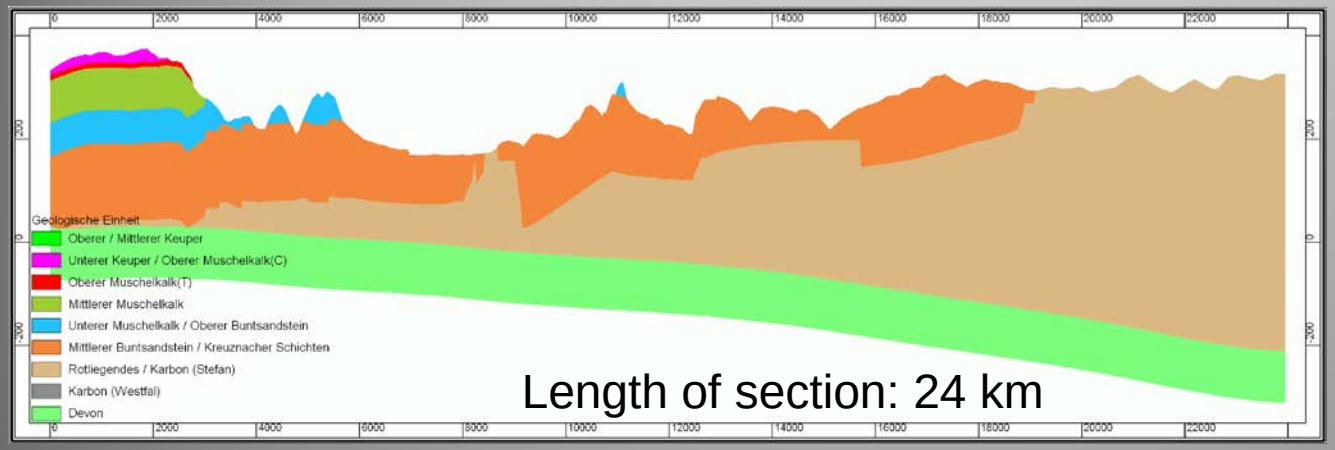
# Model Conception



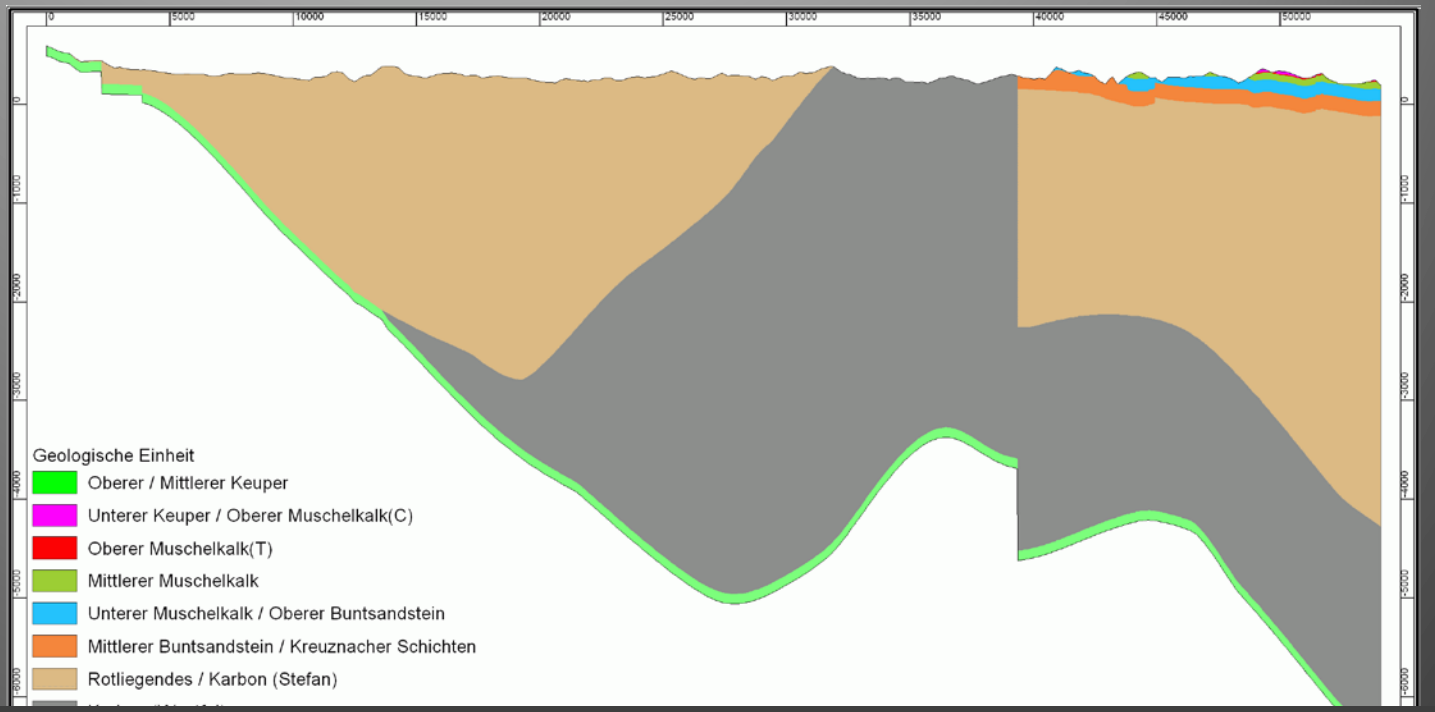
# Geology and Hydrogeology



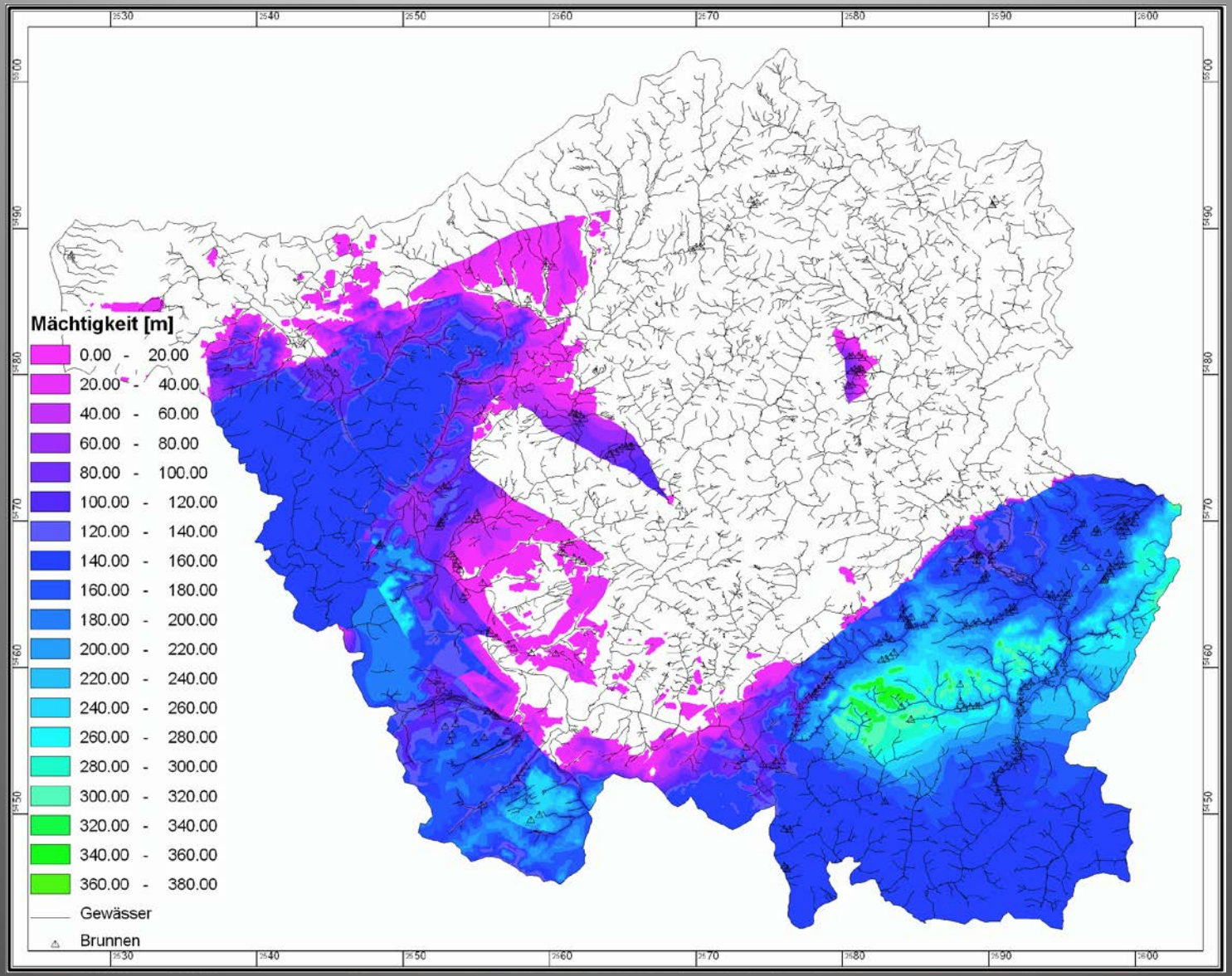
# Exemplary Profiles




Length of section: 24 km



# Main Aquifer Geometry

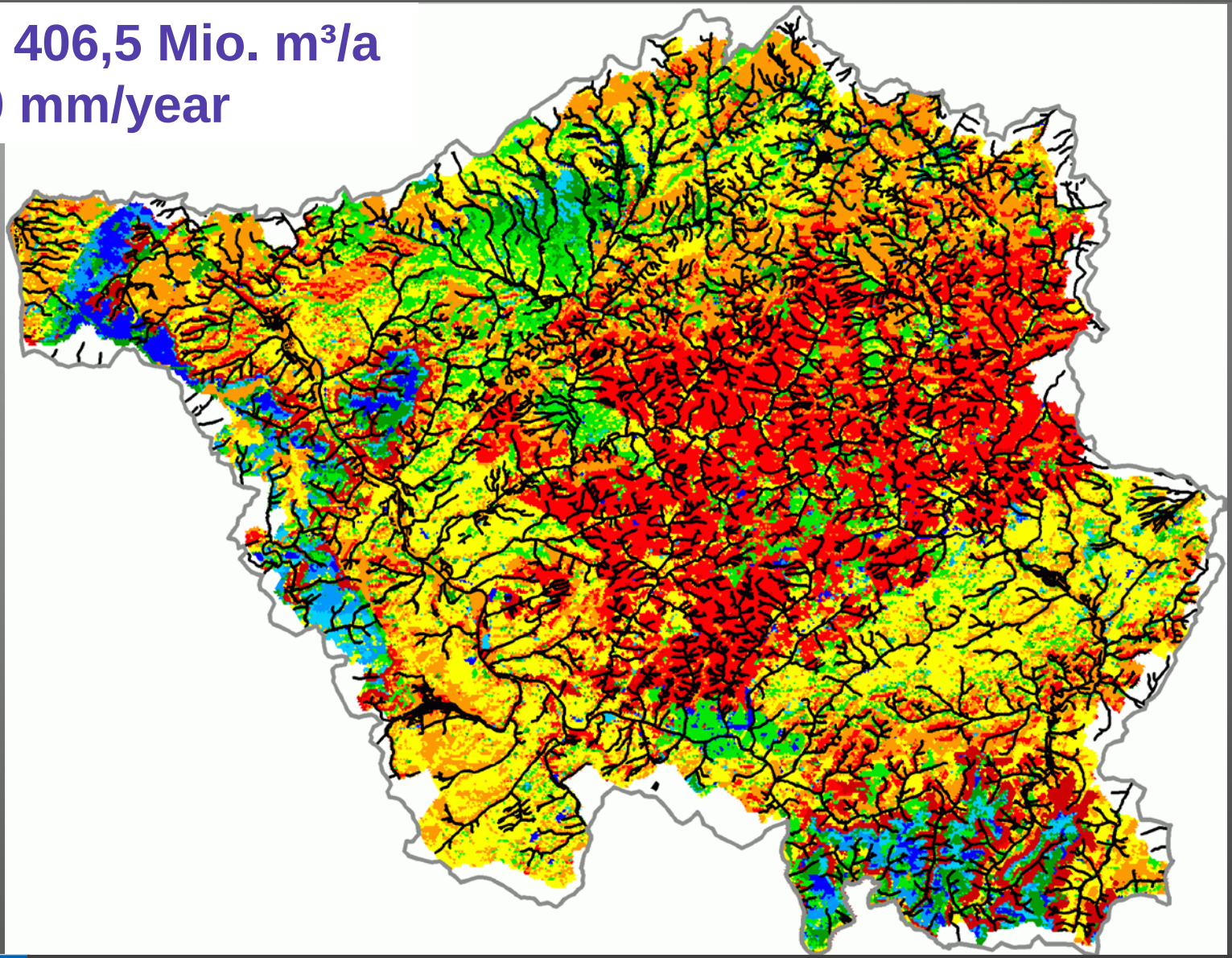


# Layer Structure and Parametrisation

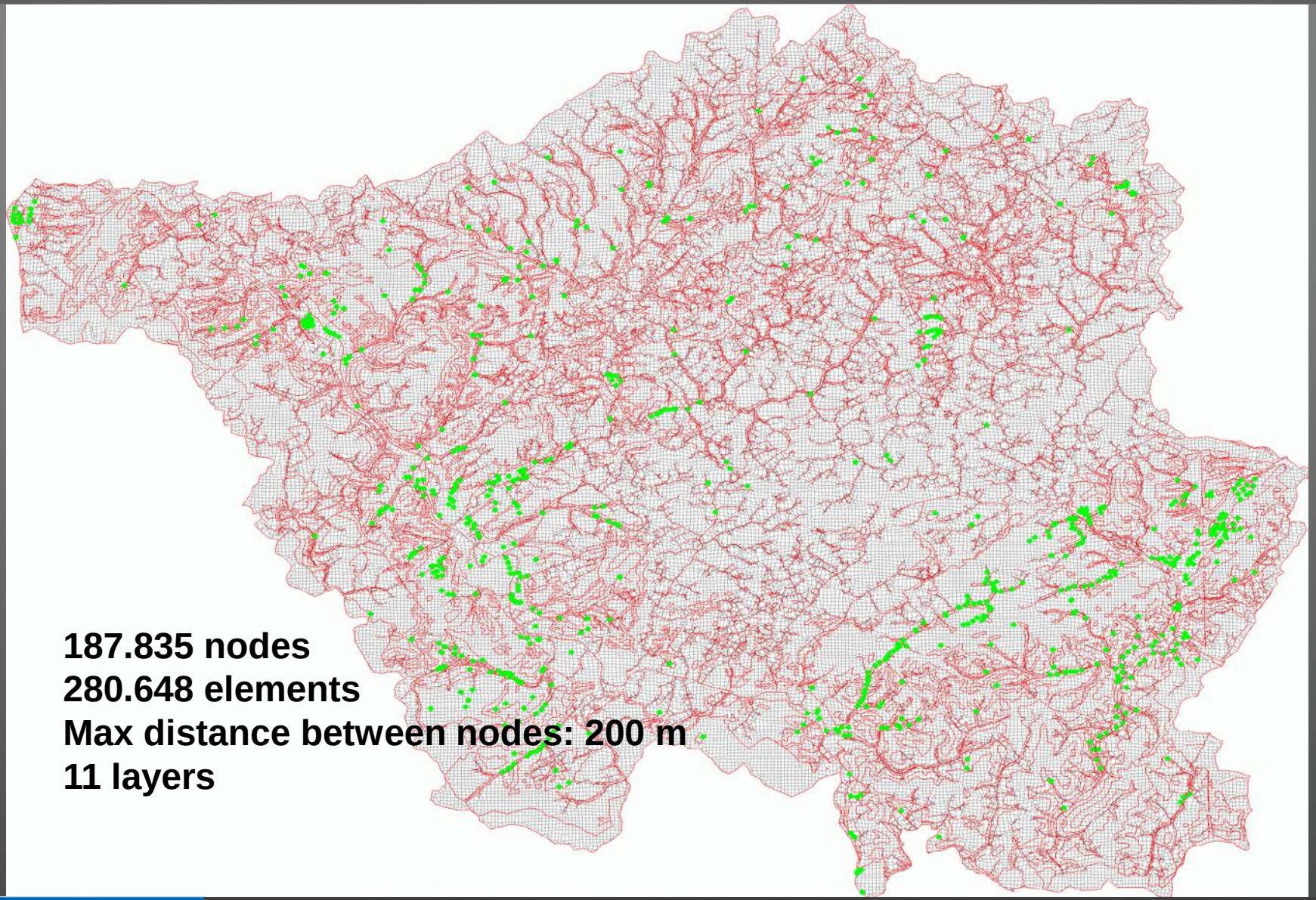
| Layer | Stratigraphy | | | Permeability [m/s] | | |
|---|---|---|---|---|---|---|
| | | | | HÜK | Starting values | Calibrated values |
| 1 | Quater-nary | Flood plains, terraces | q | $10^{-6}$ – $10^{-4}$ | $10^{-4}$ | $10^{-4}$ - 5 ·$10^{-4}$ |
| 2 | Upper Triassic | Upper Keuper | ko | $10^{-5}$ | 9·$10^{-6}$ | 9 ·$10^{-6}$ |
| | | Middle Keuper | km | | | |
| 3 | | Lower Keuper | ku | $10^{-6}$ - $10^{-4}$ | 5 ·$10^{-6}$ | 5 ·$10^{-6}$ |
