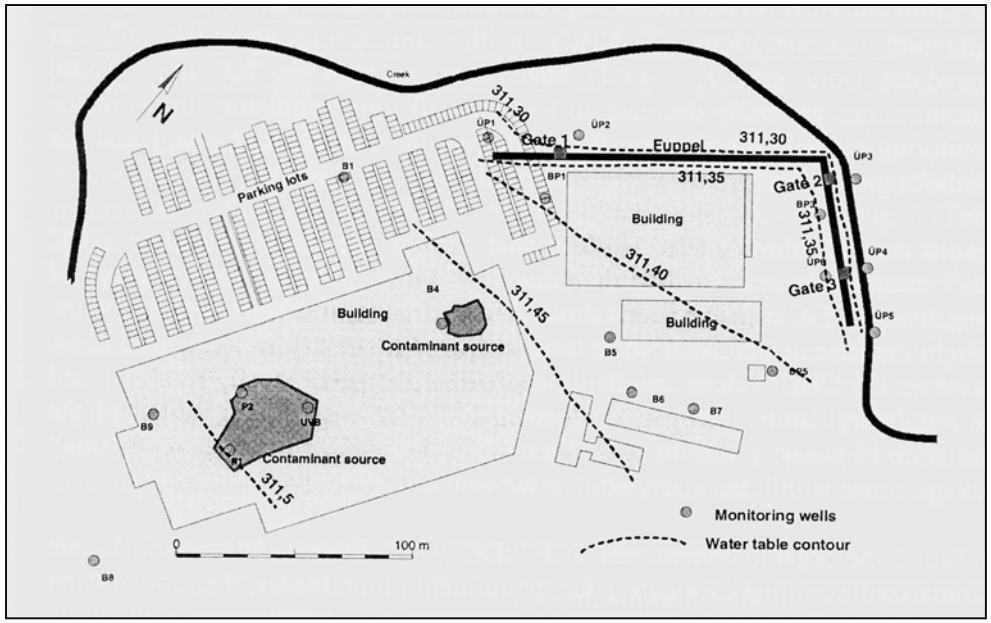
Tübingen

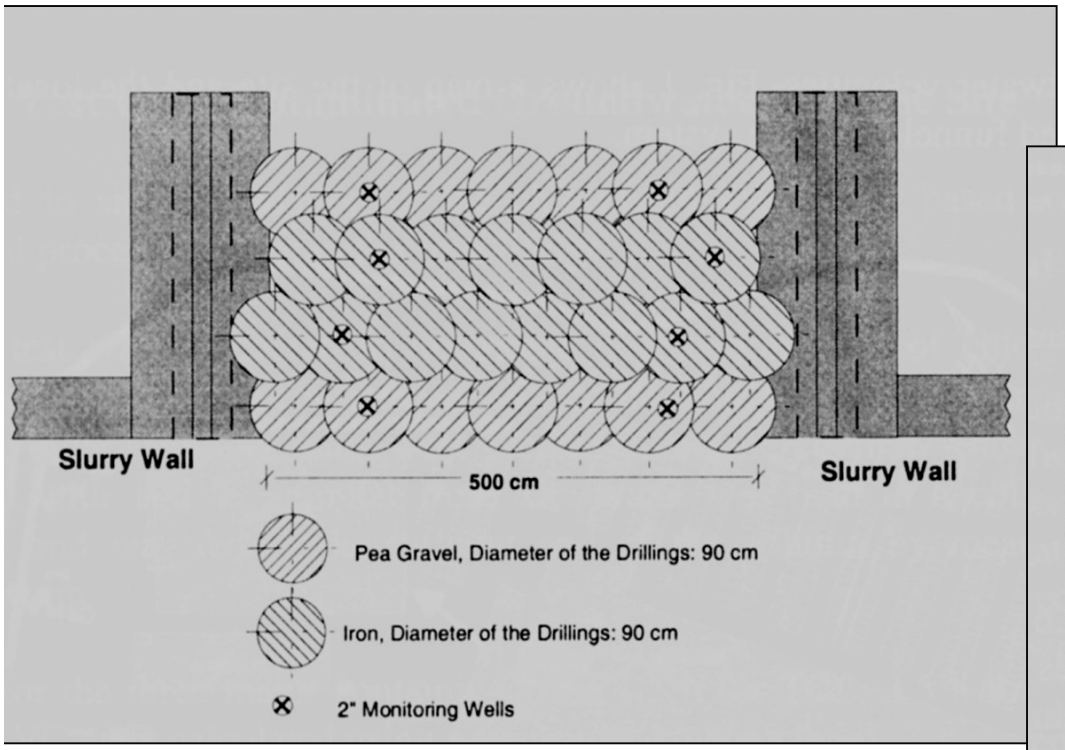
- 1998: Installation of a full-scale F&G system at the BEKA site (Neckar valley)
- ZVI to treat a plume of cVOCs
- L-shaped funnel (slurry wall, 215 m long, 0.6 m thick, 8-11 m deep) with 3 gates

