Remediation on the former uranium mining and milling site (Hungary): Case Study

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The presented work is a common work of the experts from

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and

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and other companies, institutions

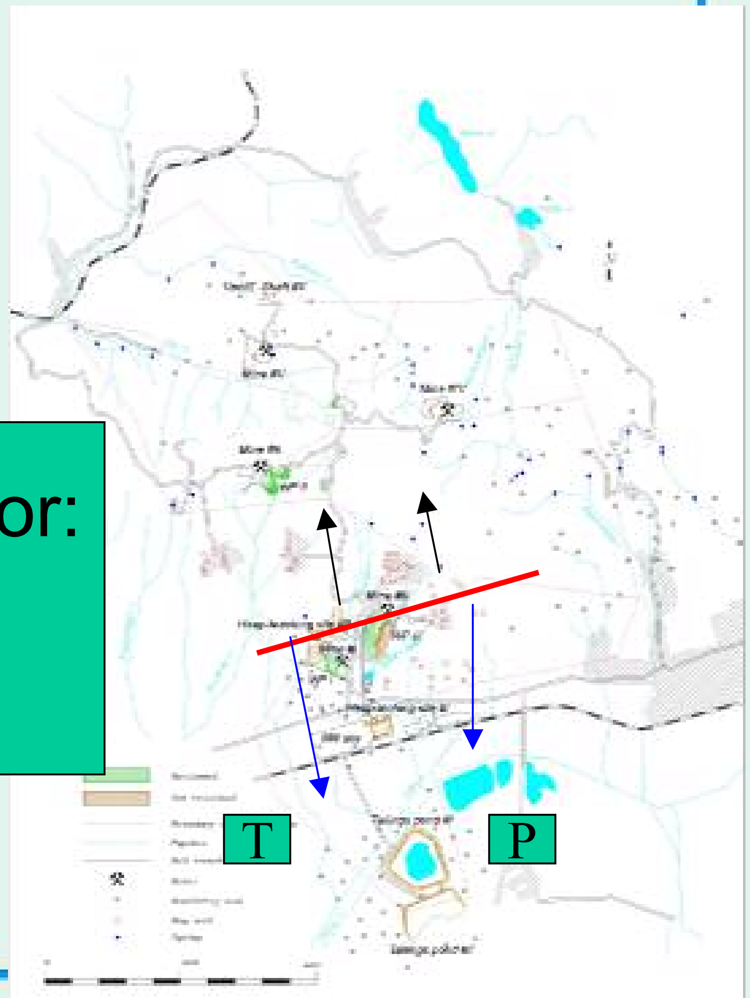
„DIFPOLMINE" CONFERENCE Budapest

4-8 July 2005

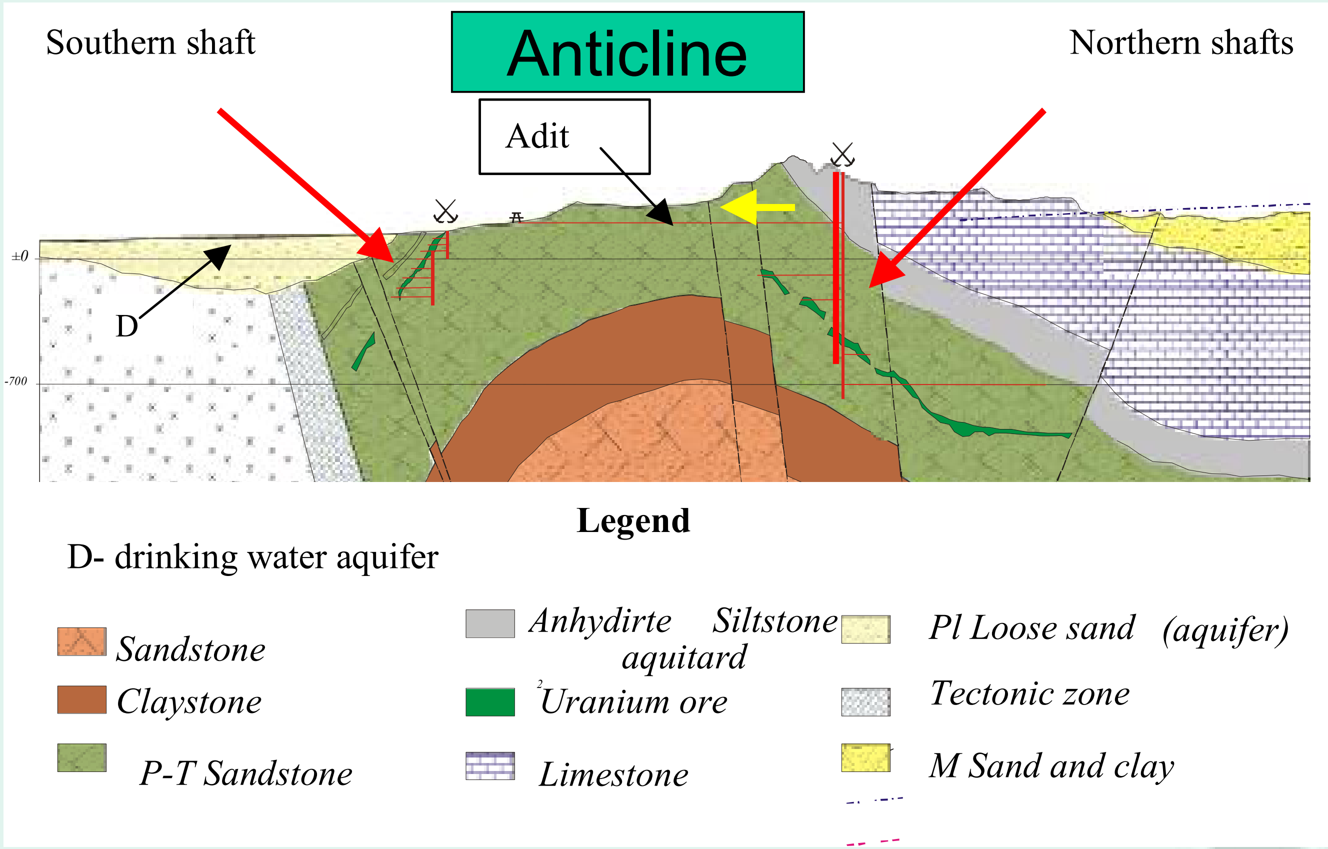
Location of the site