| | Middle Triassic | Upper Muschelkalk | mo2 | | | |
| 4 | | Upper Muschelkalk | mo1 | $10^{-5}$ - $10^{-3}$ | 5 ·$10^{-5}$ | 5 ·$10^{-5}$ |
| 5 | | Middle Muschelkalk | mm | $10^{-9}$ - $10^{-7}$ | 5 ·$10^{-8}$ | 5 ·$10^{-8}$ |
| 6 | | Lower Muschelkalk | mu | $10^{-6}$ - $10^{-4}$ | $10^{-5}$ | $10^{-7}$ - $10^{-6}$ |
| | Lower Triassic | Upper Buntsandstein | so | | | |
| 7 | | Middle Buntsandstein | sm | $10^{-5}$ - $10^{-3}$ | 5 ·$10^{-5}$ | $10^{-6}$ - $10^{-4}$ |
| | Permian | Kreuznach facies | ro3 | | | |
| 8 | | Upper Rotliegend | ro1, ro2 | <$10^{-5}$ | 5 ·$10^{-6}$ | 3 ·$10^{-7}$ |
| | | Lower Rotliegend | ru | | | |
| 9 | Carbo-niferous | Stephanian | cst | <$10^{-5}$ | 5 ·$10^{-6}$ | 3 ·$10^{-7}$ |
| 10 | | Westphalian | cw | <$10^{-5}$ | 5 ·$10^{-7}$ | 8 ·$10^{-8}$ |
| 11 | Devonian | undifferentiated | d | <$10^{-5}$ | 5 ·$10^{-7}$ | 8 ·$10^{-8}$ |

