Modelling

Complexities of Models

- **goal of forecast**
  (rough estimation ... detailed information)

- **model dimension**
  (horizontal, vertical, 3D)

- **model scale in space and time**
  (mega to small scale, steady-state or transient)

- **physical characteristics**
  (soil or rock, saturation...

- **application**
  (transport, density, non isothermal processes, multicomponent flow, multiphase flow)

Input Data

- **geometry:**
  position of receiving waters, wells, lakes...
  topographical survace, ground water underface, stratification
  model boundaries

- **boundary conditions:**
  measured potential heads and concentrations
  infiltrations, exfiltrations
  recharge rate
  leakage to and from surface water and other aquifers

- **initial conditions:**
  potential head and concentrations at t=0

- **material parameter:**
  permeability
  density, viscosity, fluid compressibility
  porosity, soil compressibility, fractures
  pressure-saturation-permeability-relations
  diffusion, dispersion, sorption, degradation....

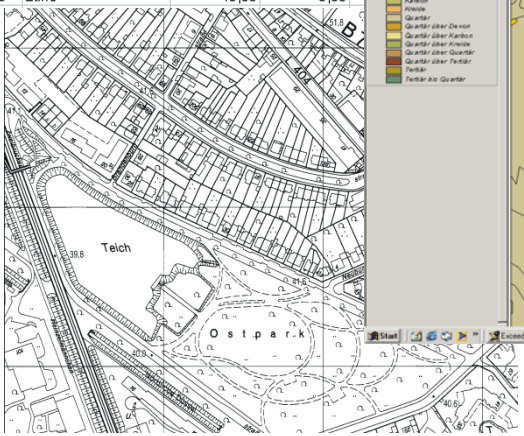
Input Data

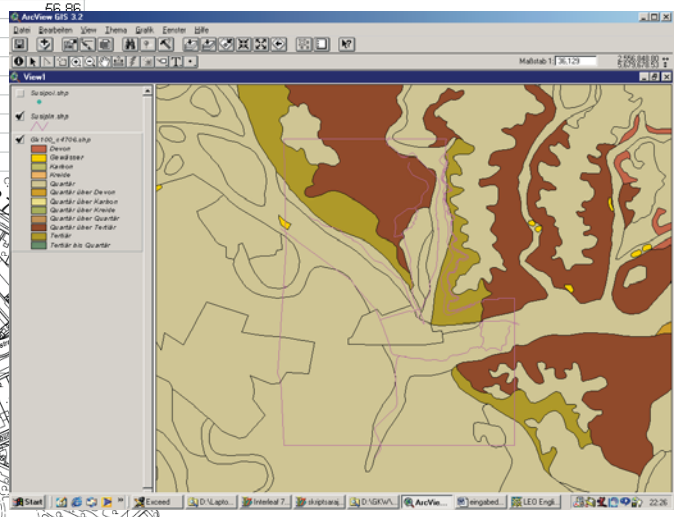
Geometry, material parameters, boundary conditions, measured states…

...given in:

Geological, topographical, hydrological maps
GIS-Data (shape-files)
digital Data
other information...

	A	B	C	D	E
1	BNR	Bemerkung	OKP	BSH	OKG
2	16/02	Trinkwassernotbr.	68,06	8,06	68,06
3	16/03	Trinkwassernotbr.	80,48	63,48	80,48
4	16/05	Trinkwassernotbr.	62,58	2,58	62,58
5	17/01	Trinkwassernotbr.	41,75	28,70	41,75
6	17/02	Trinkwassernotbr.	42,77	28,18	42,77
7	17/03	Trinkwassernotbr.	41,05	21,02	41,05
8	032030368	Land	43,25	0,00	43,25
9	032030617	Land	65,55	0,00	65,57
10	032030629	Land	53,15	0,00	53,15
11	032030630	Land	56,86	0,00	56,86
12	032030642	Land	46,21	0,00	
13	032030654	Land	47,85	0,00	
14	032030666	Land	45,84	0,00	
15	032030678	Land	39,79	0,00	
16	032030680	Land	39,94	0,00	
17	032030708	Land	43,23	0,00	
18	032031051	Land	47,26	0,00	
19	032031063	Land	46,33	0,00	





… must be digitalized, formated, modified...

Calibration

Calibration

Material parameters and physical processes in underground are only known in some points. Most parameters can not be measured directly. Some parameters (permeability !) are heterogenous. In most cases the measurements are not enough for modelling the natural processes.

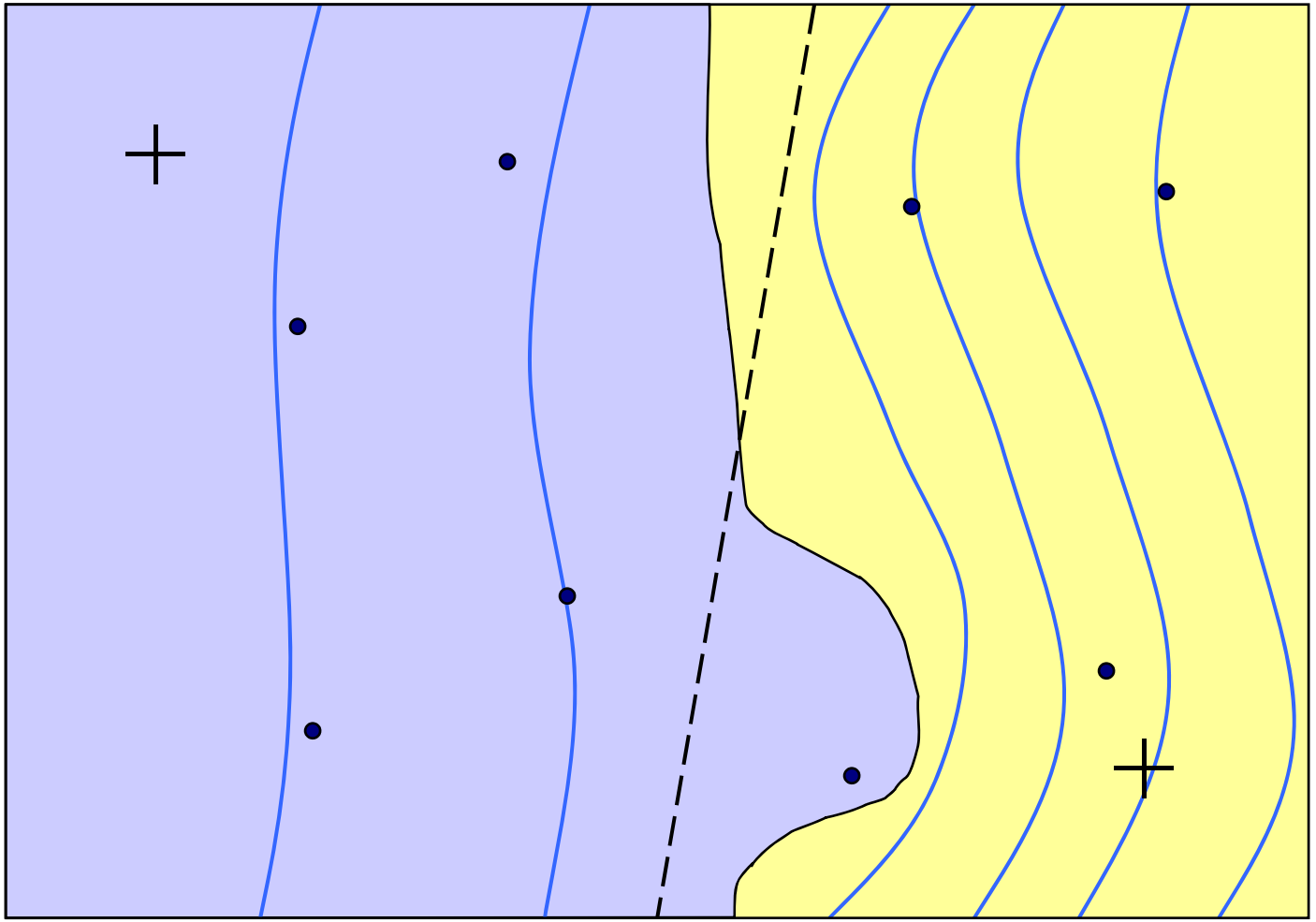
Groundwater table and concentrations can be measured directly. Groundwater table has no discontinuities.
The uncertain material parameters are calibrated by simulating a measured state of groundwater table (concentration).