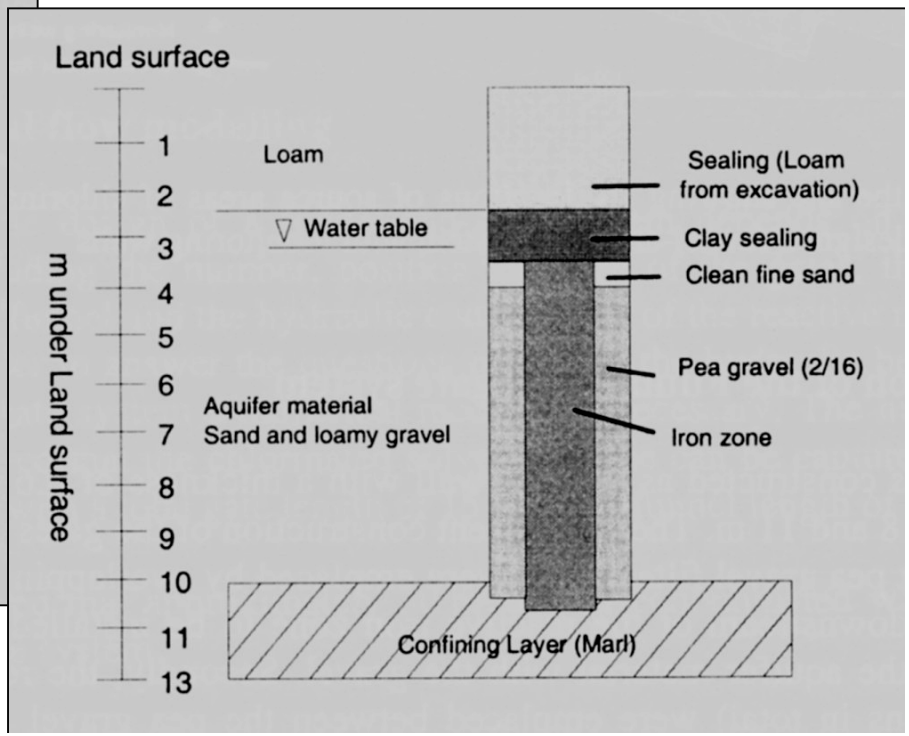


Tübingen

Gate construction

- upstream and downstream pea gravel filter zones were emplaced by overlapping boreholes



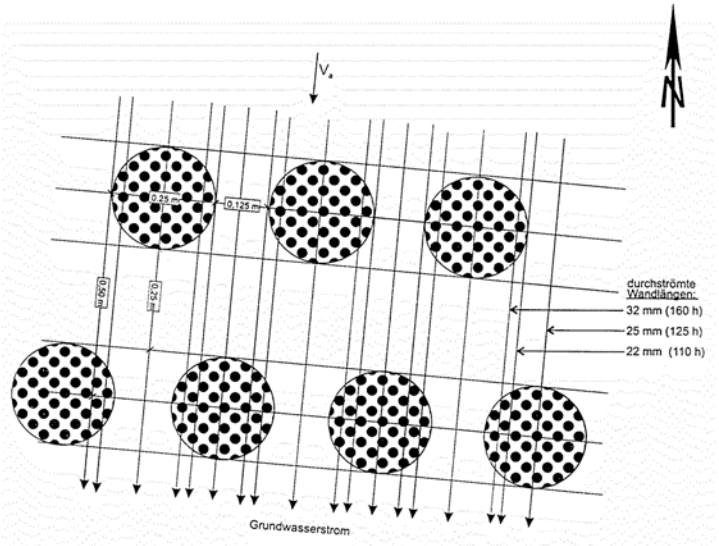


Tübingen

- ZVI were emplaced right between the pea gravel filter zones using the same technique
- Within the iron zones, cVOC concentrations decrease to below detection limits
- However, downgradient of one gate a slight increase in cVOC levels compared to the values in the iron zone is found
- Performance of the BEKA PRB will be scrutinized in a member project of the network RUBIN (University of Kiel)

Reichenbach

- 2000: representing the first full-scale adsorptive continuous reactive barrier (CRB) in Germany
- A homogeneously distributed cVOC contamination of the groundwater had been identified
- Non-overlapping boreholes
  diameter 0.25 m each
  aligned in two parallel rows
  packed with GAC