The site has a close connection with **drinking water** catchement areas (T and P).

Water treatment is neccessary for:
Mine water
Contaminated groundwater



Geological cross-section of the former mining site (Western Mecsek)



Water treatment processes

1) Mine water treatment

Anion-exchange process is used for U

(TDS~1.6 g/l; U~5 mg/l; As<12 mg/l, Ra~0.3 Bq/l)

2) Groundwater treatment

Pump and treat process

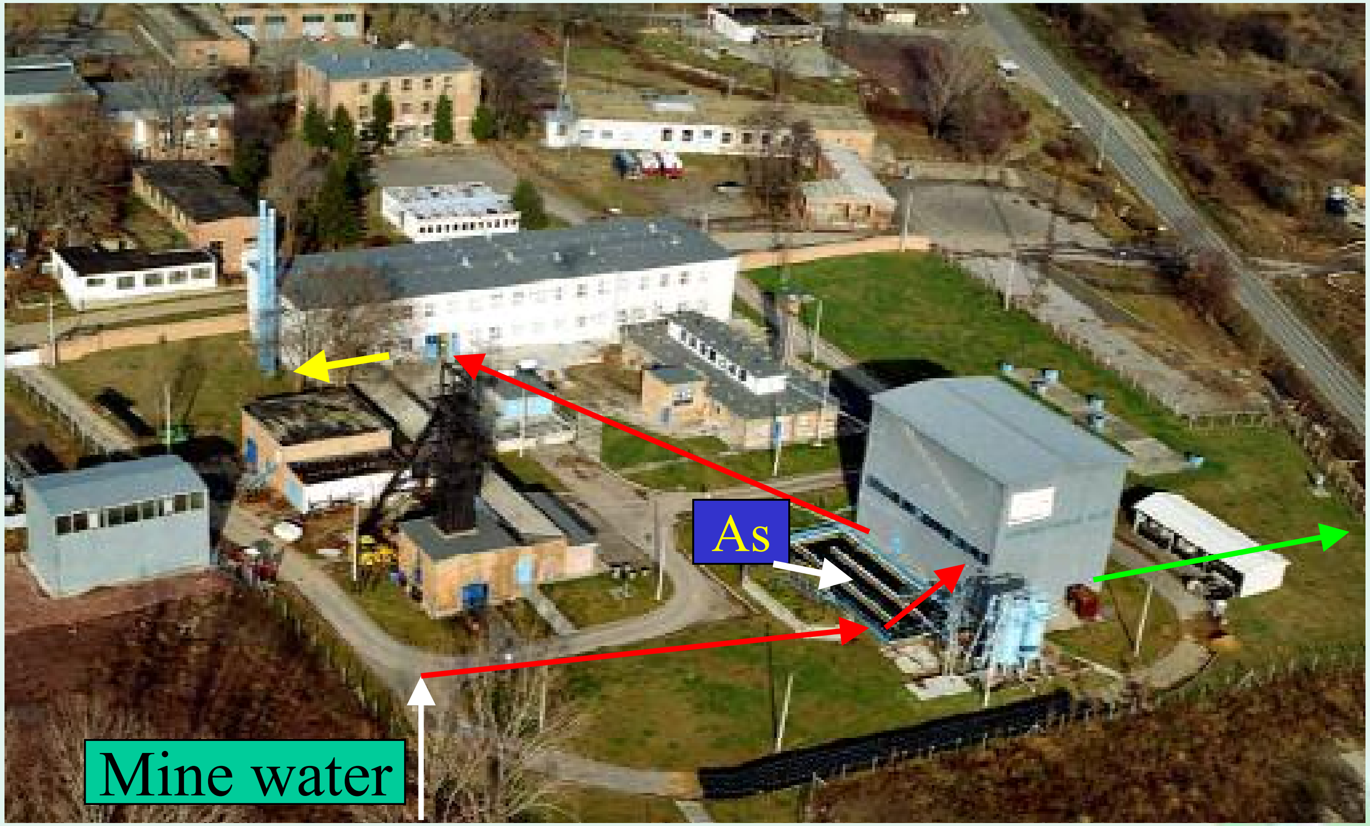
(TDS~3-15 g/l; U<0.1 mg/l; Ra~0.08 Bq/l)