→ **Calibration**

Attention: calibrated material parameters contain all model uncertainties

Uncalibrated models are called type models.

Calibration



Calibration procedure

steady-state flow	→	permeability, (leakage coefficient)
transient flow	→	permeability, storage coefficient, (leakage coefficient)
transport	→	dispersivity

Calibration is a plausibility check of input data!

→ Often the calibration indicates bad quality of input data, that lead to a revision of some input data

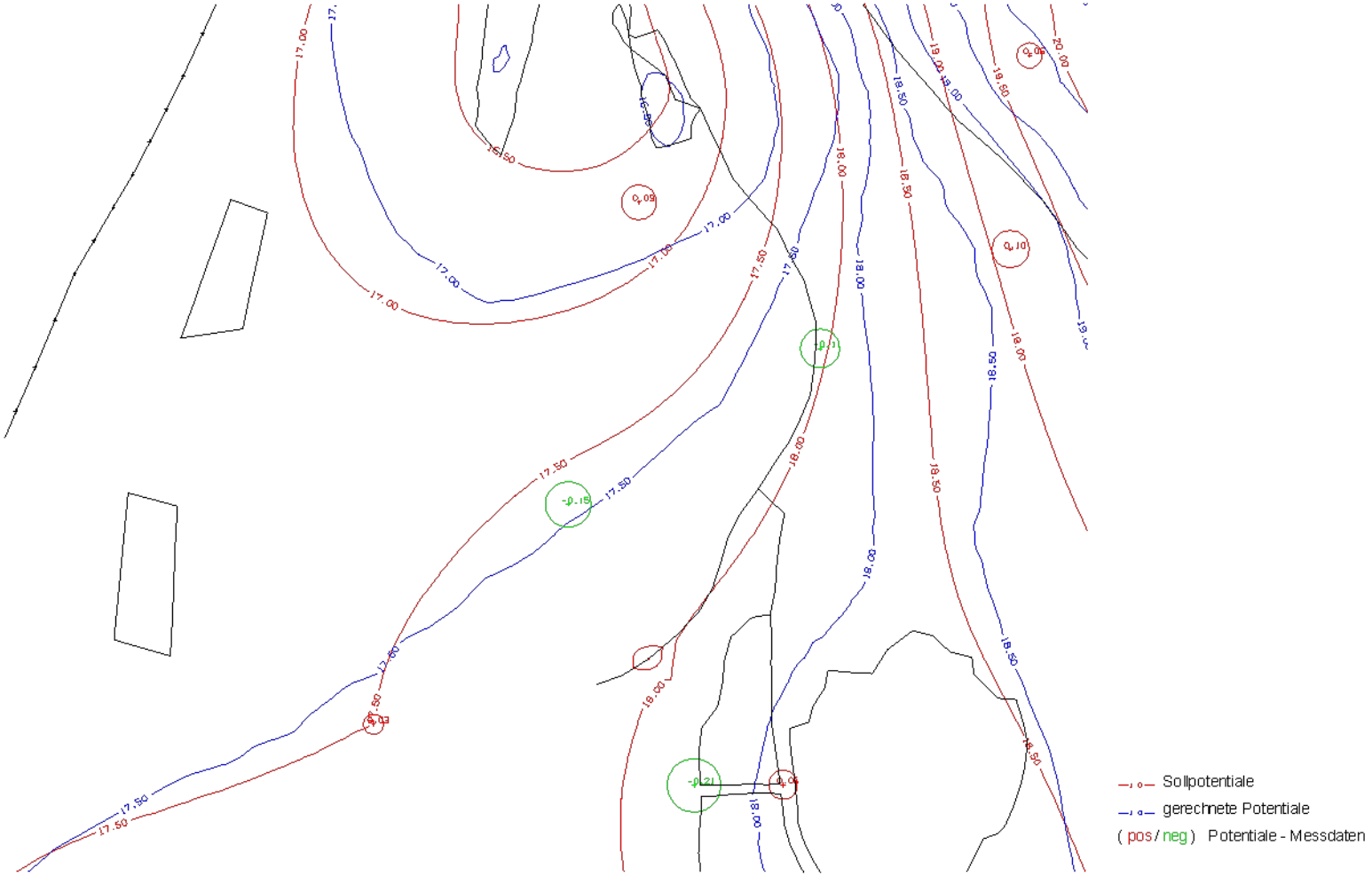
Calibration

Iterative variations of starting values for permeabilities:

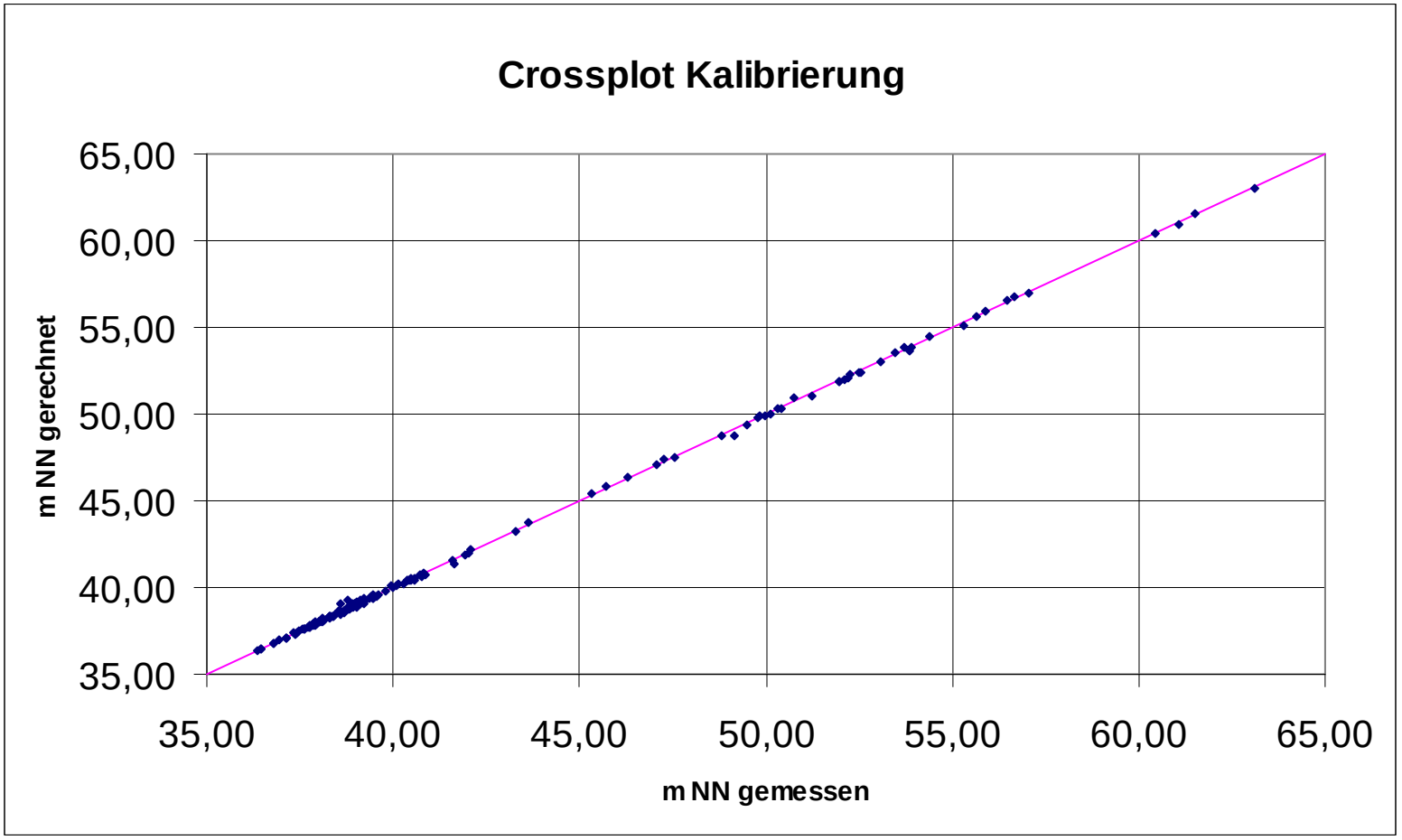
automatically	Gradient methods (comparison between measured and interpolated gradient and simulated gradient)
	inverse modelling (expensive, not always good results)
manual	„hydrogeological knowledge“
	Trial and Error

→ mostly combinations

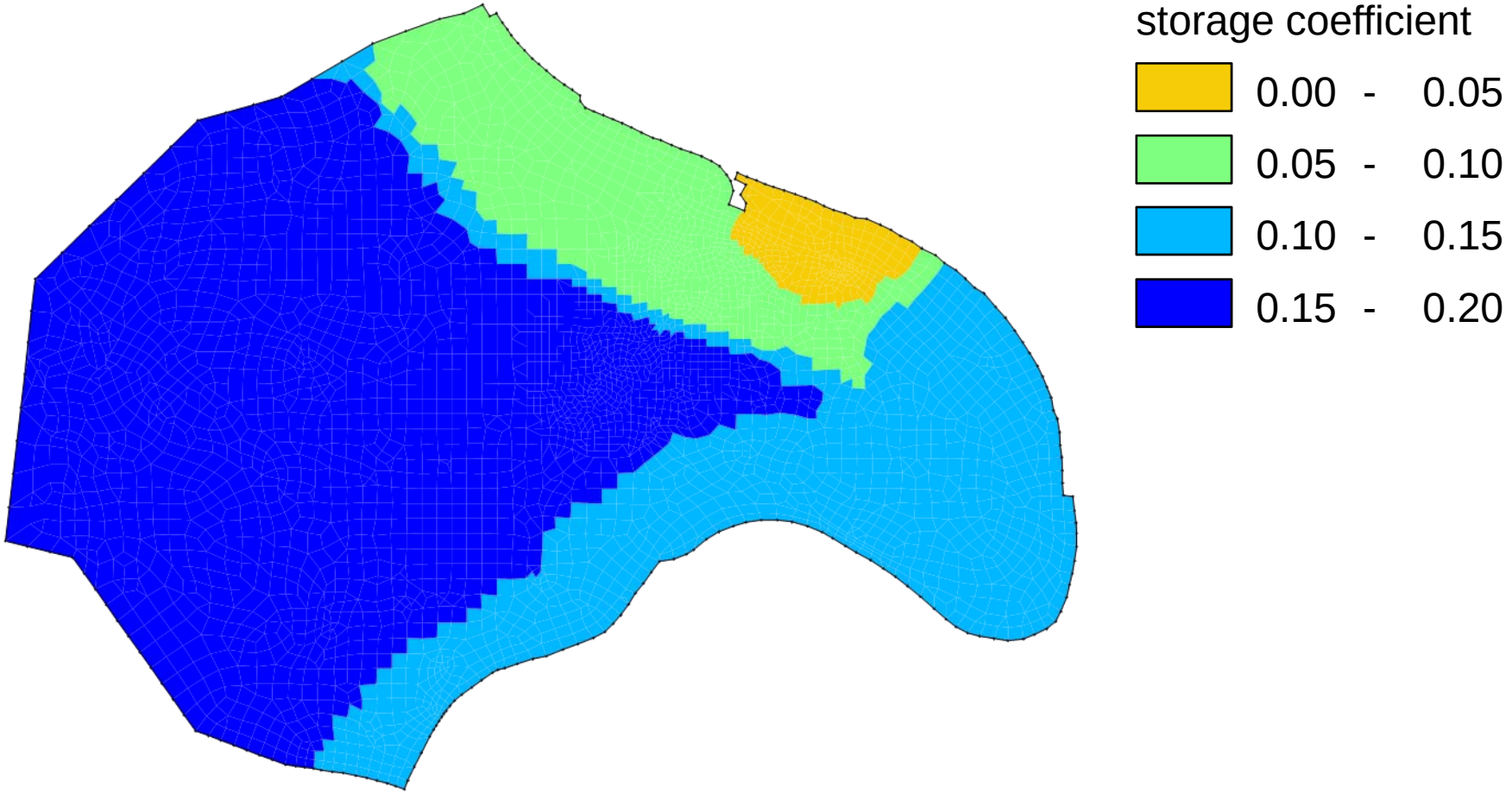
Steady-state Calibration (Example)