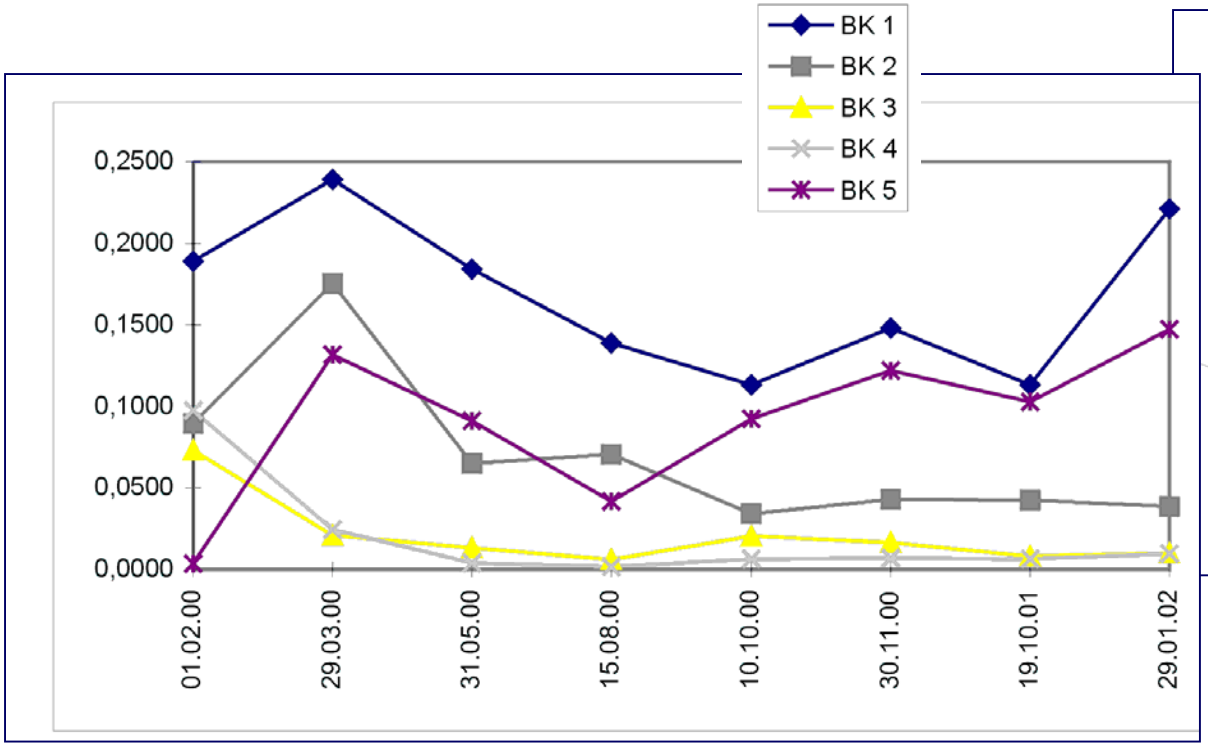
Reichenbach

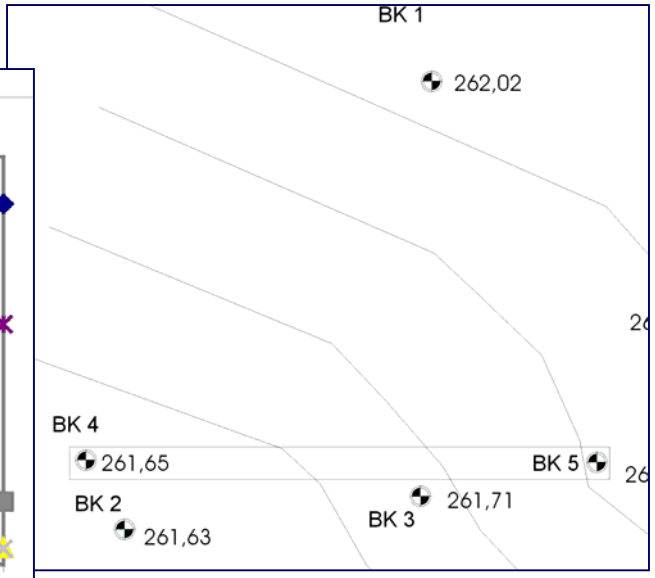
CRB (20 m long, 7 m deep) had to be erected directly inside a manufacturing hall (2000)

Reichenbach - Performance

Summe Leichtflüchtige halogenierte Kohlenwasserstoffe (mg/l)

Probe	01.02.00	29.03.00	31.05.00	15.08.00	10.10.00	30.11.00	19.10.01	29.01.02
BK 1	0,1890	0,2392	0,1840	0,1390	0,1130	0,1480	0,1130	0,2210
BK 2	0,0896	0,1754	0,0650	0,0707	0,0341	0,0429	0,0426	0,0386
BK 3	0,0730	0,0207	0,0133	0,0060	0,0206	0,0166	0,0082	0,0100
BK 4	0,0977	0,0245	0,0041	0,0016	0,0066	0,0070	0,0065	0,0095
BK 5	0,0035	0,1317	0,0909	0,0419	0,0922	0,1220	0,1026	0,1473





Rheine

- 1998: representing the first installation of a pilot-scale CRB in Germany (22.5 m long, 6 m deep, 0.6-0.9 m thick, overlapping boreholes), circular steel caisson installation
- Primary contaminants: PCE and cis-DCE, plume: 400 m long, 200 m broad
- Barrier contains two types of ZVI:
  - Granular iron mixed with gravel at 1:2 (v/v) (69 tons, wall segment 10 m long)
  - “Iron sponge” (85 tons, 12.5 m long)

Rheine

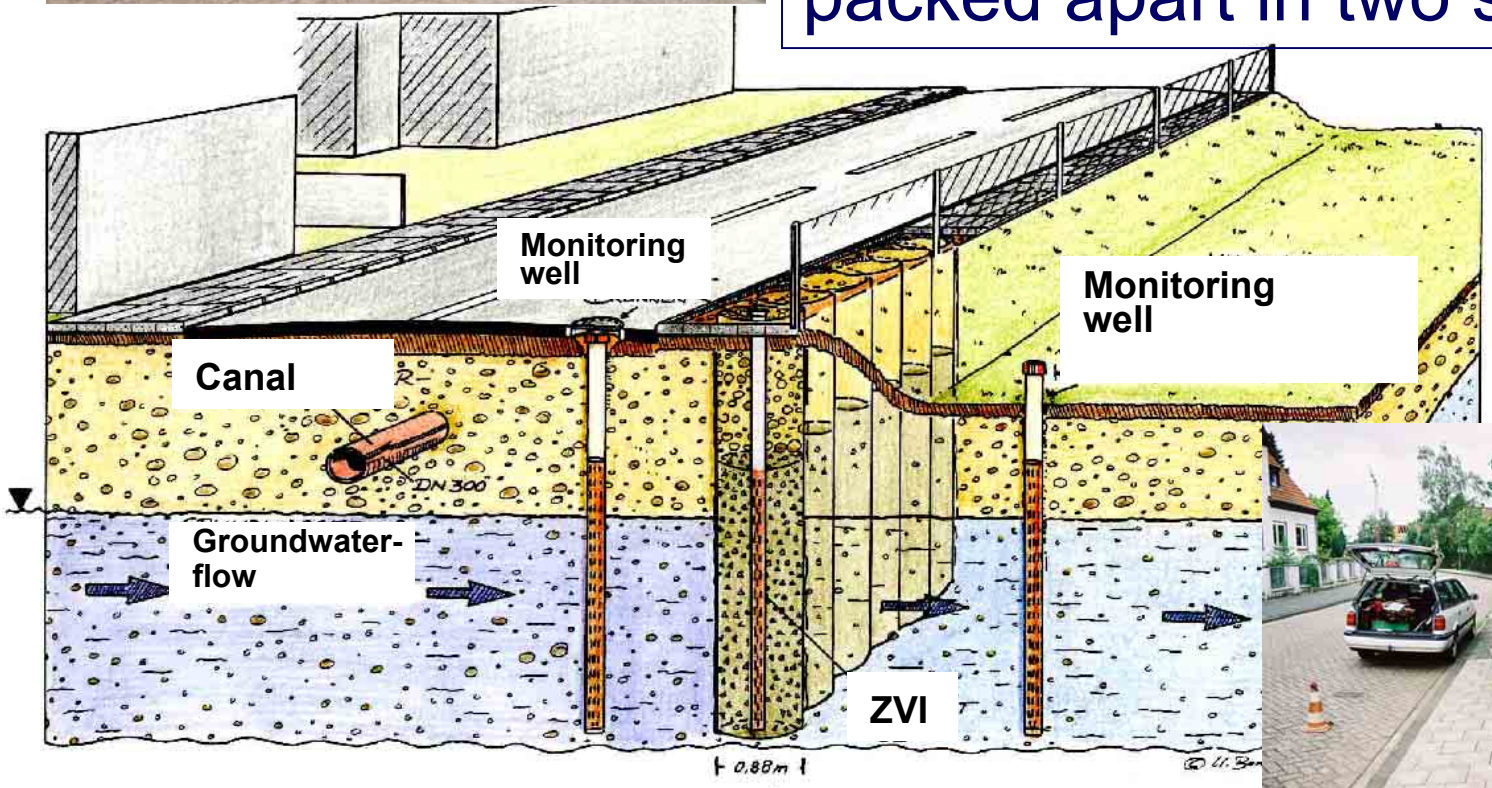
Three RUBIN-project(s):