Heavy metals:As<12 mg/l;

Pilot-scale PRB (ZVI + sand mixture)

(in situ groundwater treatment, experiment)

I Mine water treatment station

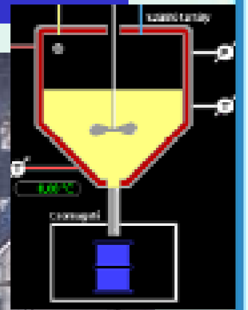


Station is situated on the area of former Shaft NI

Yellow cake production

Precipitation of uranium peroxide

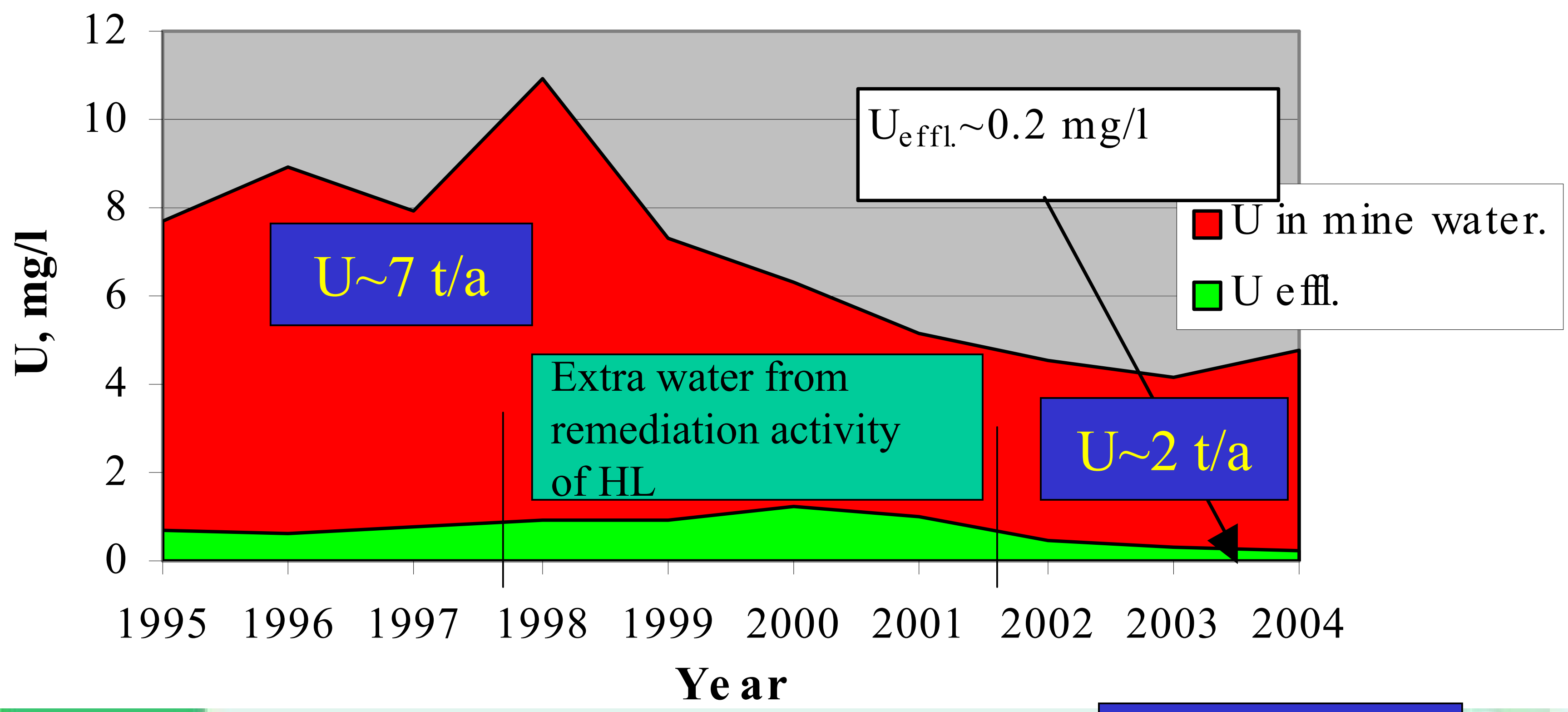
