

Enhancing the Efficacy of Permeable Reactive Barriers

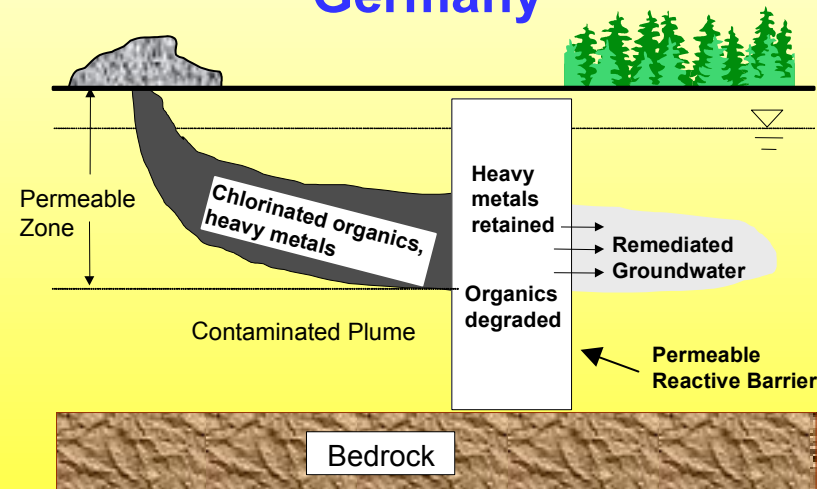
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PEREBAR EU-project

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Permeable Reactive Barriers (PRB)

Treatment types (in-situ)

**physical,
chemical
biological**

Reactive materials in underground trenches

No groundwater removal or soil excavation

Structure types

**continuous reactive barriers
funnel-and-gate**

Feasibility - life span of the reactive materials

**remediation processes (oxidation)
reaction products (precipitates)
exhaustion of sorption capacity**

10 to 20 years - no experience over such periods

PEREBAR EU-project

Long-term Performance of Permeable Reactive Barriers

Participants: Austria, Germany, Greece, Hungary and UK

Overall goal: evaluate and enhance the long-term performance

Emphasis: sorption, precipitation of heavy metals

Processes impairing barrier performance

Test sites

Pécs, Southern Hungary: uranium

Brunn am Gebirge, Austria

Materials considered/tested

zeolite

hydroxyapatite (HAP)

activated carbon

hydrated lime

elemental iron

Uranium attenuation mechanisms:

HAP: precipitation

Iron: reductive precipitation & adsorption

Sulphates: no detrimental effect

Carbonates: detrimental effect (iron only)

Development of a selective contaminant-binding chemical compound

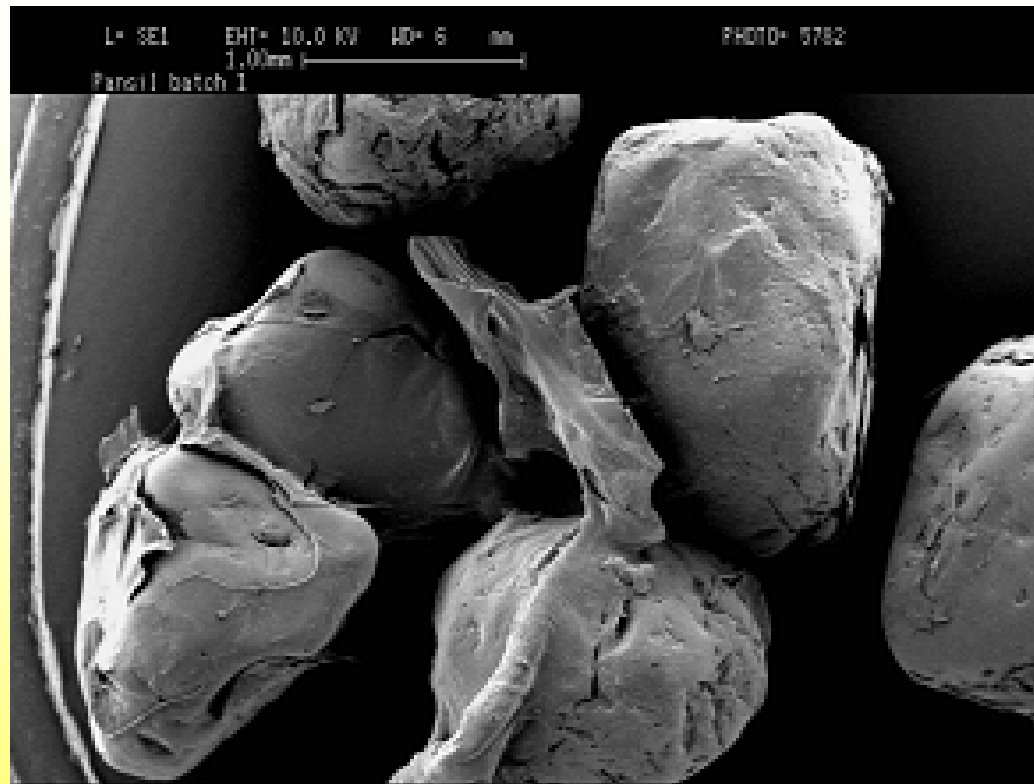
PANSIL: silica coated with modified polyacrilamidoxime