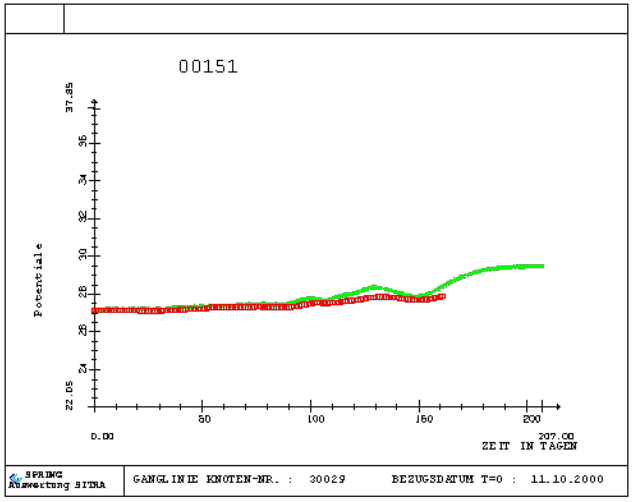
Steady-state Calibration

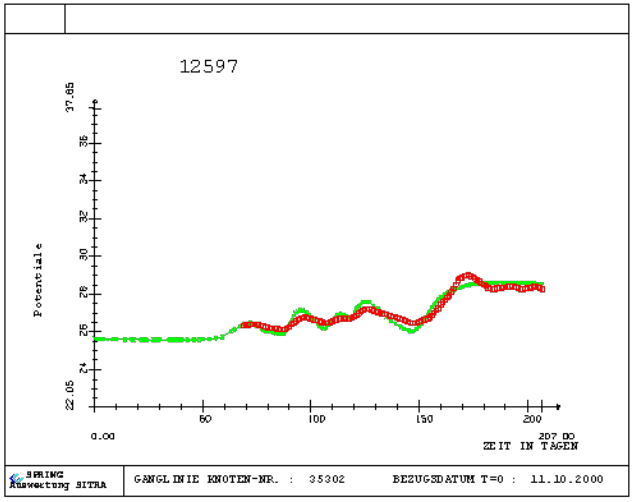


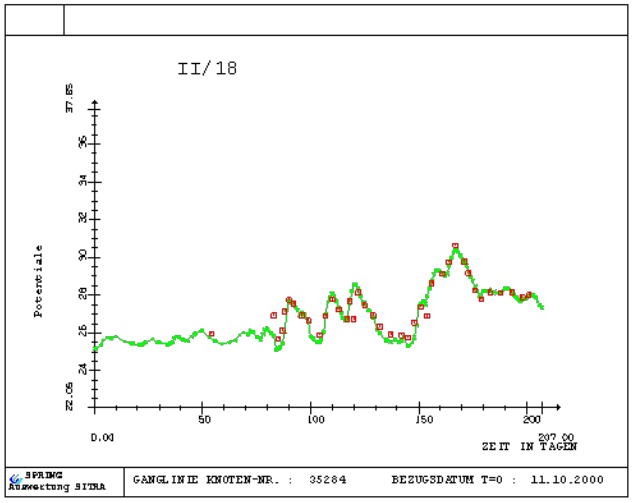
Transient Calibration (Example)

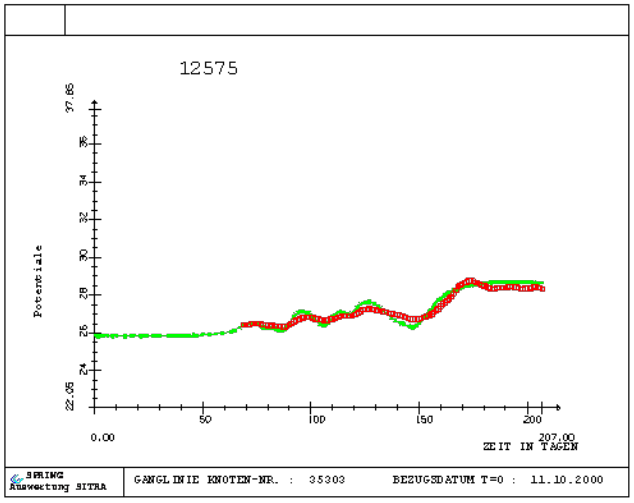


Transient Calibration (Example)









Forecast Data

Groundwater table

contaminant plume (concentration of a substance)

distance betwenn groundwater table and surface

mass balance (global / local)

flow velocity

pathlines / streamlines

catchment area (of wells, rivers ....)

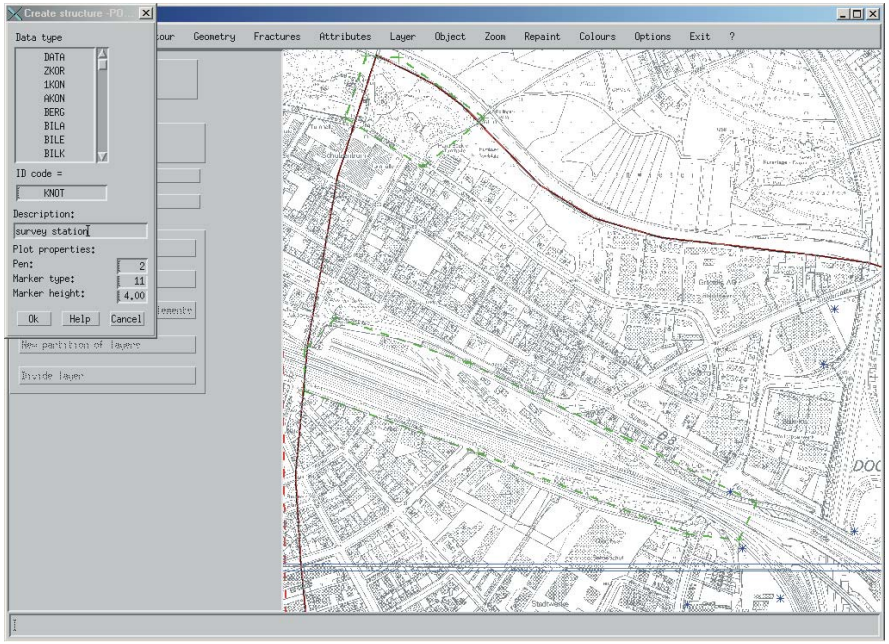
hydrographs / breakthrough curves

Forecast Data

- potential heads or pore water pressure
- concentrations (e.g. contaminant plume)
- mass balance
- velocities .....