("Mull und Partner GmbH", University of Kiel, Technical University of Berlin)

- Effects of precipitation and differences in the composition of the reactive materials
- Scrutinizing the surface properties of the ZVI types
- Characterization of microorganisms
- Gathering more geological and hydrogeo-logical data due to the heterogeneous and apparently instationary plume

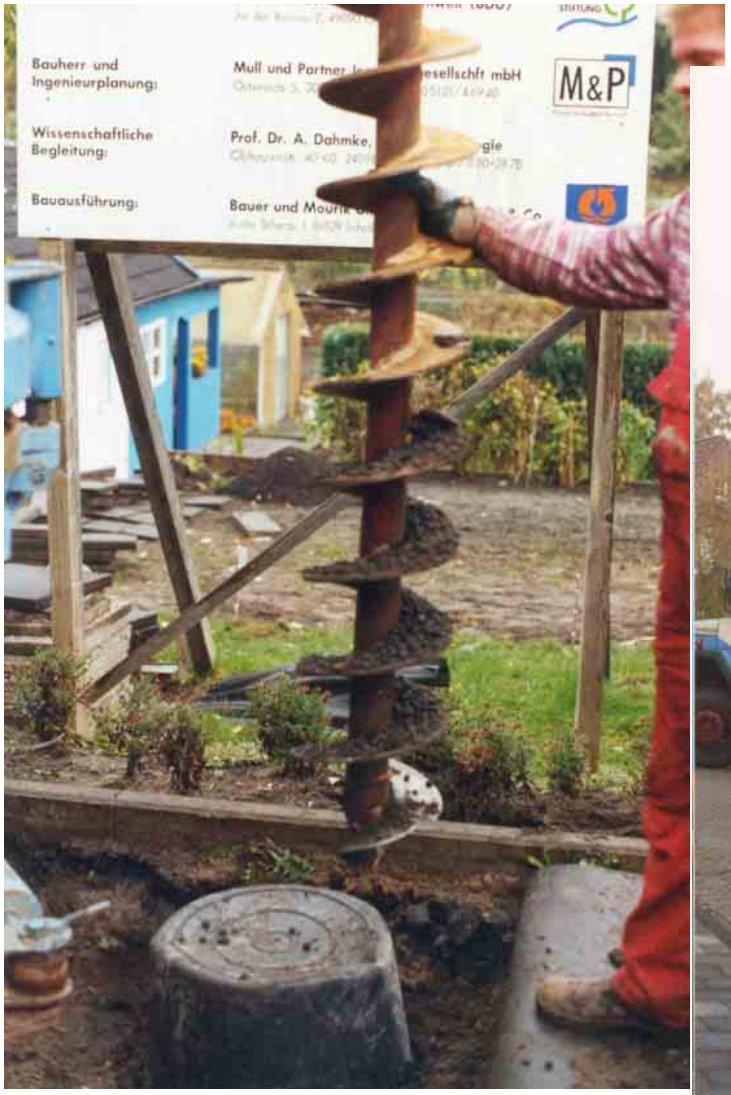
Rheine

Pilot CRB (1998): overlapping boreholes; two ZVI types (granular and “sponge”), packed apart in two segments