Packing unit



B

U-concentrate **accretion** on the mixer in dryer causes some problems

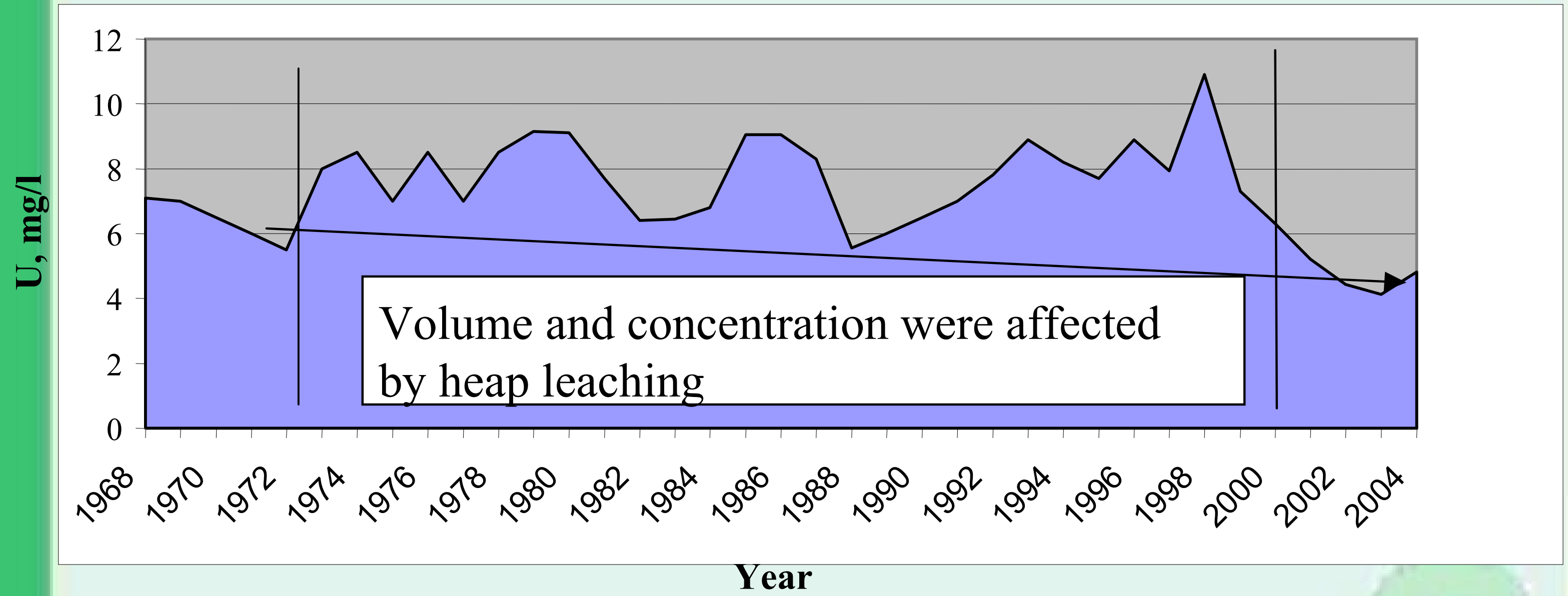
Mine water treatment
Sorption efficiency for uranium



V~1.2 Mm³/a

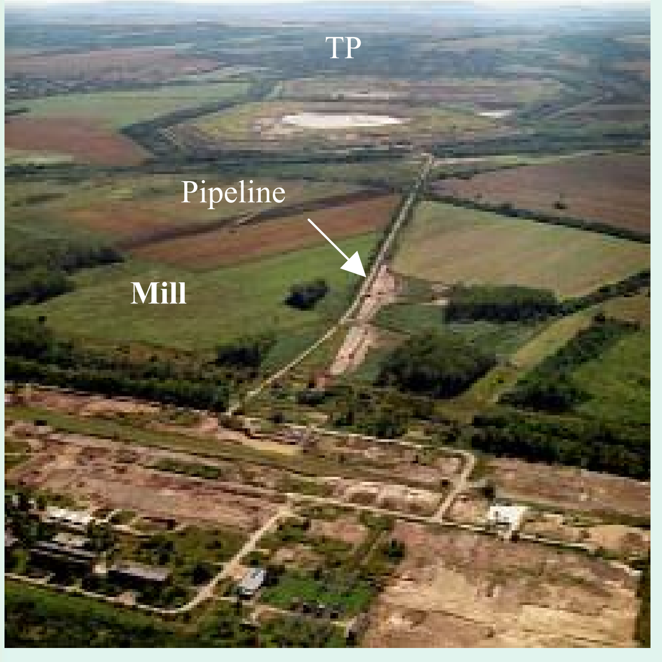
V~0.44 Mm³/a

The change of uranium concentration in mine water over long period (1968-2005)