Datenstruktur

Beschreibung von Modellgeometrien und anderen
Eingangsdaten als Punkte, Linien und Flächen, ggf. mit „Attributen“



rote Linien: Grenzen und Vorfluter

grüne Linien: Flächen für Neubildung

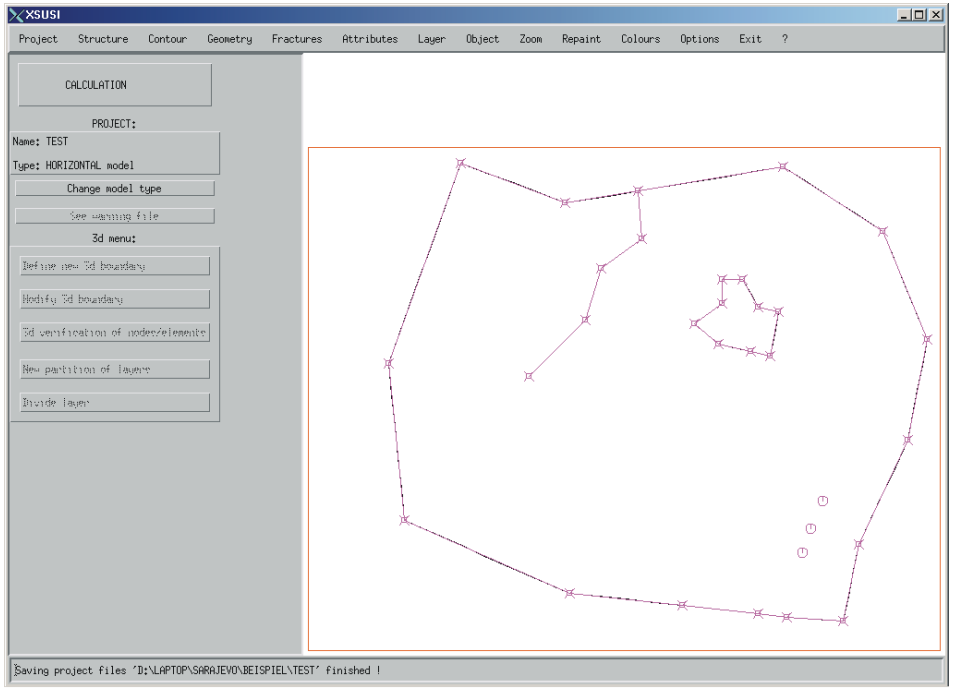
blaue Punkte: Beobachtungsbrunnen

Hier: Erstellen von Strukturen durch Digitalisieren von einer topographischen Karte

Datenkontur

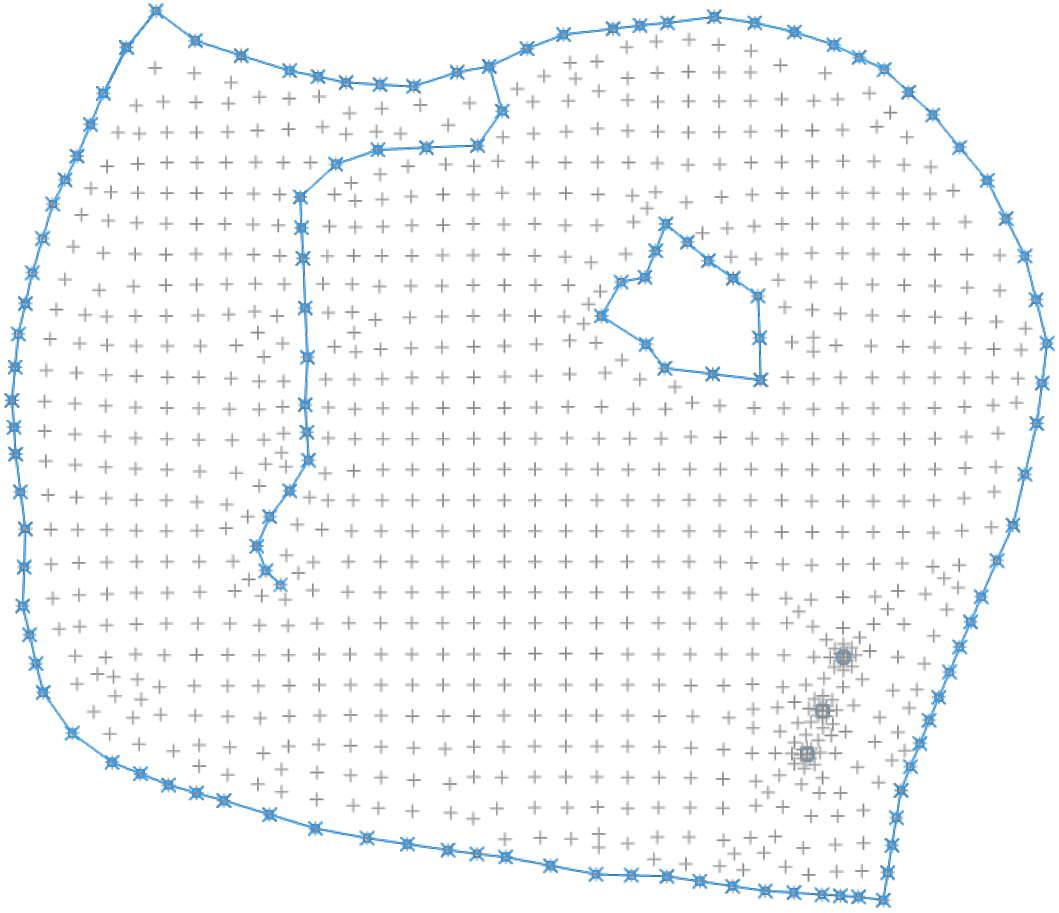
Aus allen netzrelevanten geometrischen Daten wird die Kontur erstellt