# Mean Long Term Groundwater Recharge

**Recharge: 406,5 Mio. m³/a**
**i.e. ca. 160 mm/year**



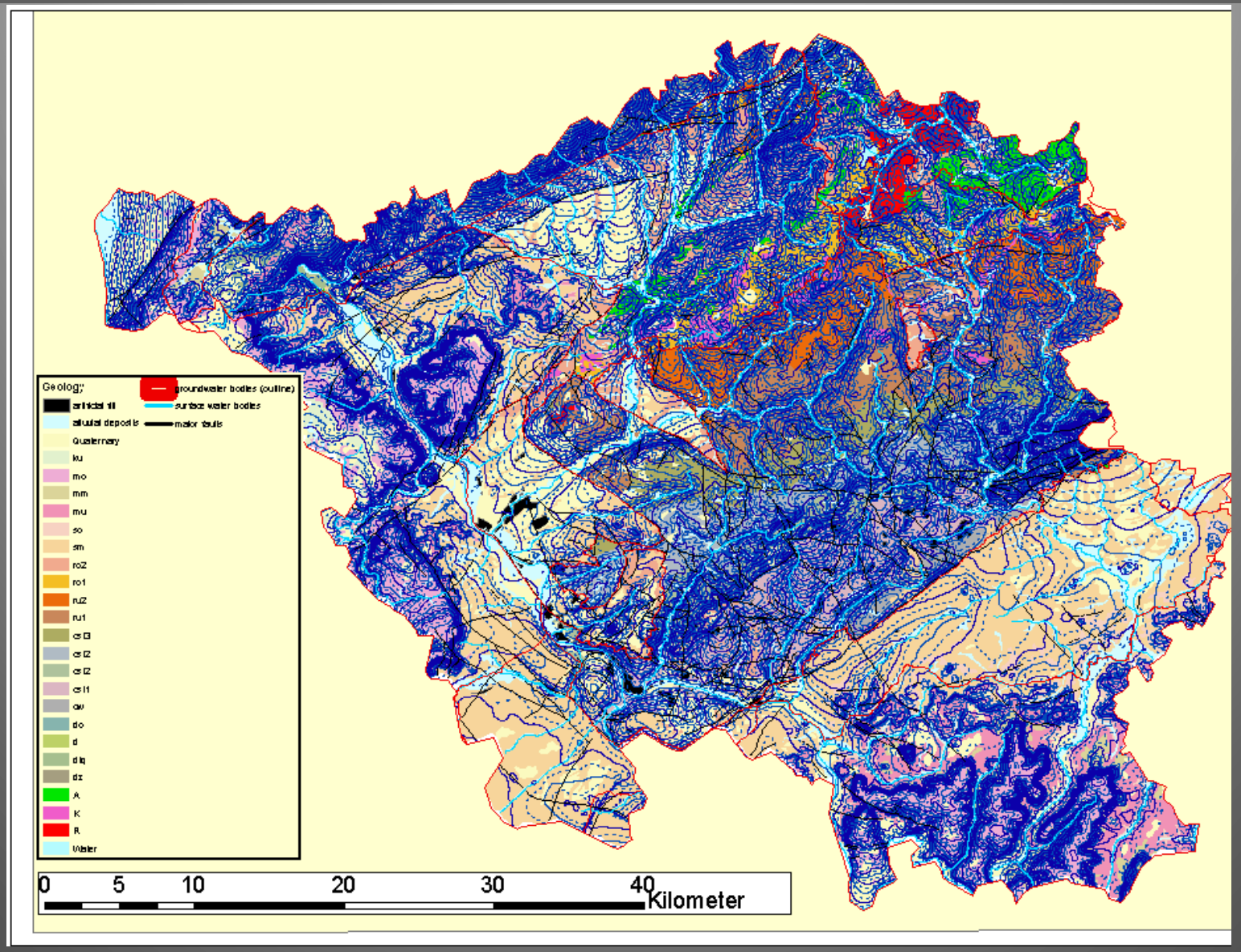
# Final Mesh



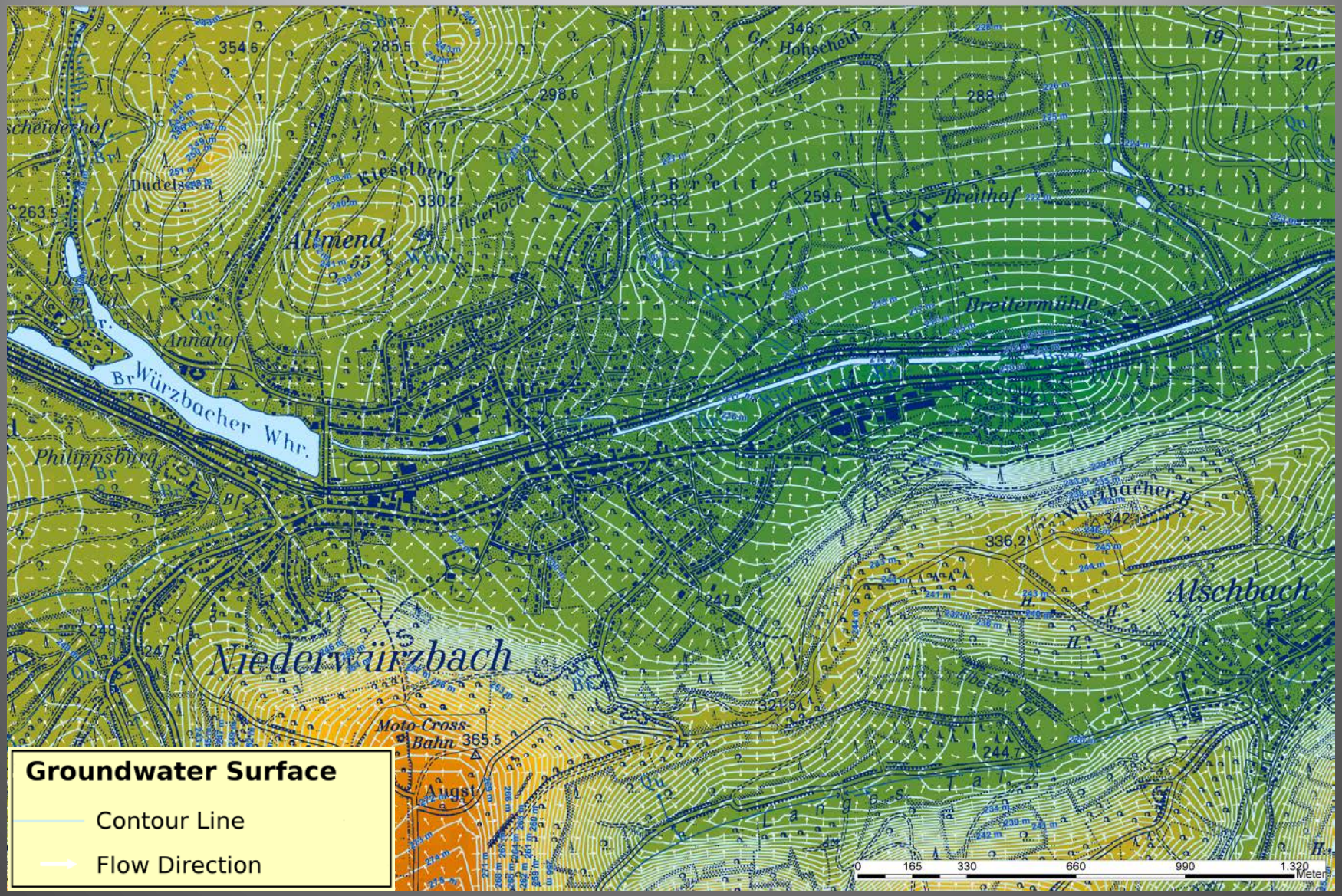
**187.835 nodes**
**280.648 elements**
**Max distance between nodes: 200 m**
**11 layers**