Reactive barrier

Rheine

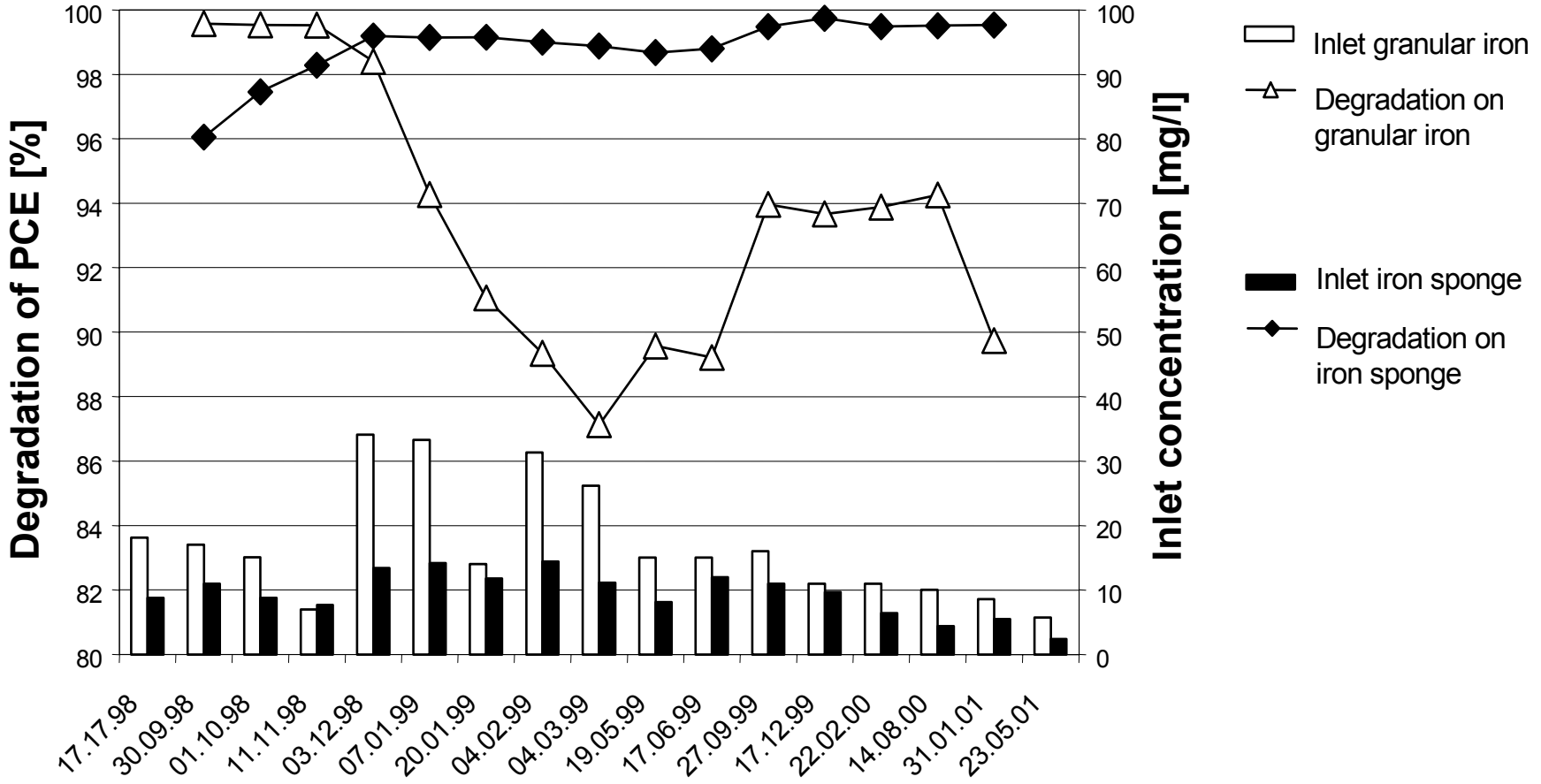


Coring
(Nov. 2001)

Rheine

Monitoring (July 2002)