z.B. Ränder, Seen, Vorfluter, Entnahmebrunnen, Meßstellen …

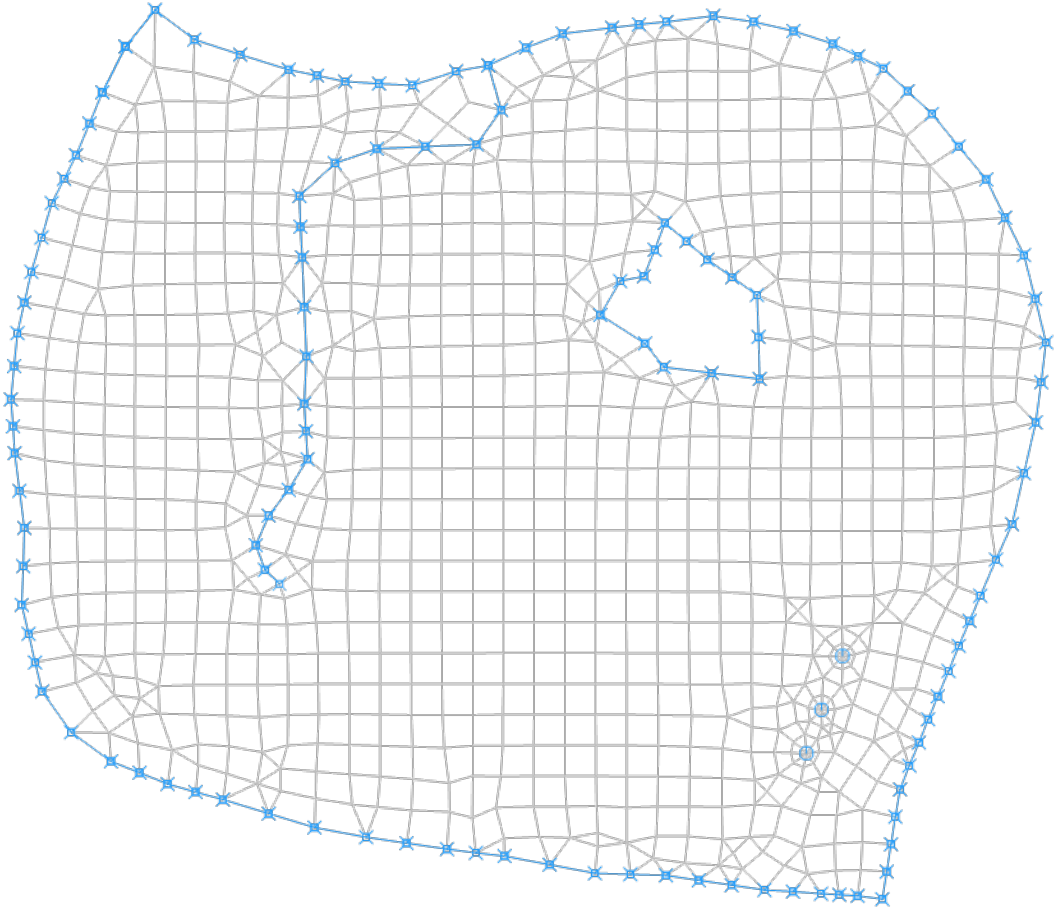


Erstellung aus bestimmten Strukturen oder direkt durch Digitalisieren

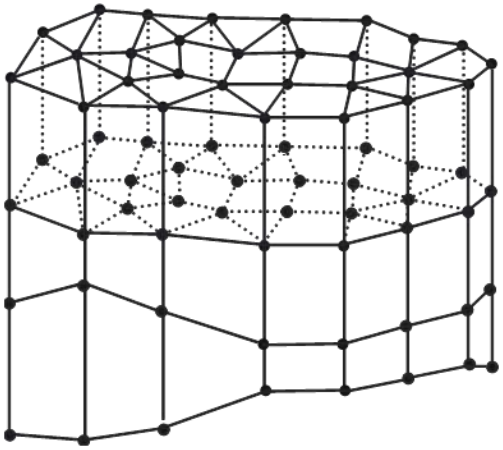
Netzaufbau



Finite-Elementnetz



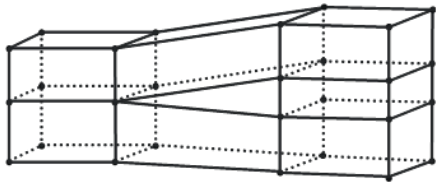
3D-Netzgenerierung



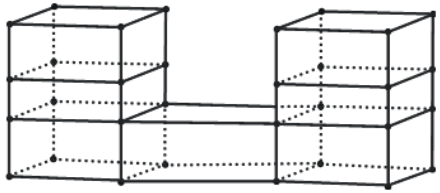
1. Generierung eines 2D-Netzes

2. Projektion der Knoten in die tieferliegenden Schichten

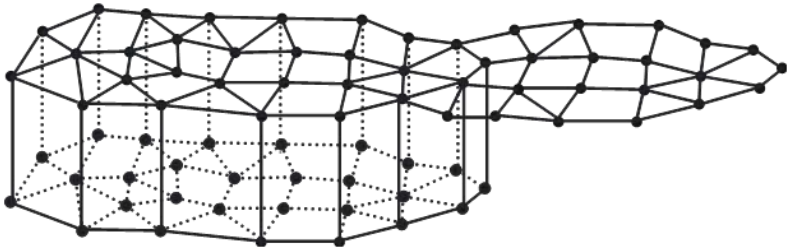
3. Zuweisen der Höhen auf die Knoten der tieferliegenden Schichten