6-7 mg/l → 35 years → **4.5-5 mg/l**

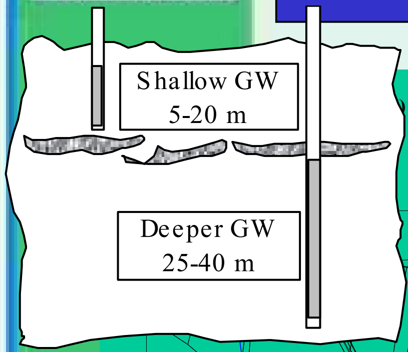
II Groundwater treatment
Tailings Ponds

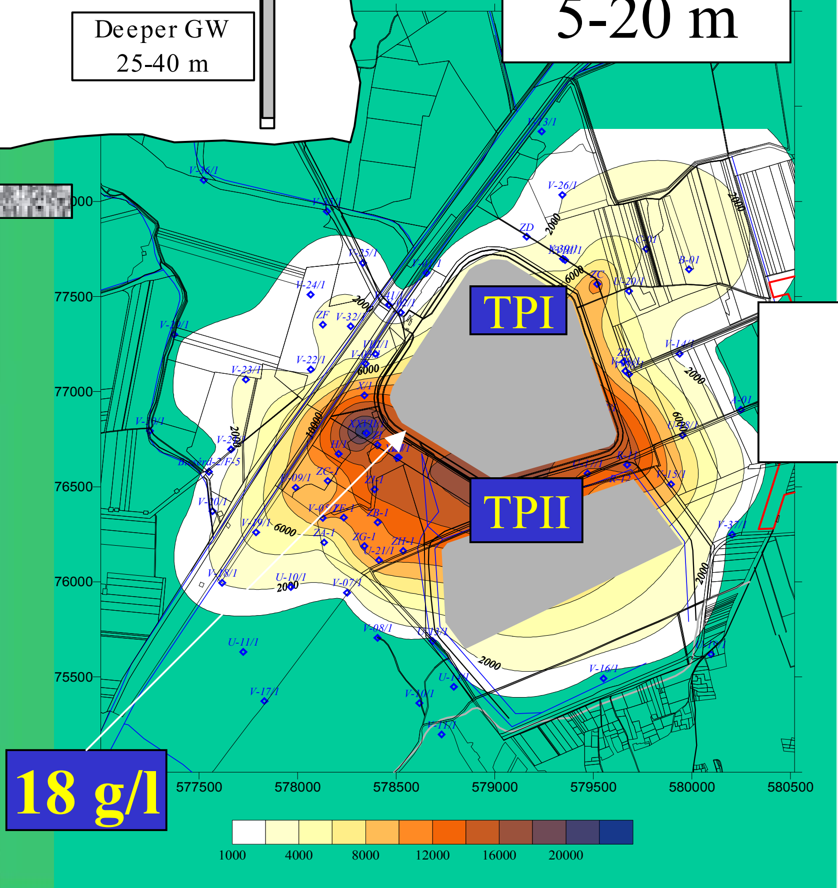


Total volume of the tailings:
20.4 kt solid + 32 Mm^3 of liquid