Rheine – Performance

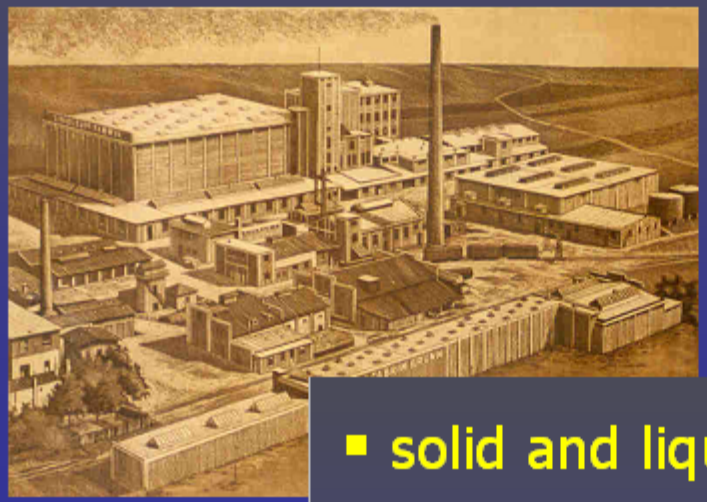


Brunn am Gebirge AUSTRIA

site: former industrial plant

- tar plant
  1878 - 1932
- linoleum
  production
  1933 – 1965

area 60.000 m²



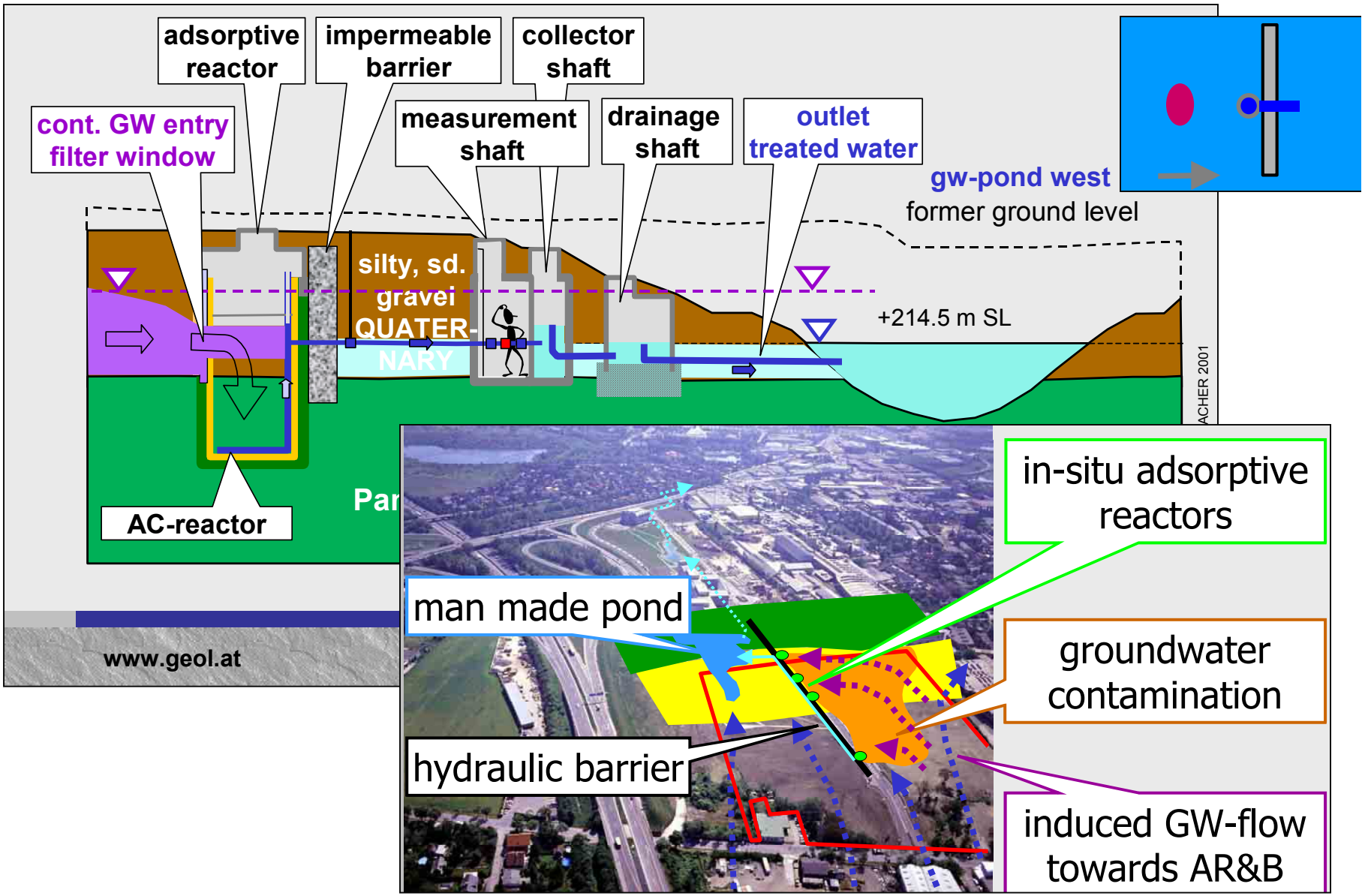
www.geol.at tech

Site fundamentals

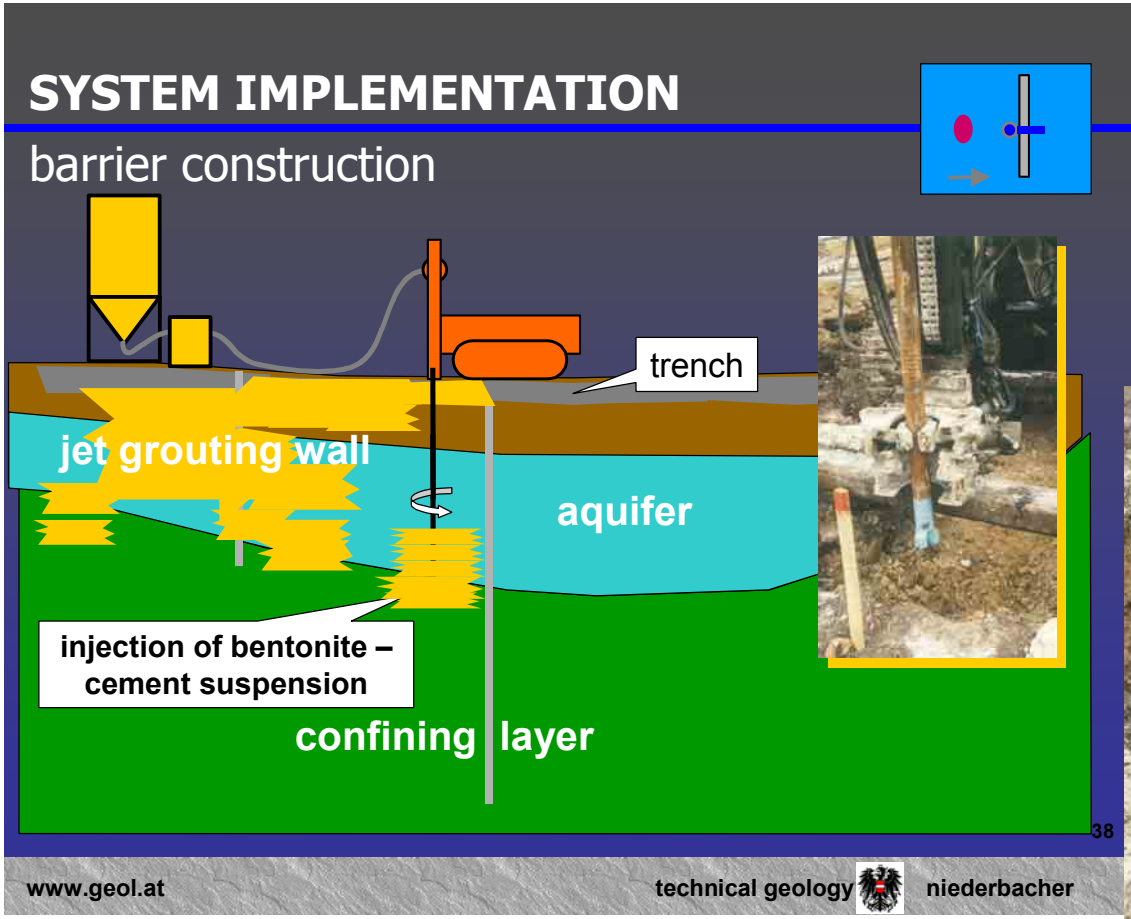
- solid and liquid residuals of tar and linoleum production
- result of more than 100 years of industrial land use