3D Elemente können 4 -8 Knoten haben
hier: auslaufende Schicht

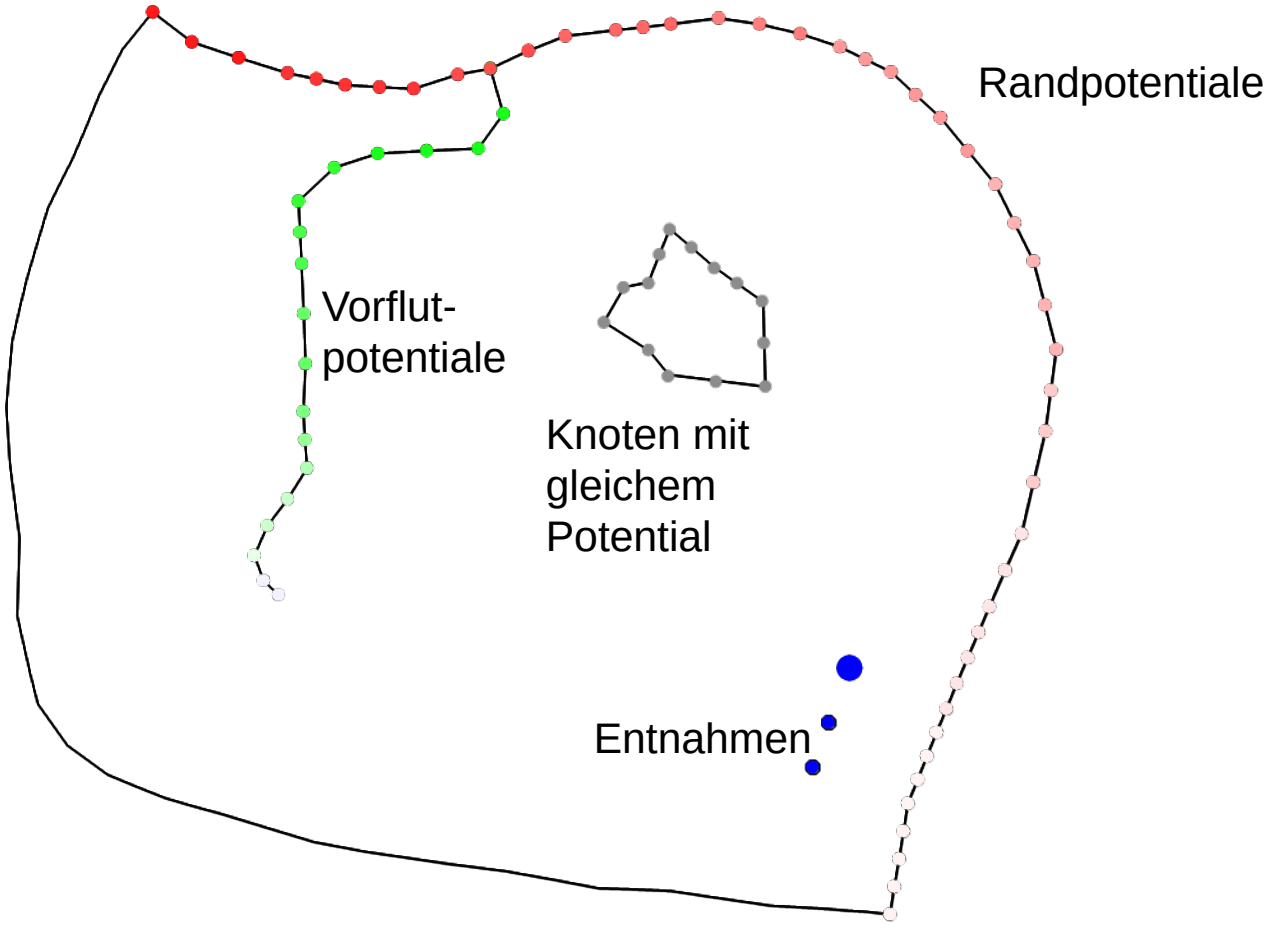


ausgehobene Bereiche

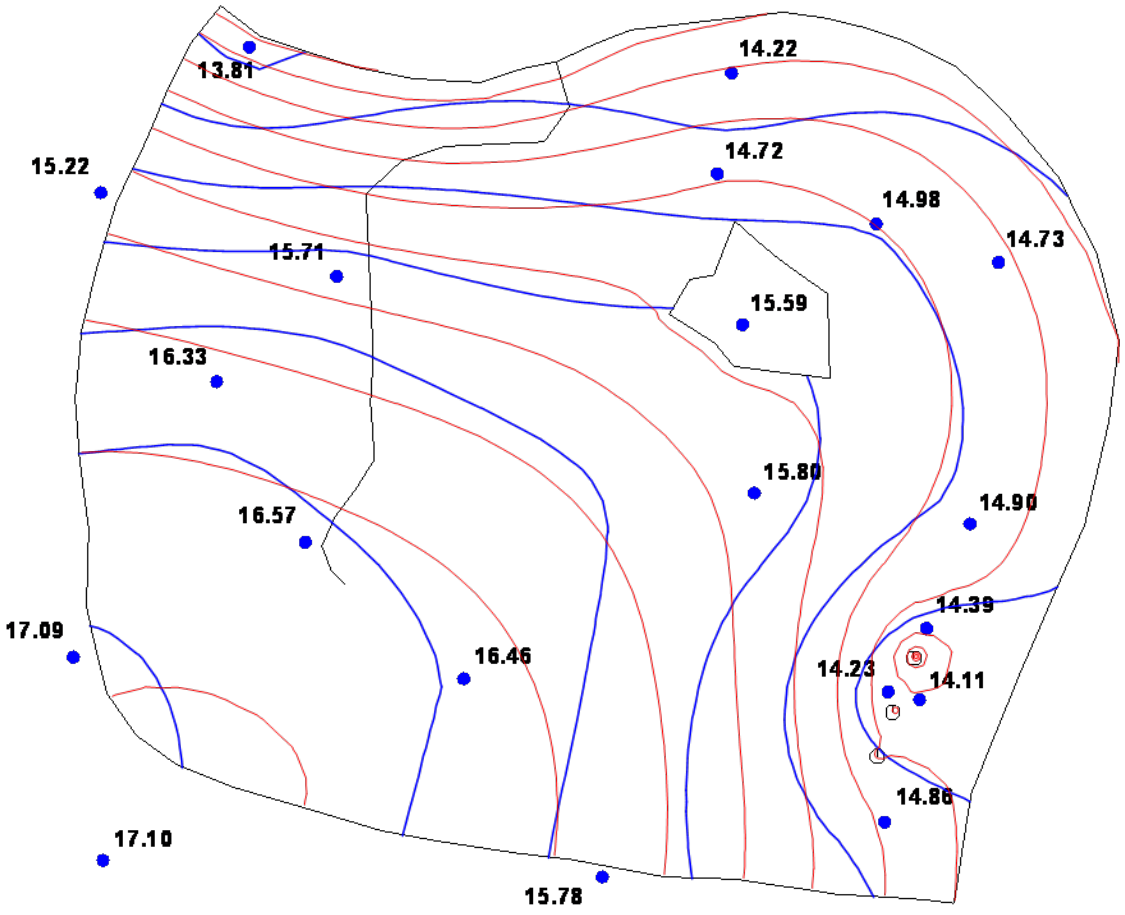


kombinierte 2D-3D-Gebiete

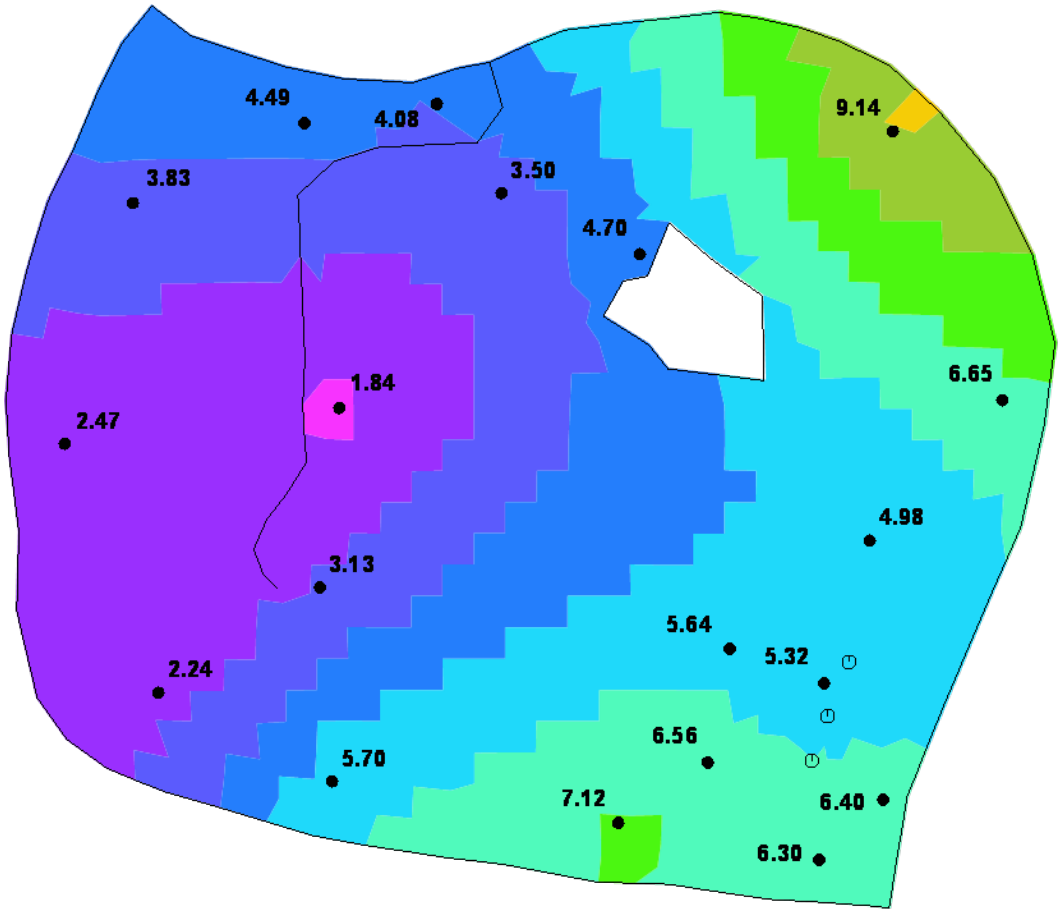
Rand- und Nebenbedingungen



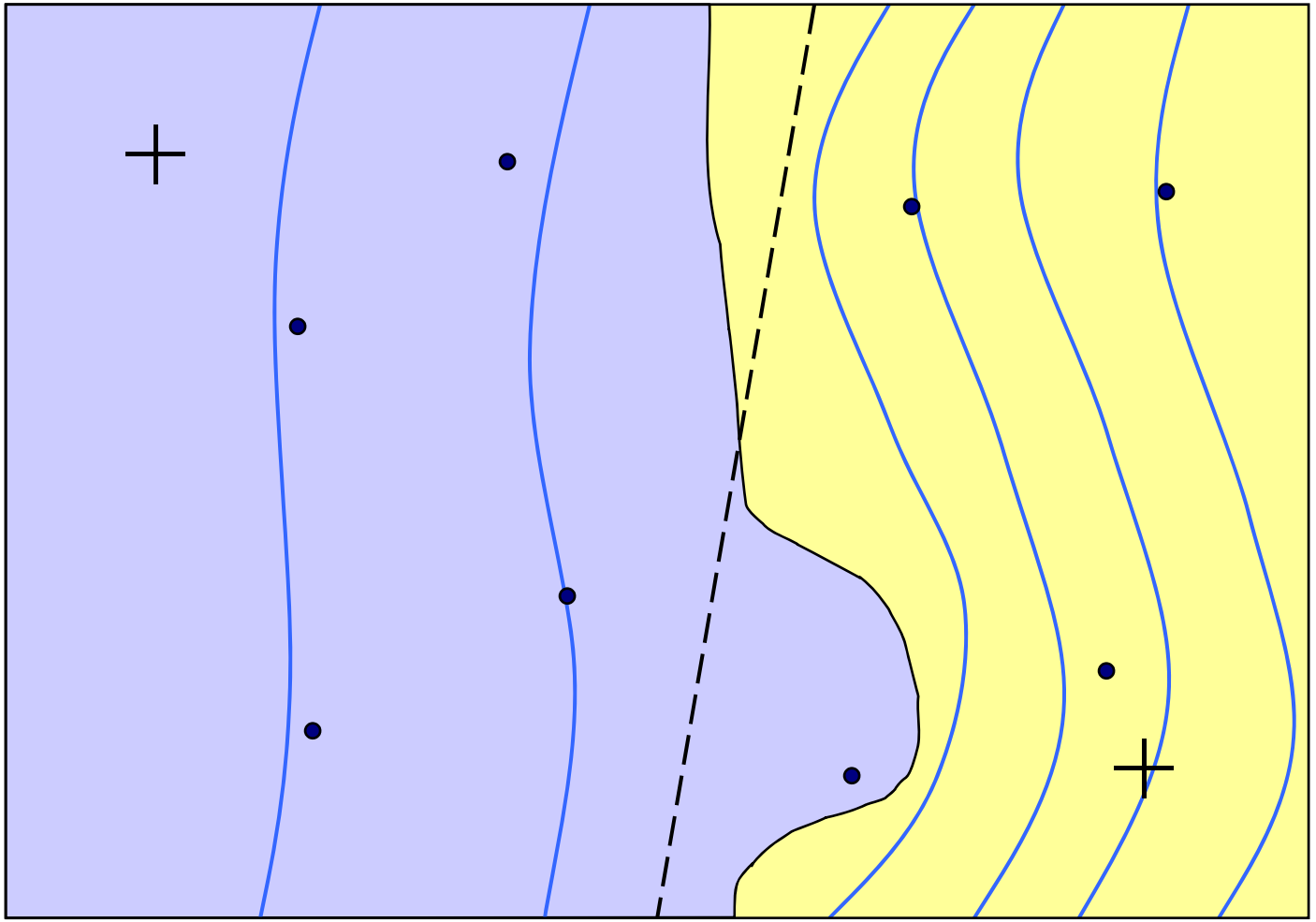
GW-Messwerte



Unterkante


4.49
4.08
9.14
3.83
3.50
4.70
6.65
1.84
2.47
4.98
3.13
5.64
5.32
2.24
6.56
5.70
7.12
6.40
6.30

Kalibrierung



Validation

Model check after calibration with an additional measured state without new calibration.

1. Creation of model with given information

2. Calibration of some material parameters (permeability, storage, leakage, dispersion)

→ calibration state can be represented

3. Validation: Simulation of an additional measured state

no change of material parameters

only input of boundary conditions of new state

→ Good representation of the measures state - the model is validated

3b. New Calibration