Support matrix: sand

High efficiency: pH 4 – 8

Uranium-specific

No precipitation of by-products



Electron micrograph of PANSIL

Electrokinetic technique to enhance the long-term performance of PRB

Electrokinetic fence

Upstream installation

Preventing charged species from being transported by the groundwater

Precipitation around the electrodes

Removal of groundwater constituents helps increase life span of PRB

Accelerated testing to model ageing processes

Column experiments

Uranium-contaminated water flowing through a laboratory column filled with iron or HAP

Tracking the movement of uranium

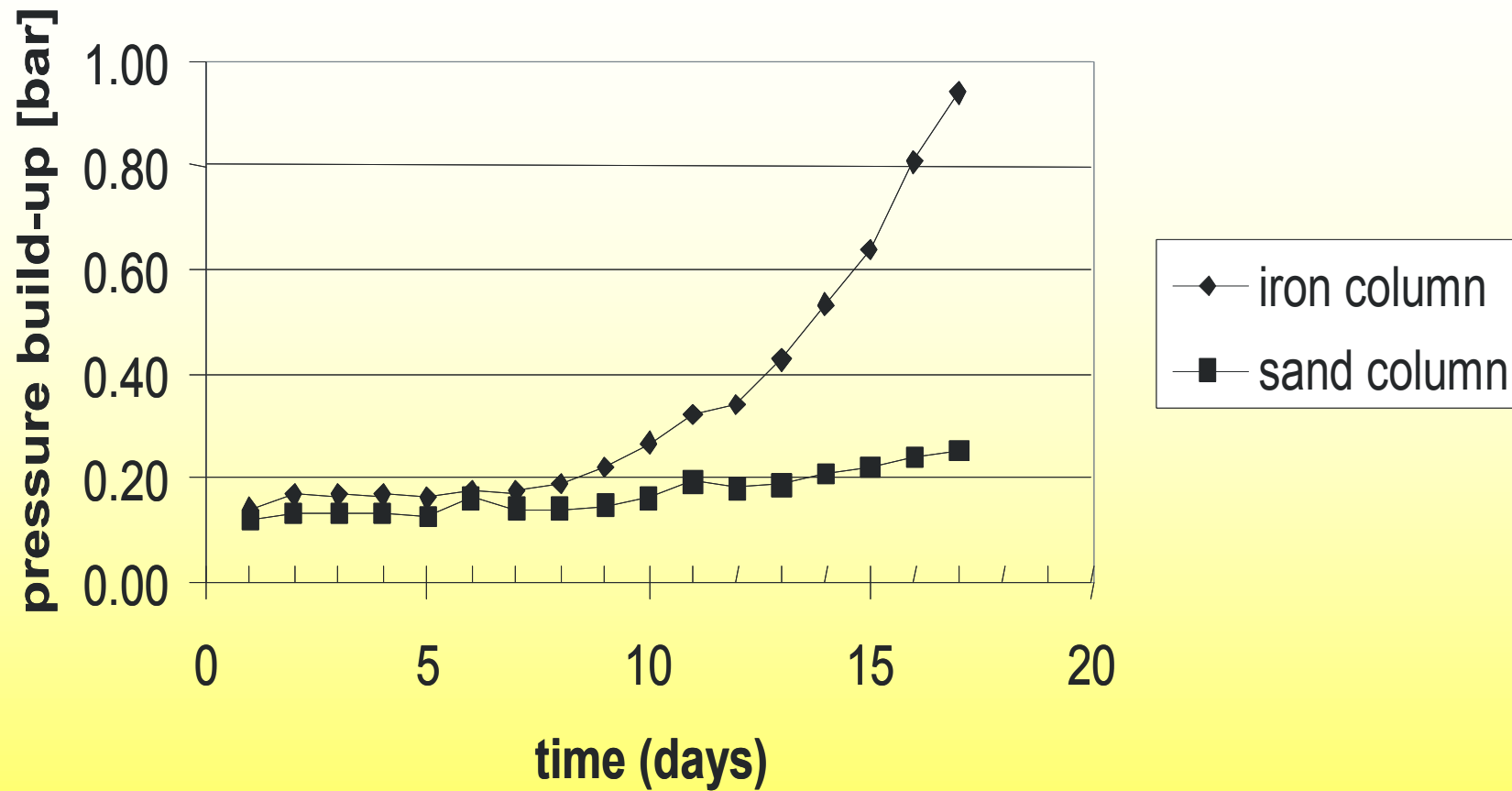
^{237}U radioindicator (half-life 6.75 days)