# EXEMPLARY RESULTS

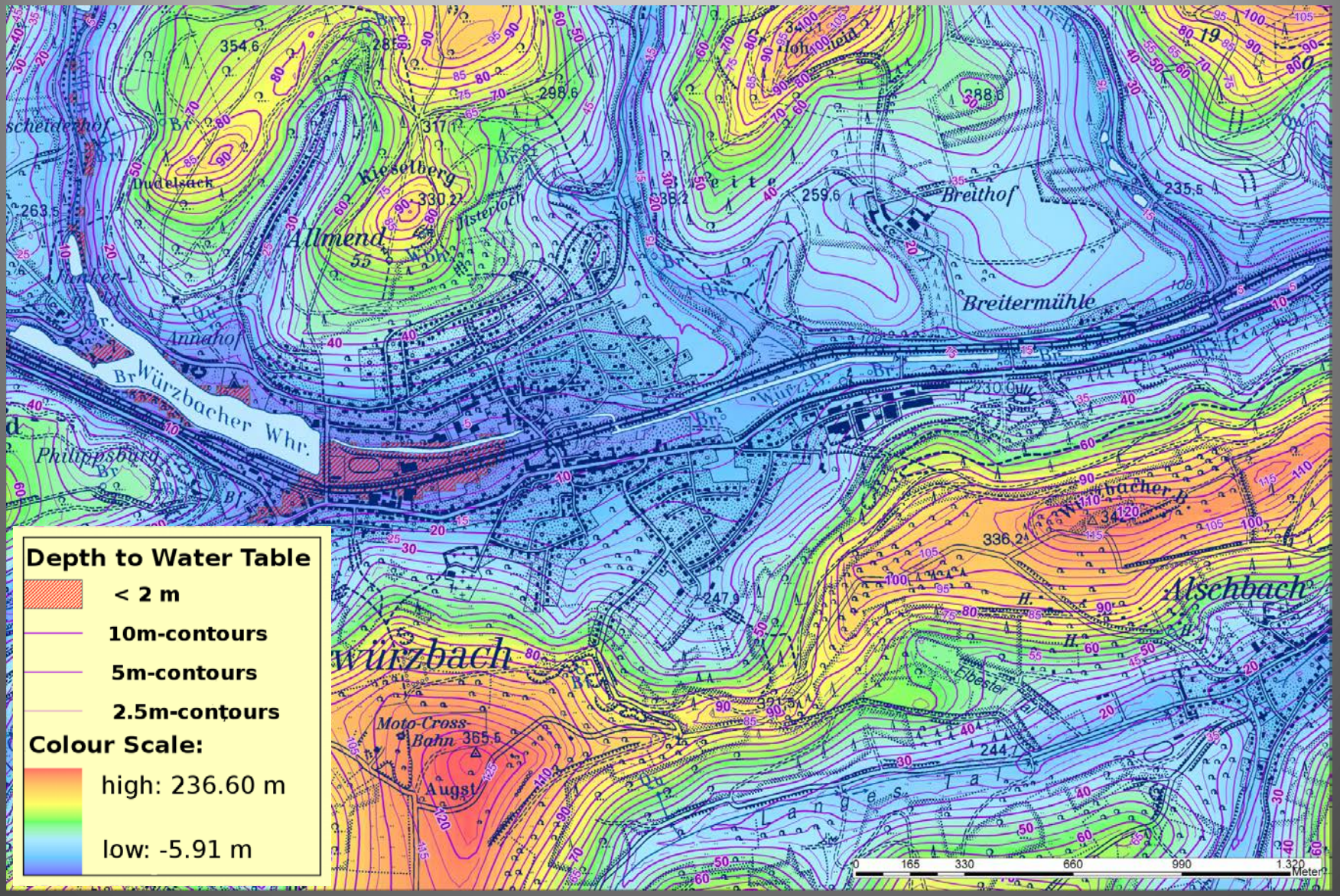
# GW Surface and Geology



# GW surface map

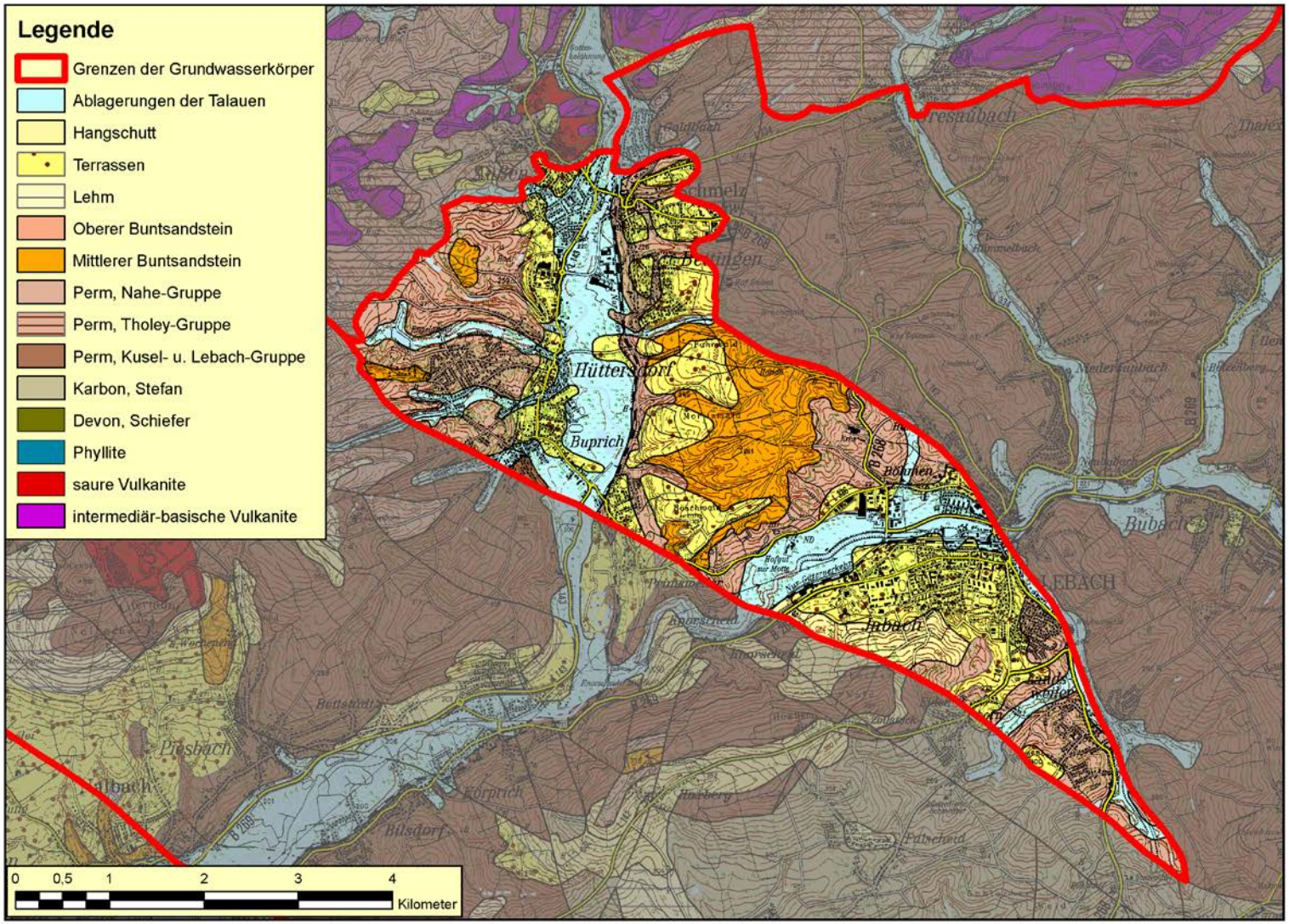


# Depth to groundwater