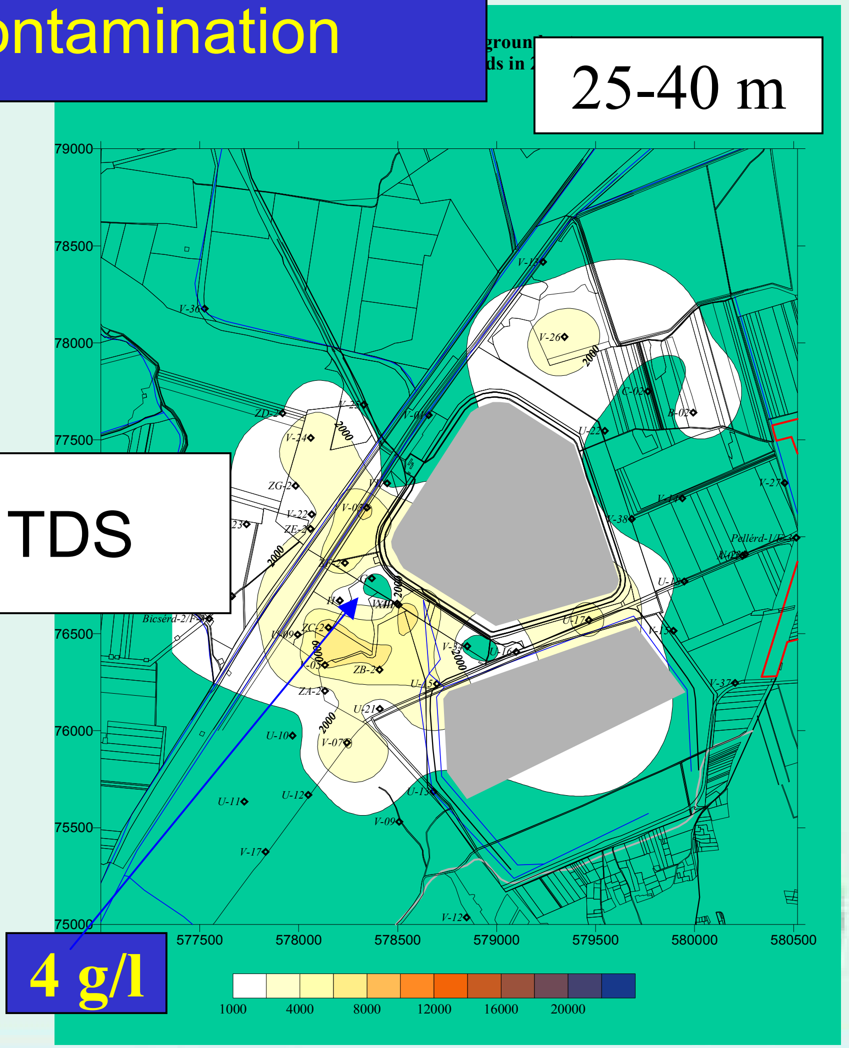
Groundwater restoration

GW contamination

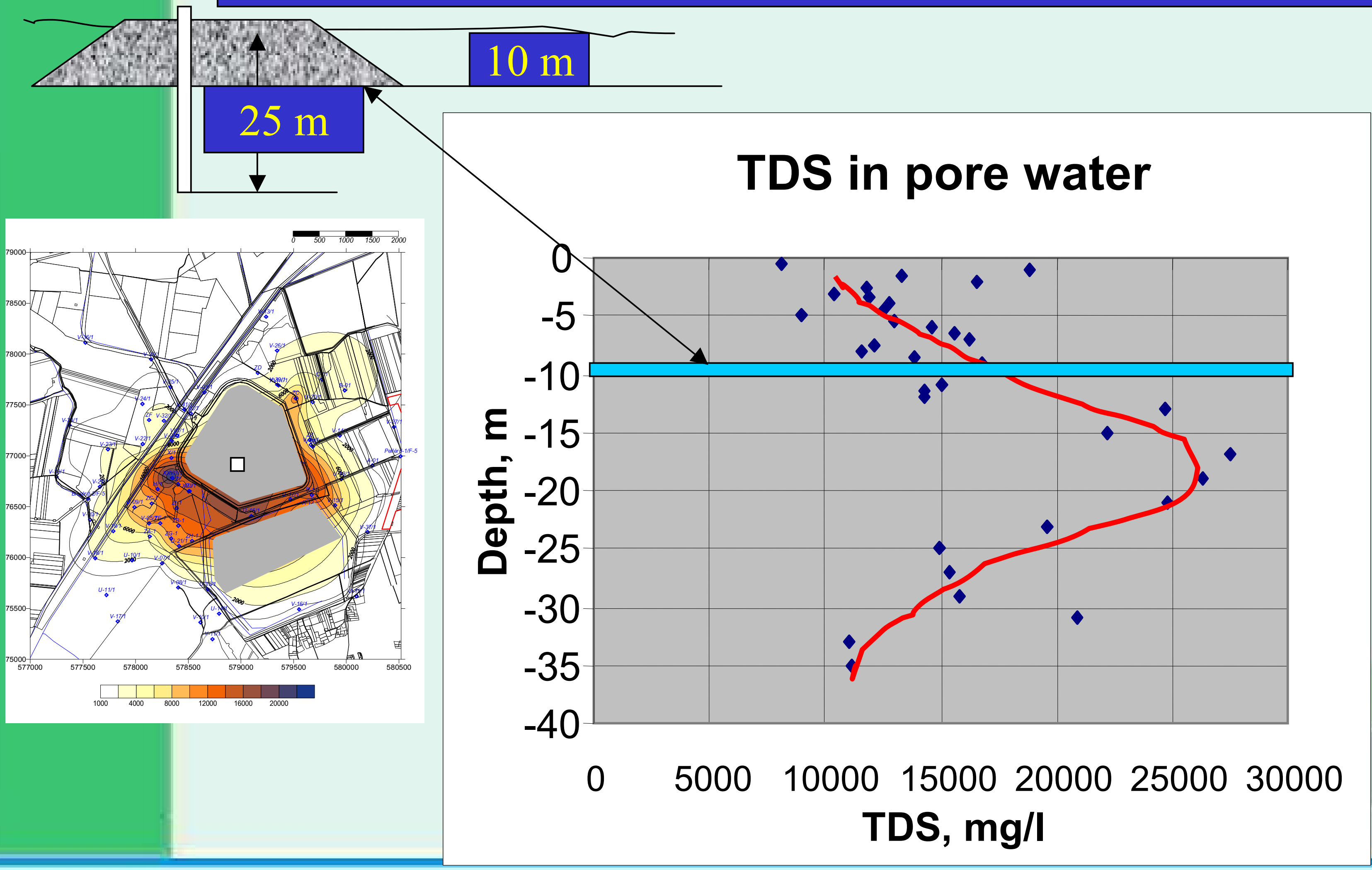




TDS



Groundwater contamination under the TP



Groundwater treatment process

Shallow GW: TDS~10-12 g/l