12

Brunn am Gebirge AUSTRIA



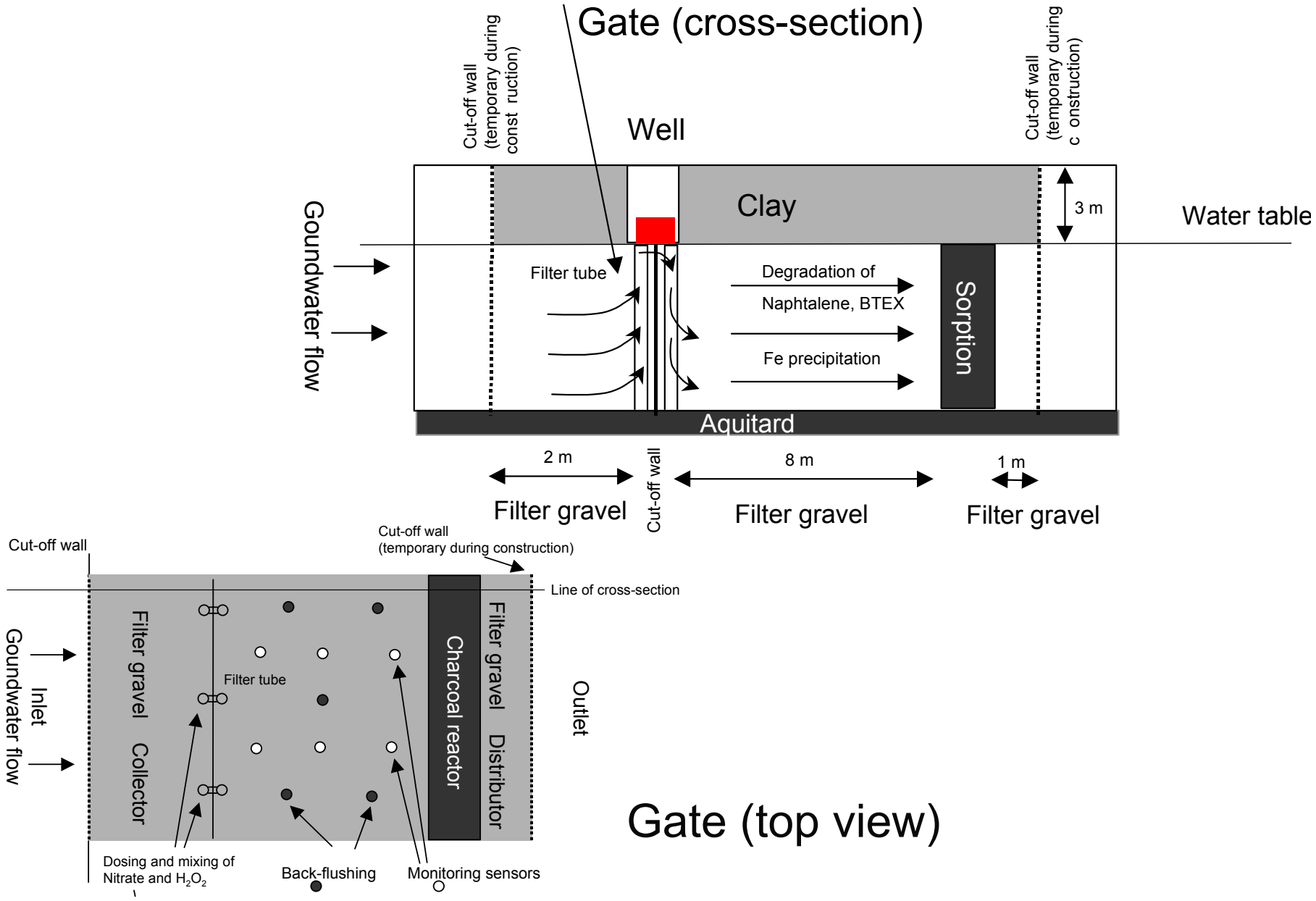
Brunn am Gebirge AUSTRIA



Offenbach (upcoming), RUBIN

- Specifically designed F&G (microbiology + GAC), BTEX/PAH plume (former tar processing plant)
- Funnel: 120 m long sealing wall, vertically arranged to the groundwater flow; sheet pile wall intercepts the aquifer flow in front of the reactor
- Gravel zone in front of the sheet piles, filter pipes for diverting the groundwater flow vertically towards the reactor and for adding required/suitable electron donors
  - Microbiological degradation in the 8 m long gravel zone inward the reactor (1.5 days residence time)
  - Activated carbon (additional adsorbent for some PAHs that cannot be readily degraded biologically)

Offenbach (upcoming)