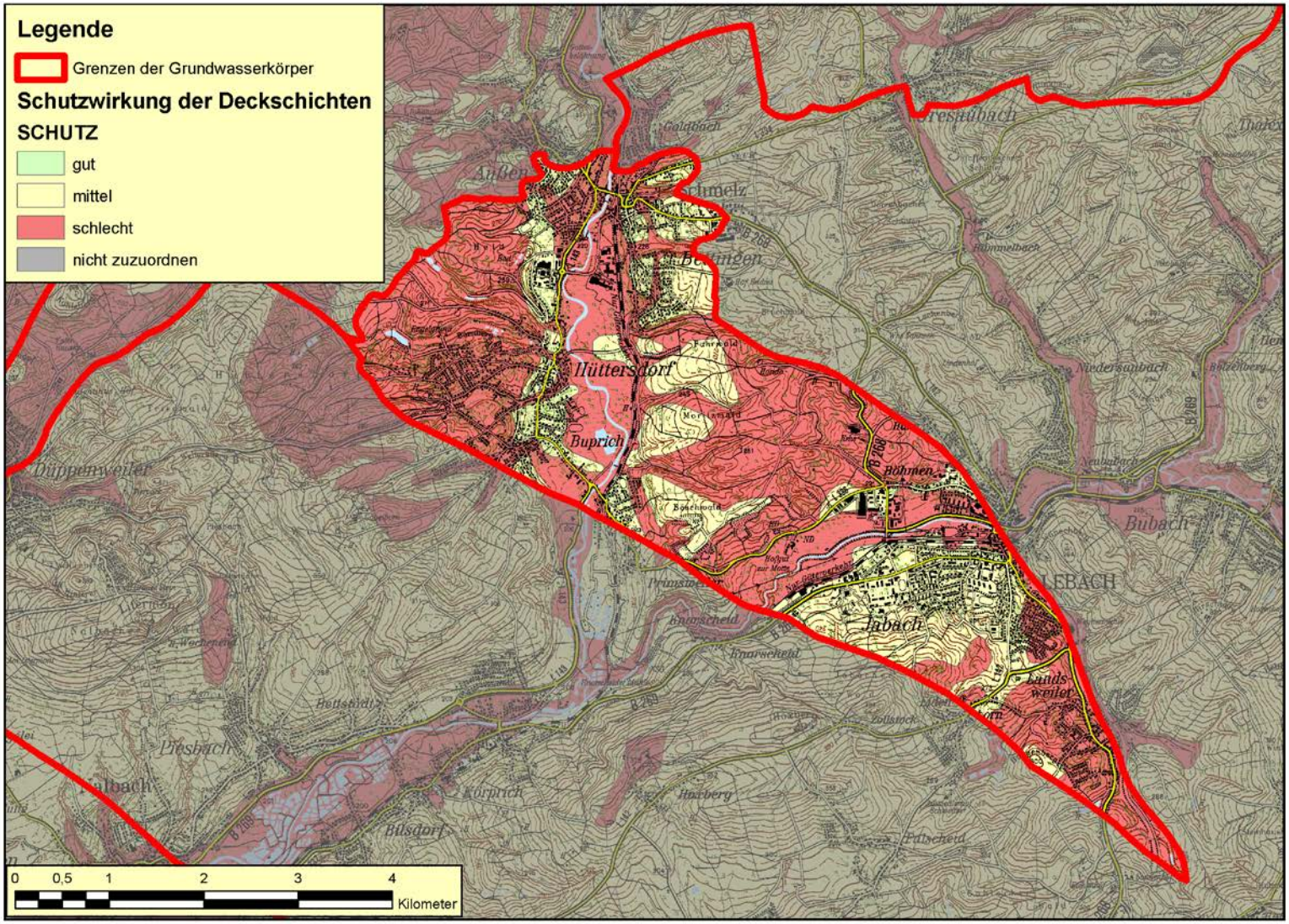


# GWB AND HYDROGEOLOGICAL MODEL

# GWB Lebach Graben

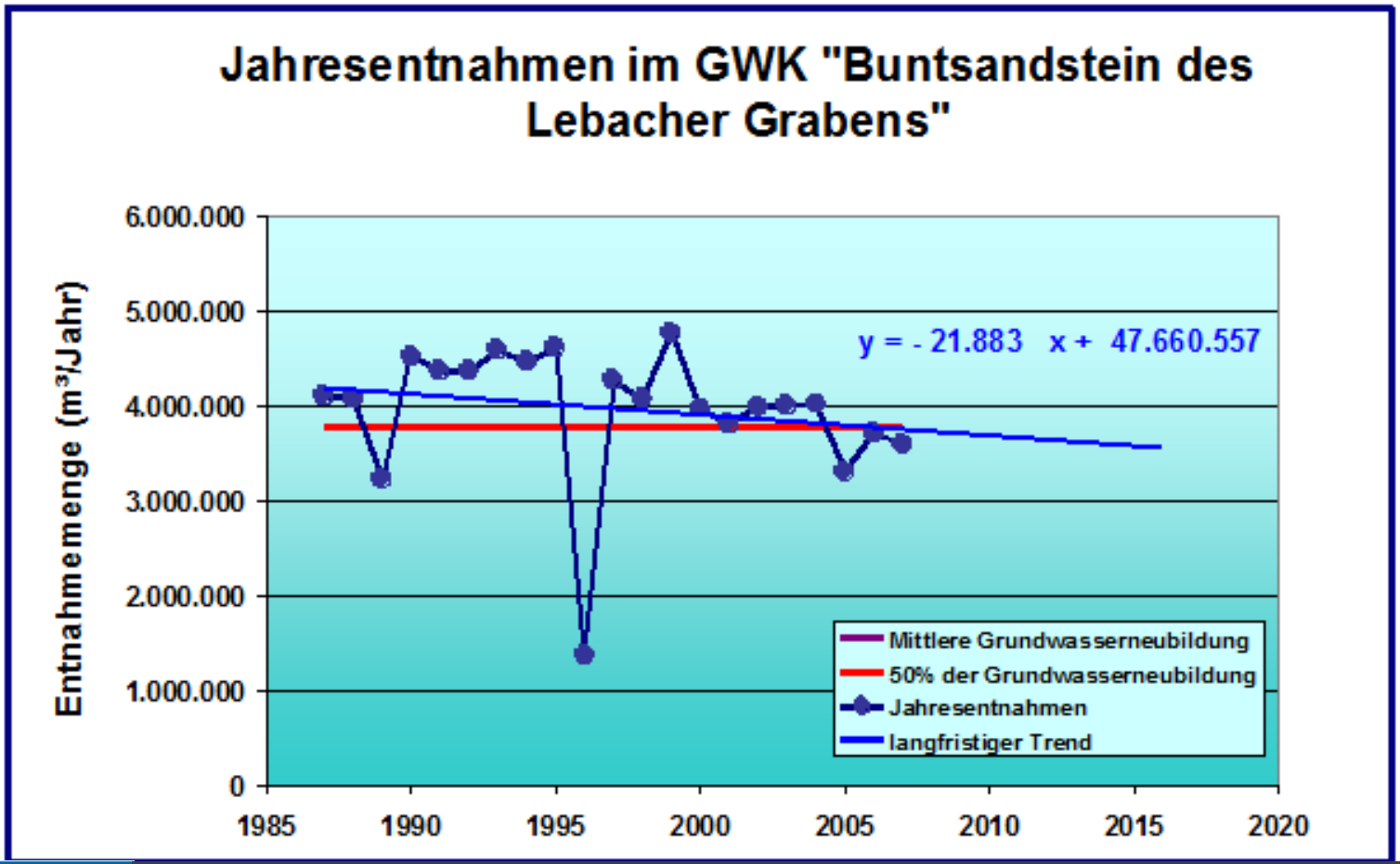


# Protective Cover

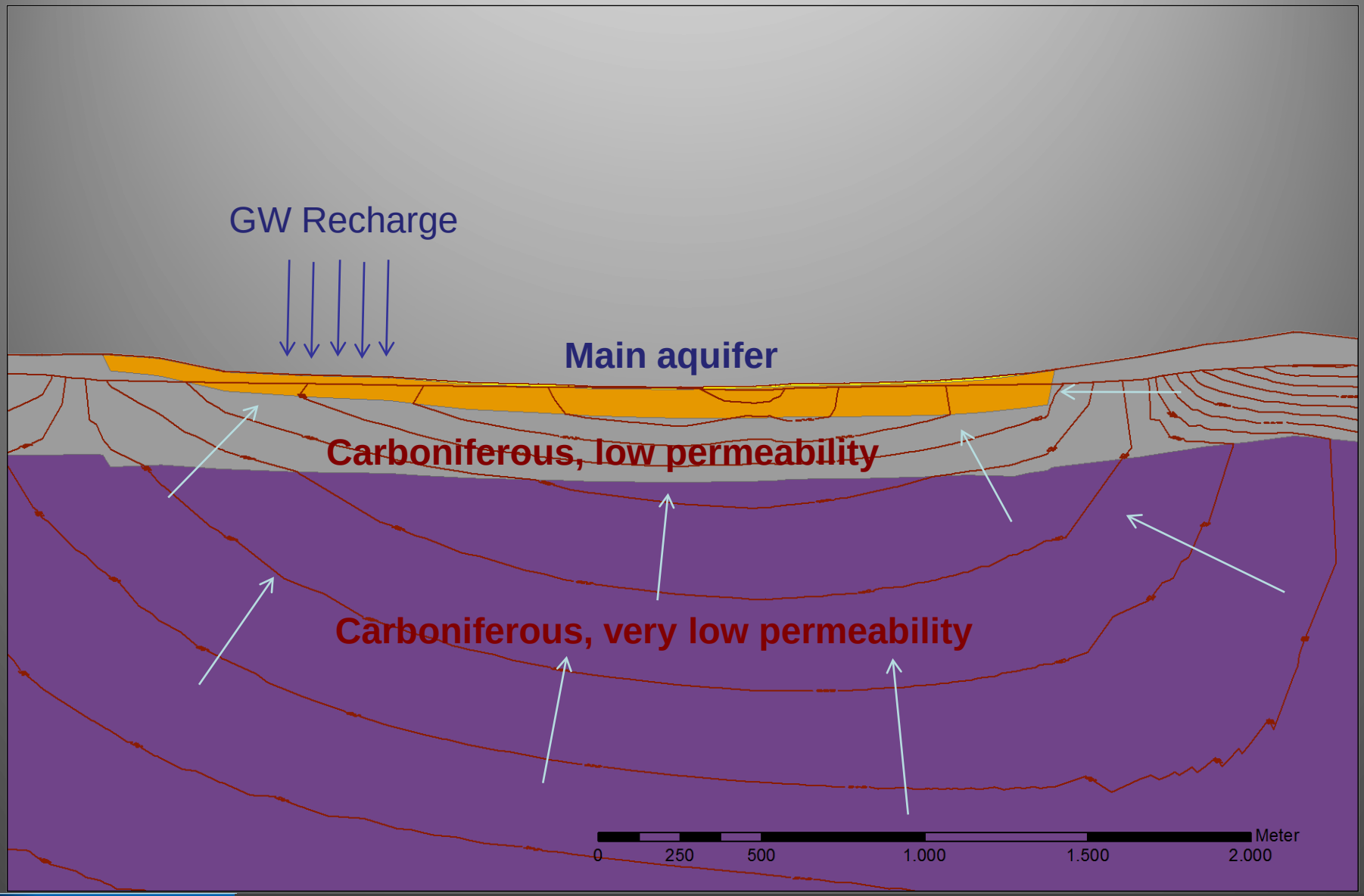