Understanding the uranium uptake capacity

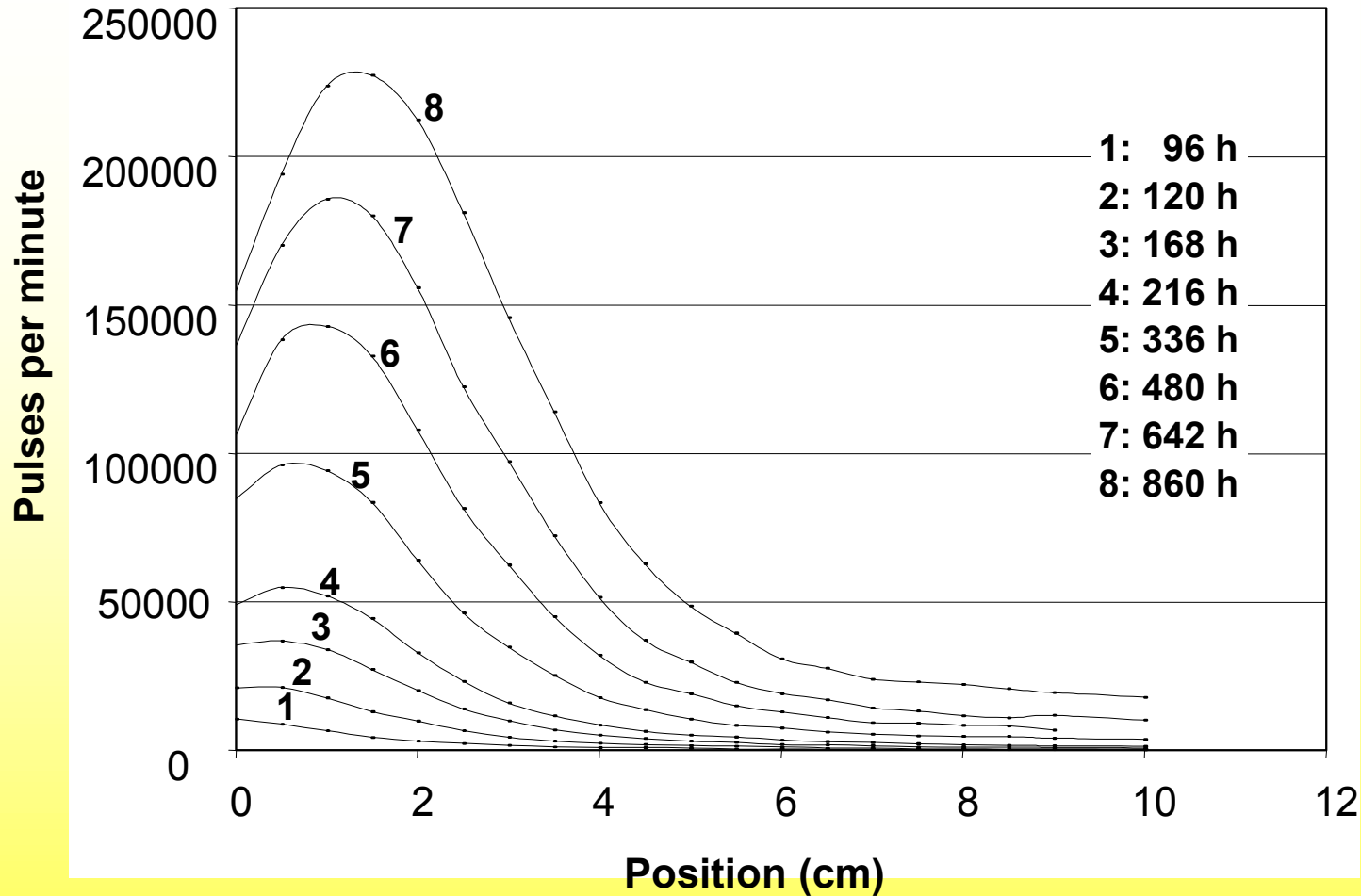
Flow velocity: 2.5 times natural GW flow velocity