For treatment

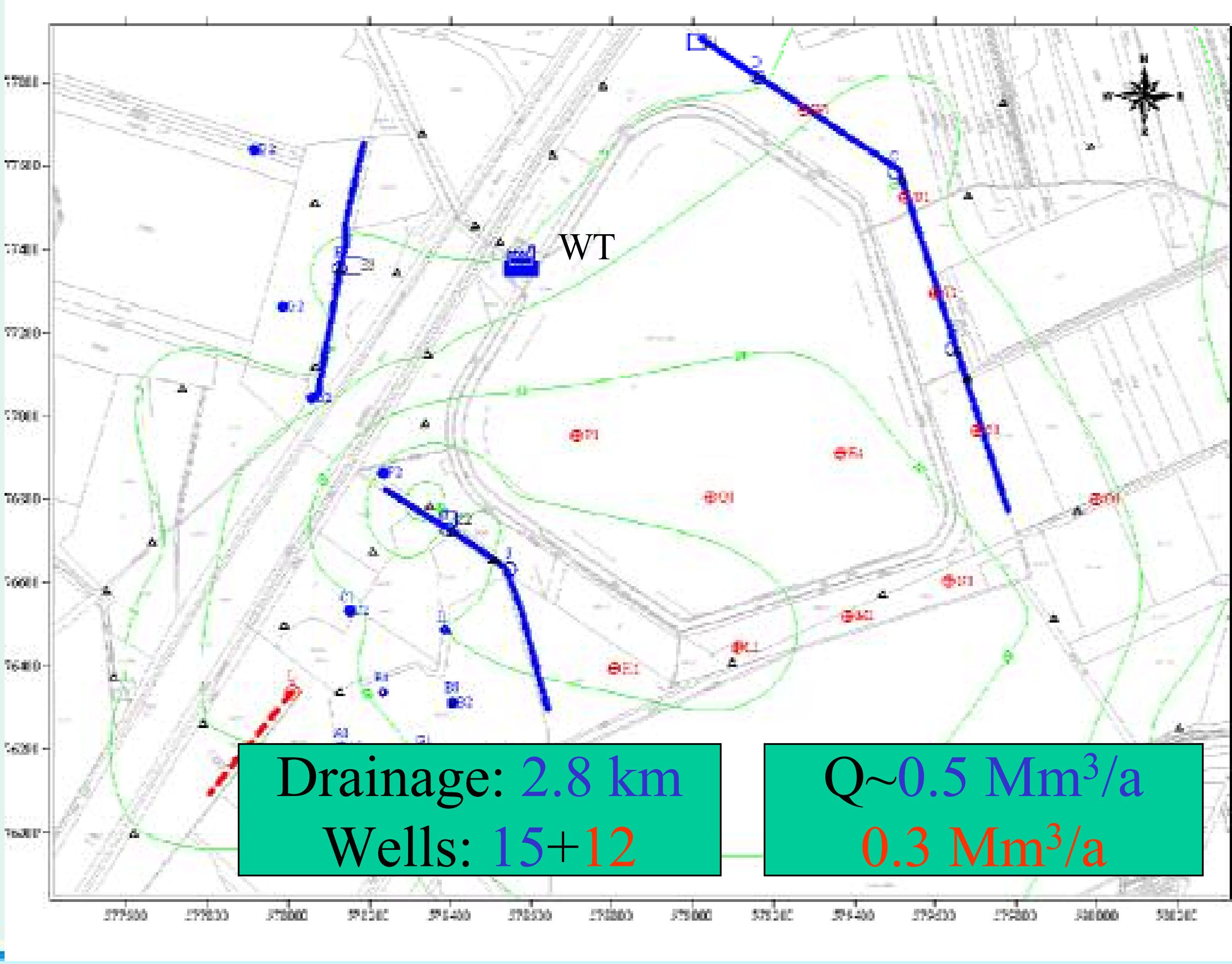
Deeper GW : TDS~3-5 g/l

Direct discharge

Treatment process consist of:

- Precipitation of magnesium and gypsum with calcium hydroxide
- Sedimentation and thickening
- Filtration