# Quantitative Status of GWB

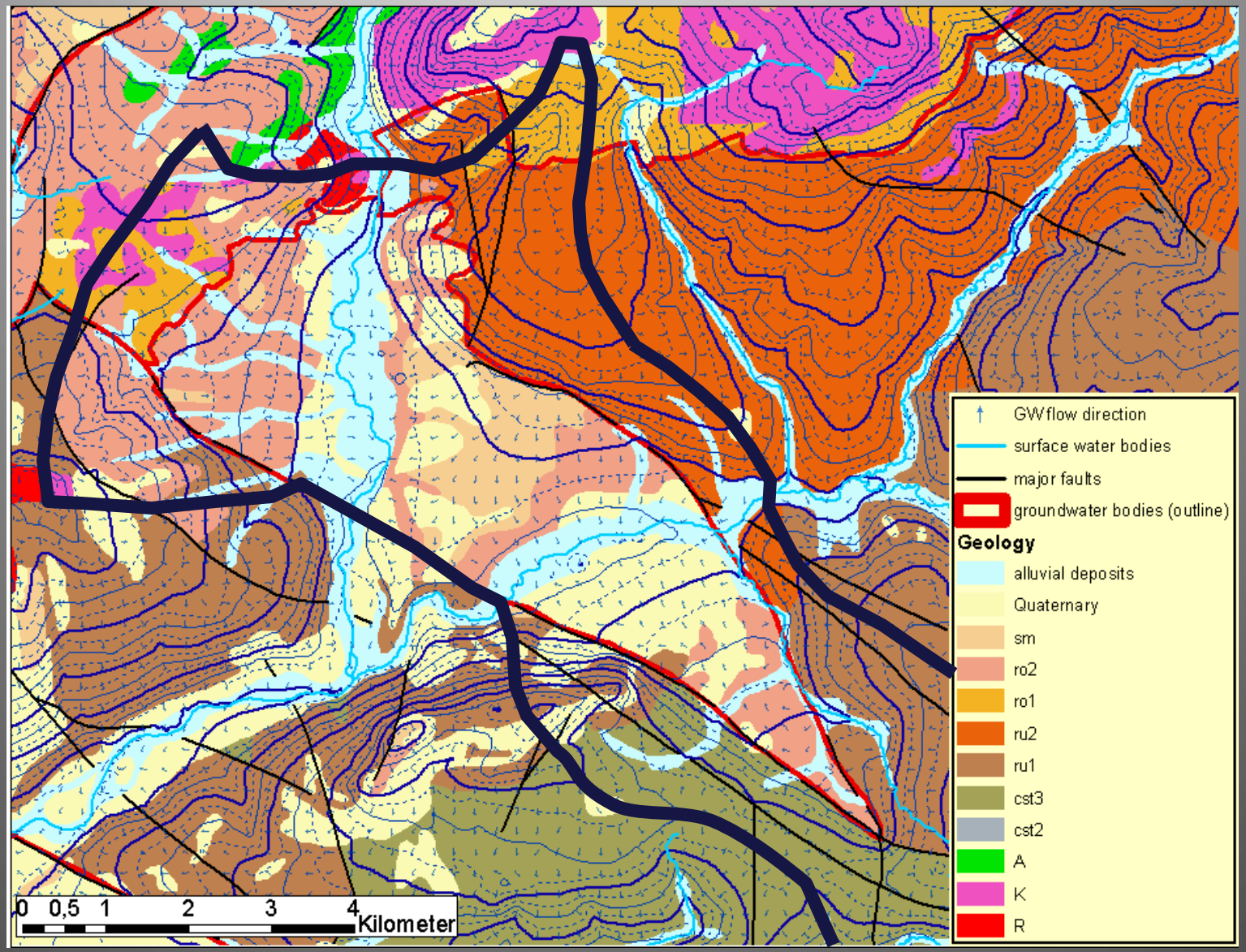
| GWR (mm) | GWR (l/s/km²) | GWR (m³/a) | source |
|---|---|---|---|
| 346,0 | 10,96 | 7.556.713 | ÖWAV-Südwest |