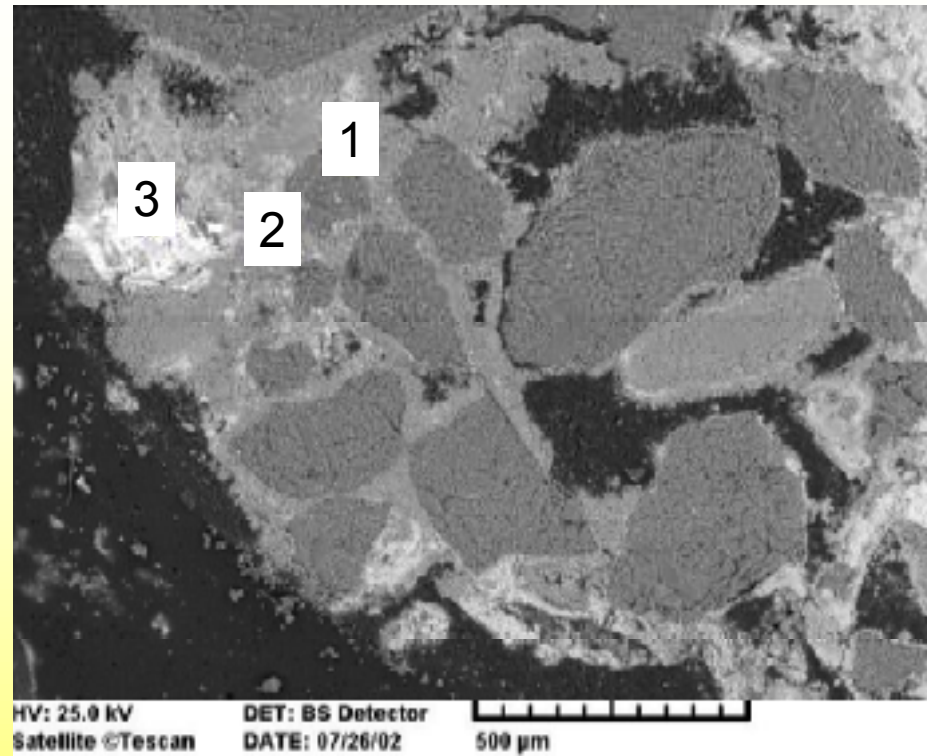
Accelerated test of ageing: pore clogging, BAM, Berlin