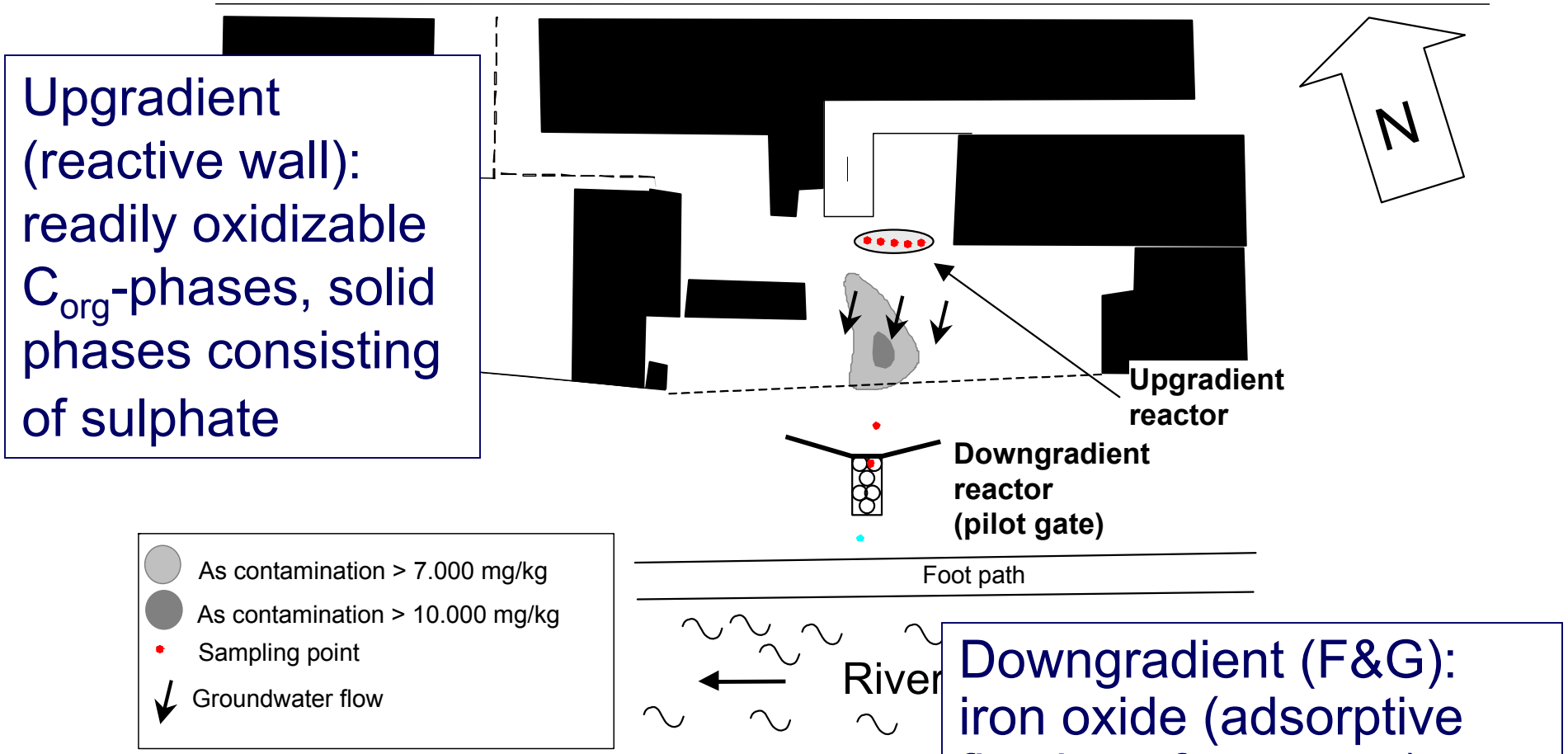


Wiesbaden (planned), RUBIN

- Applicant HIM GmbH, ASG, Wiesbaden
- Co-operation Partners
  - Peschla + Rochmes GmbH
  - University of Kiel
  - Technical University of Hamburg-Harburg
- Kind of Pollutants
  Different arsenic compounds

Wiesbaden

Plan of site



Upgradient (reactive wall): readily oxidizable C_{org}-phases, solid phases consisting of sulphate

Downgradient (F&G): iron oxide (adsorptive fixation of arsenate),non-redoxsensitive sorbents

R&D/Spanning RUBIN Projects

University of Kiel, Prof. Dr. A. Dahmke

in co-operation with Dr. R. Wienberg, Hamburg

Evaluation and Further Development of Pre-investigation, Monitoring and Quality Management Regarding Reactive Walls - A Comparative Laboratory and Site Study -

University of Tuebingen, Prof. Dr. G. Teutsch

Comparative Technical and Economical Assessment of In-Situ Permeable Reactive Barriers

University of Applied Sciences of North-East Lower Saxony, Suderburg, Prof. H. Burmeier

Co-ordination of the Large Scale R&D Program RUBIN and Making up a Comprehensive Documentation and Manual

Conclusions

- 2002:

Germany – 9 PRBs, 2 planned; Austria – 1 PRB

- PRBs with “directed GW flow“ prevail (7 in total, F&G, “drain-and-gate“ and modified F&G systems (partly applying pumping))

- Reactors/gates often installed/accessible nearby the surface – Germans and Austrians “love control“?!

- ZVI and GAC: preferred reactive materials

Conclusions (cont.)

- The need for new materials to meet complex pollutant mixtures is an important issue; novel media are therefore intensively investigated
- German PRBs: ≈ 14 Mio $ public funds
- Some German PRBs do not meet remediation goals (e.g., 10 μg/L cVOCs)
- Some German PRBs are facing hydraulic problems (after 2-3 years of operation)

Special thanks to:

- Peter Hein („INGAAS GmbH“, Berlin, for Bernau)
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- Kerstin Schmidt, Markus Schleyer („ARCADIS GmbH“, Karlsruhe, and „Stadtwerke Karlsruhe“, resp., for Karlsruhe)
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- Hermann Schad, Christoph Schüth („I.M.E.S. GmbH“, and University of Tübingen, resp., for Denkendorf)
- Peter Niederbacher (for Brunn am Gebirge)

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