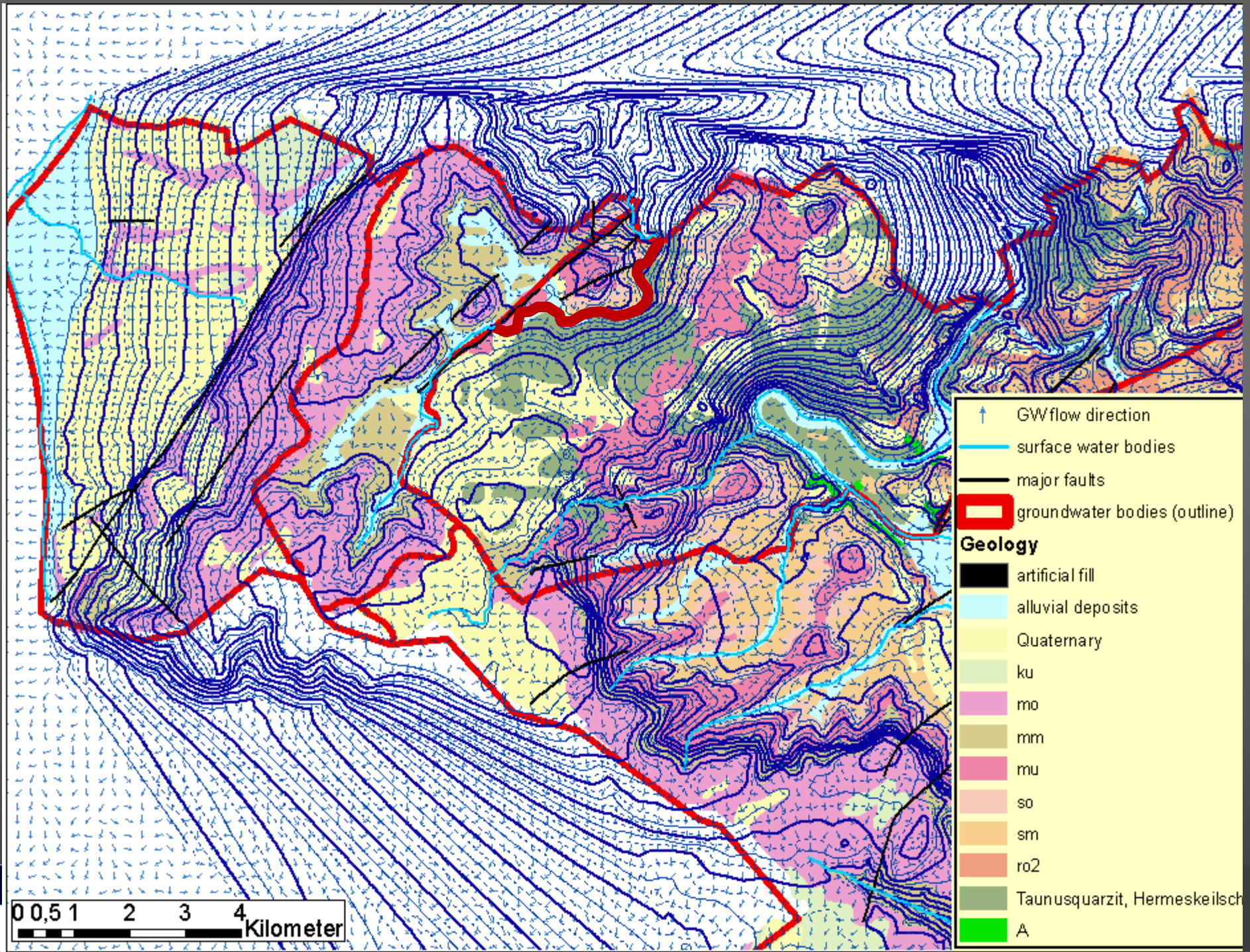


# Lebach Graben

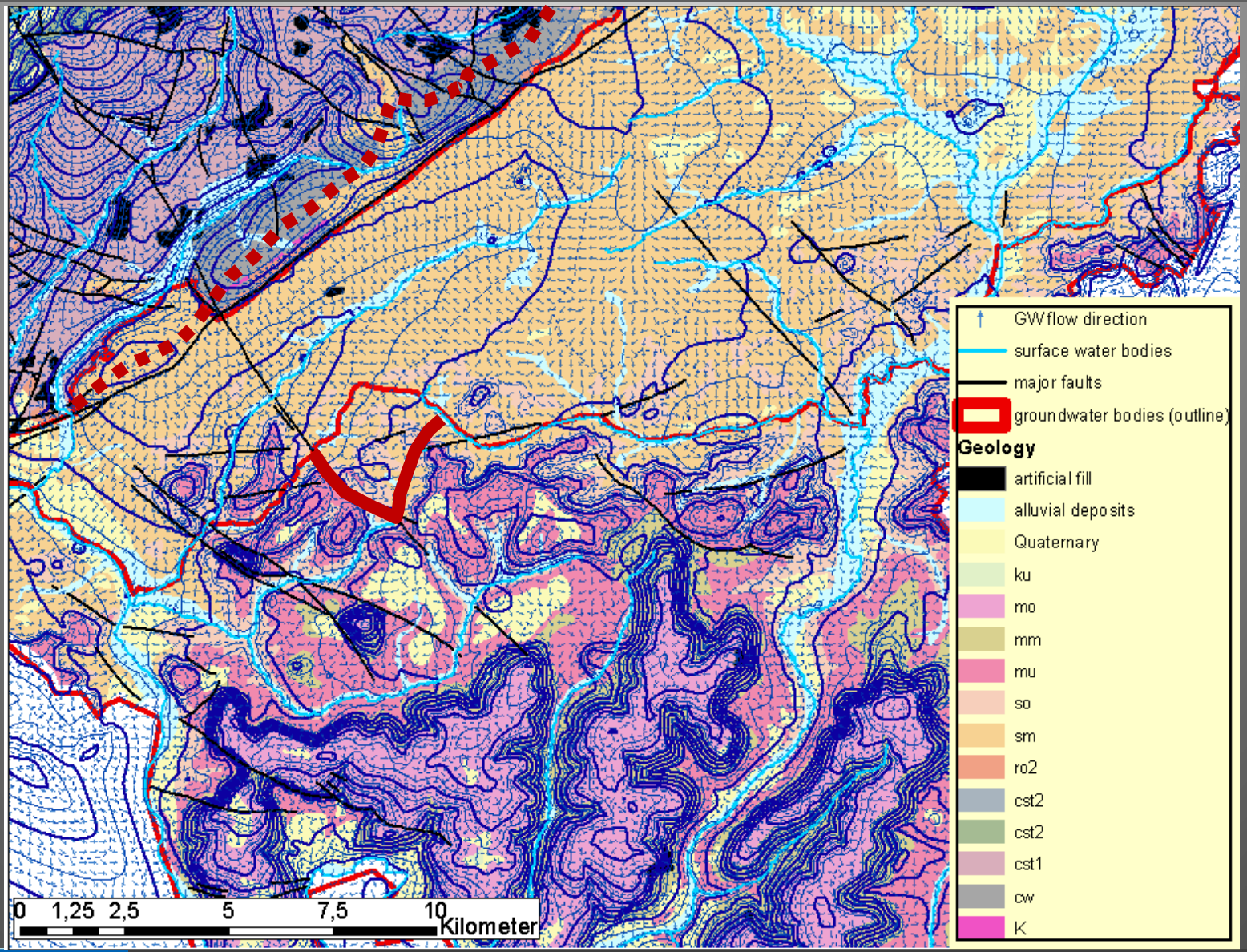


# GWB and GW Catchment

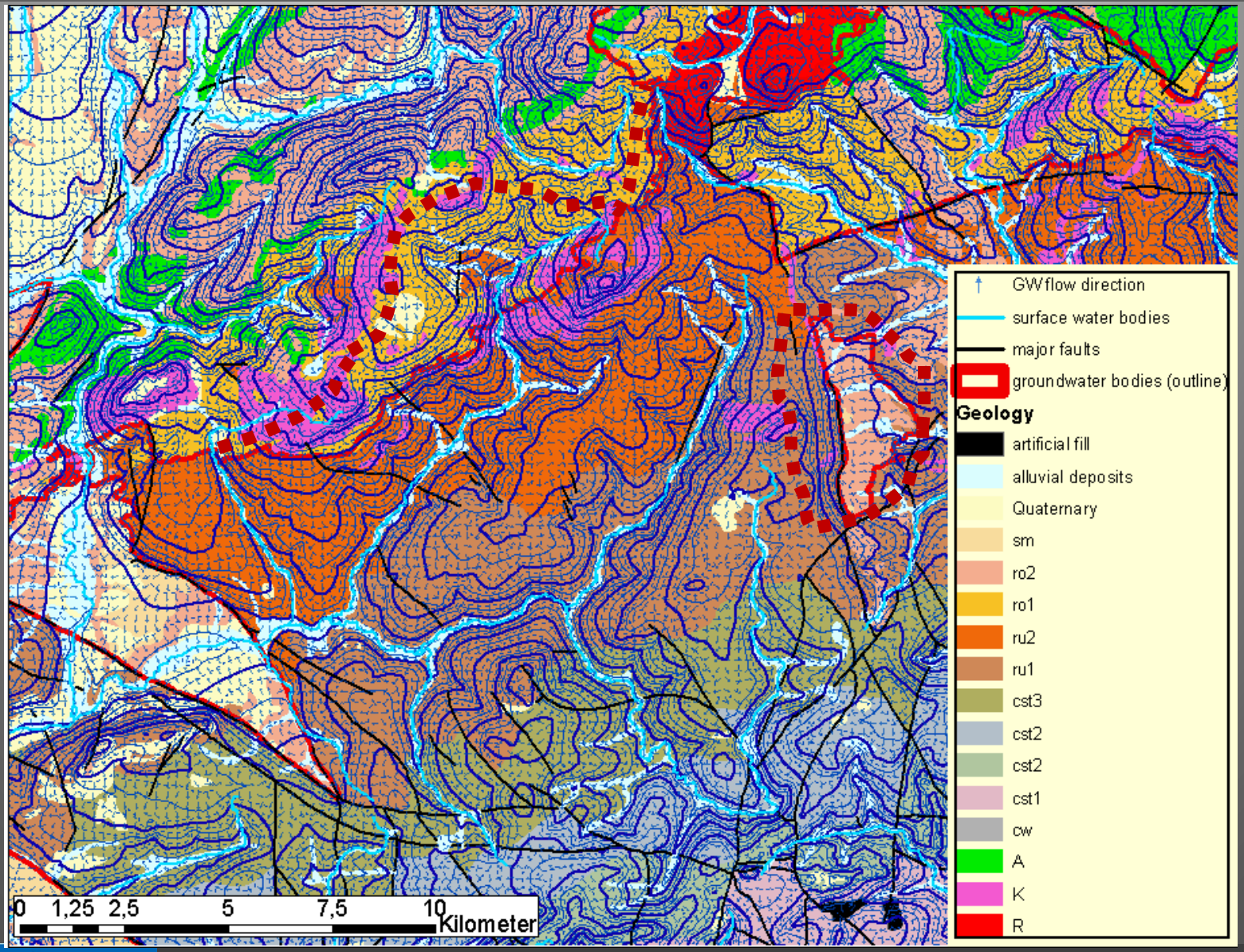



GW flow direction
surface water bodies
major faults
groundwater bodies (outline)
Geology
artificial fill
alluvial deposits
Quaternary
ku
mo
mm
mu
so
sm
ro2
Taunusquarzit, Hermeskeilsch
A
0 0,5 1 2 3 4 Kilometer

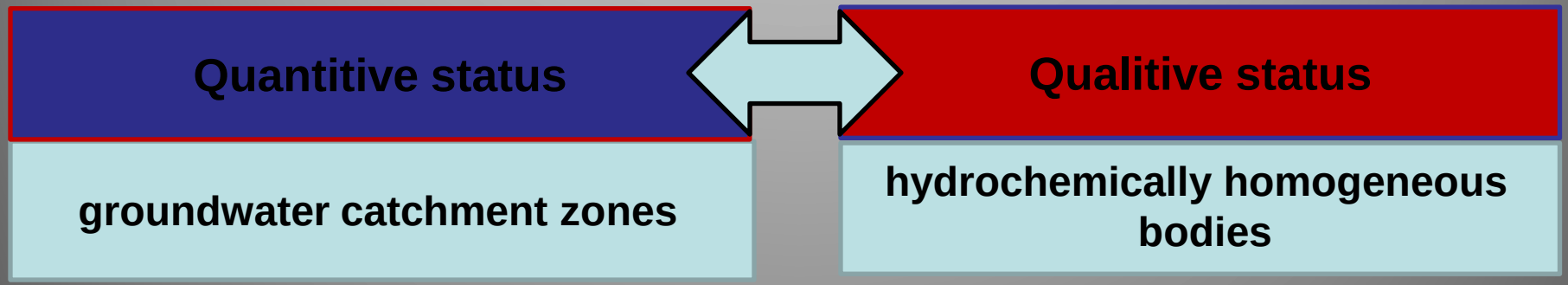
# Eastern Saarland



# Central Saarland

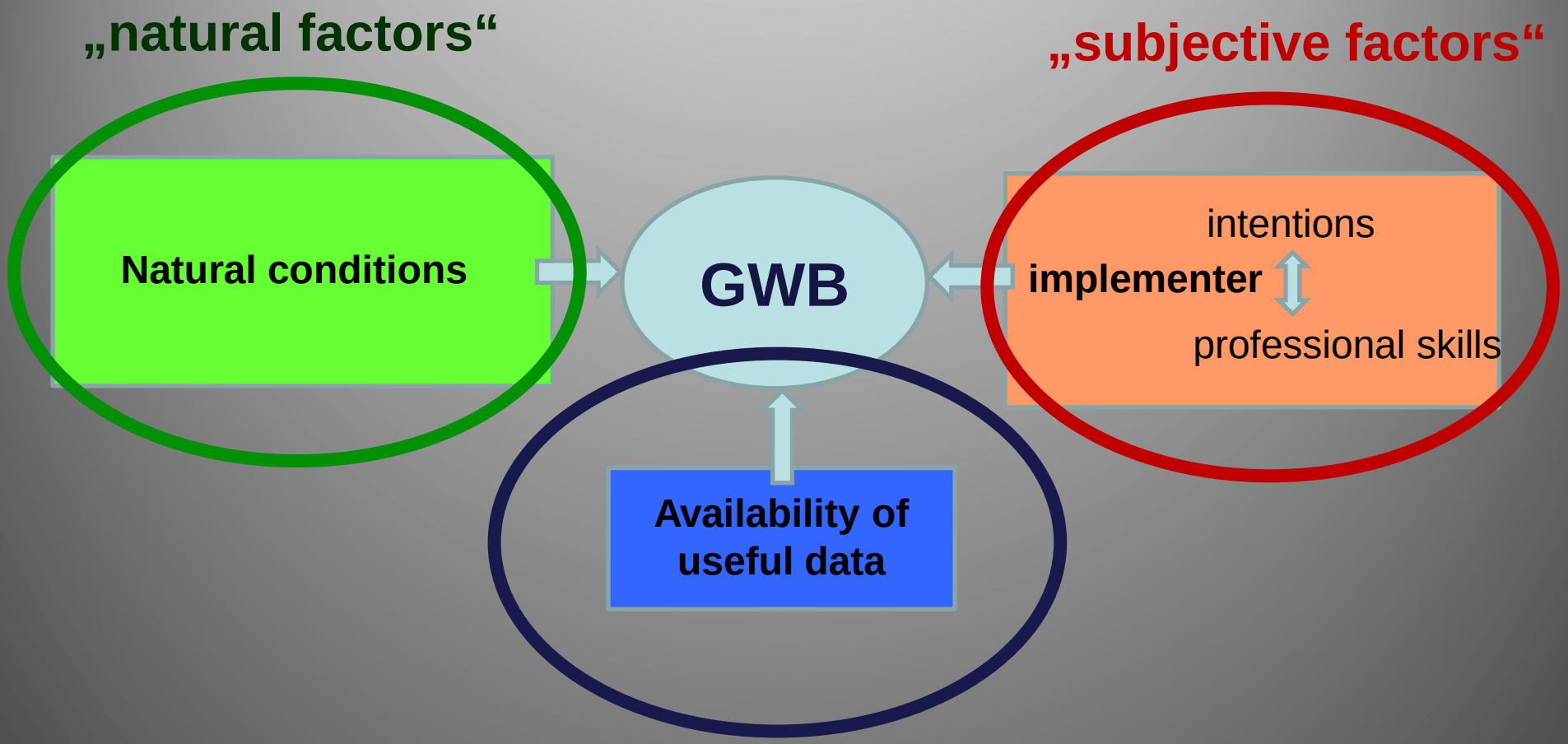


# Conflicting Interests




**Additional factors also apply (politicals borders, pressure on resource etc. …)**

# GWB delineation is highly subjective



# Conclusion

**Regional hydrogeological models are very effective tools:**

-
-Flow conditions within a GWB
- quantification of lateral and vertical exchanges between GWBs
- quantification of exchanges between ground and surface waters
- improved understanding of hydraulic conditions of measuring points
- definition of residence time in unsaturated zone
- forecasting of effectiveness of measurements
- …

**Hydrogeological models can help to mitigate the influence of the „subjective factor“**

**Availability of suitable data, elevated costs and computing limitations of modern soft- and hardware are still the main hindrances for a broader application of regional hydrogelogical models**

**Use of 3D Models in geology and hydrogeology is the future!**