Accelerated test of ageing, pore clogging, BAM, Berlin



Activities measured in the column after various time intervals



**Electron microscopy image of sand/iron mixture.
1: sand particle, 2: precipitated CaCO_3 , 3: iron particle.
Surface covered with $\text{Fe}(\text{OH})_2$ and FeCO_3 precipitation.
(Debreczeni & Gombkötő)**

Experimental pilot-scale permeable reactive barrier

Pécs, Southern Hungary:

former uranium mining site

6.8 m x 2.5 m x 3.8 m

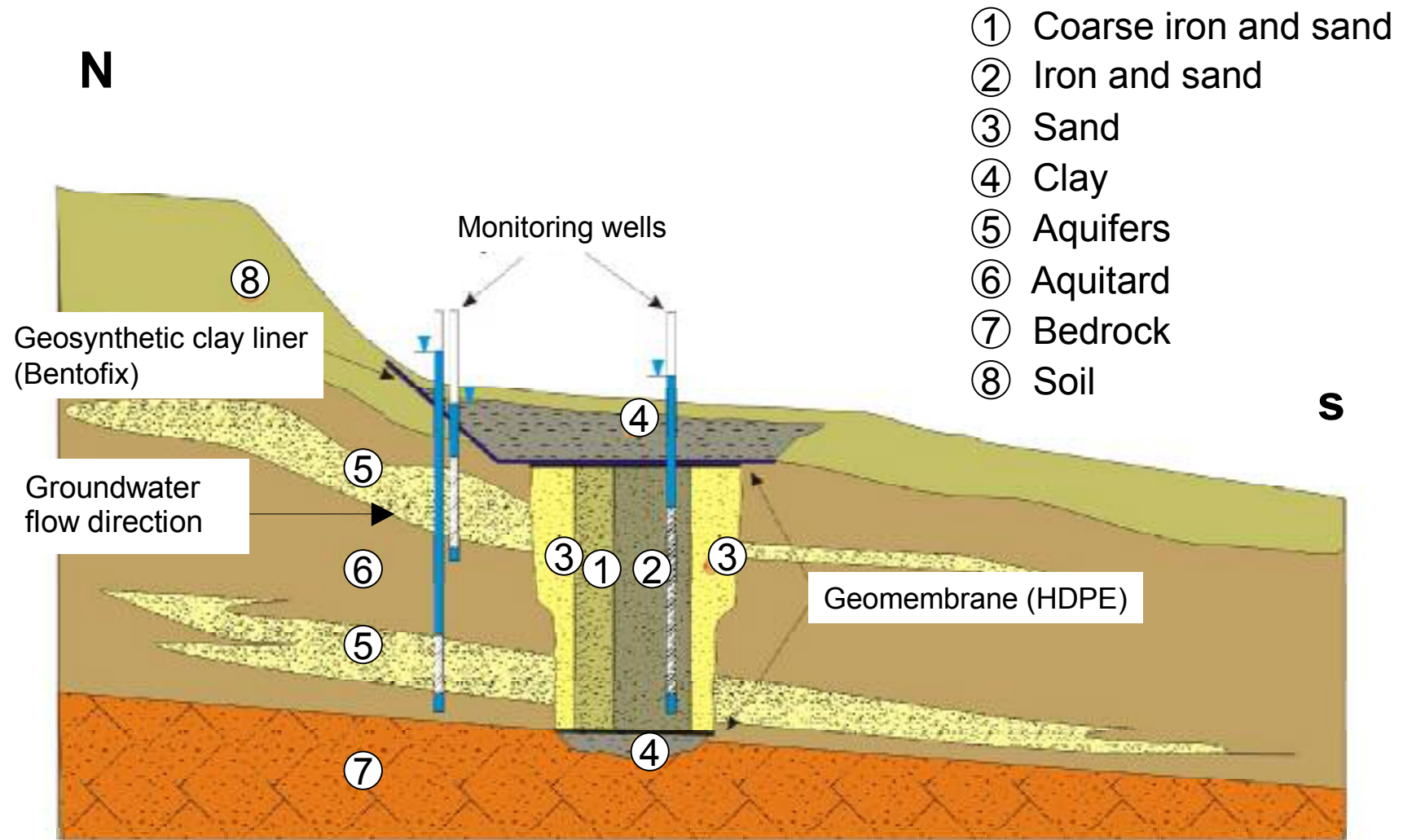
38 tonnes of iron

24 monitoring wells

Uranium concentration

Early 2002: 1,000 $\mu\text{g/l}$

Late 2002: less than 100 $\mu\text{g/l}$

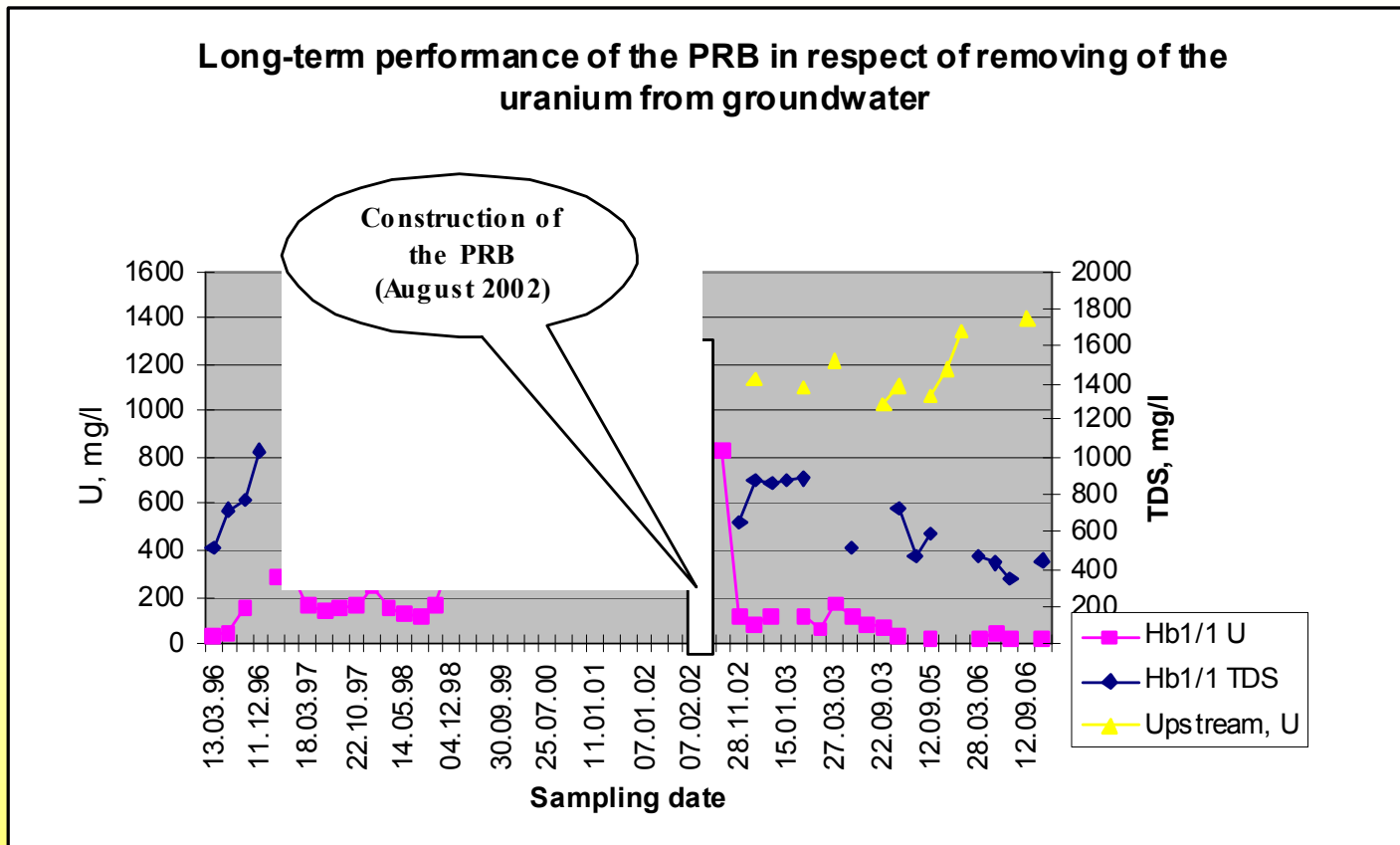


Experimental permeable reactive barrier near Pécs, Hungary (Csöväri et al.)



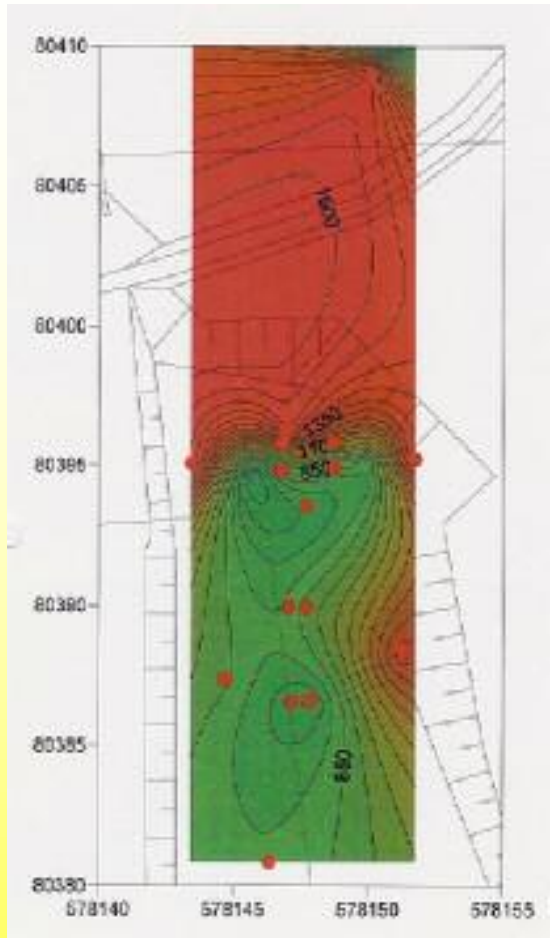
View of the experimental permeable reactive barrier with monitoring wells (Csővári et al.)

Long-term performance of the PRB in respect of removing of the uranium from groundwater



Uranium concentration and total dissolved solids (TDS) U/S and in a D/S monitoring well near the PRB

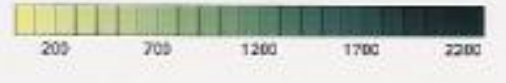




Specific electric conductivity, $\mu\text{S}/\text{cm}$



U
($\mu\text{g}/\text{l}$)



Monitoring wells

Uranium concentration and electric conductivity in groundwater



Life span calculation (example)

Criterion: loss of porosity due to precipitation

Fe: electron donor > formation of OH^- > increase in pH

Decrease in solubility of carbonates

700 mg of carbonates precipitation for every litre that passes through PRB

Flow rate $750 \text{ m}^3/\text{y}$ > 525 kg/y precipitate ($2.75 \text{ g}/\text{cm}^3$) > $0.192 \text{ m}^3/\text{y}$ precipitate

PRB volume: $6.8 \text{ m} \times 1.5 \text{ m} \times 3.8 \text{ m} = 38.8 \text{ m}^3$

Pore volume: $38.8 \times 0.3 = 11.6 \text{ m}^3$

$11.6 \text{ m}^3 / 0.192 \text{ m}^3/\text{y} = 60 \text{ years}$

Book:

**Roehl, Meggyes, Simon, Stewart (eds): Long-term
Performance of Permeable Reactive Barriers**

published by Elsevier in the series

**J.O. Nriagu (series ed): Trace Elements and Other
Contaminants in the Environment**

<http://www.elsevier.com/locate/isbn/0444515364>

PEREBAR project website:

<http://www.perebar.bam.de/>