Groundwater extraction system



Drainage: 2.8 km
Wells: 15+12

Q~0.5 Mm^3/a
0.3 Mm^3/a

Sludge from treatment

Sludge
7kt/a (with 50% water content)

Treated water:~0.36 Mm^3/a

TDS~6-7 g/l (retention time!!)
(NaCl~3 g/l)

Mg~17%
Ca~17%
SO4~26%
U~60-70 g/t
Ra~24 Bq/kg

Gypsum accretion on the surface of technological equipment

Critical parts and units must be monthly cleaned from gypsum accretion

Water discharge summary

Treated groundwater

V:0.36 Mm^3

Treated mine water

V:0.44 Mm^3

Mixing basin
TDS:3.2 g/l
U:0.2 mg/l
Ra:0.18 Bq/l

Non-treated water (e.g.deeper GW)

V:1.27 Mm^3

Receiver

Data for 2004

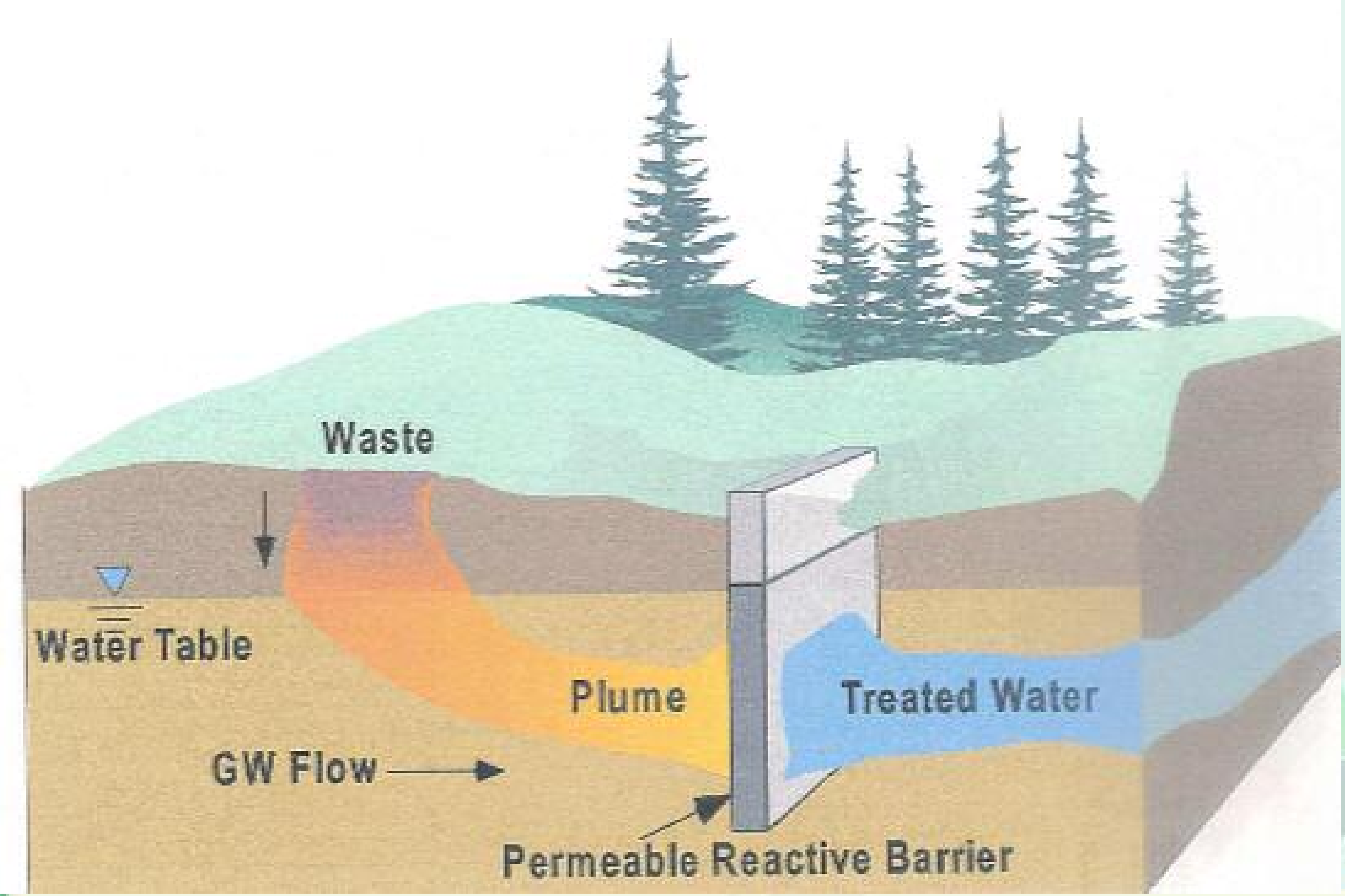
III Pilot-scale PRB (for in situ treatment of GW)

Field test aiming at investigating of long-term performance of PRB (EU project: EVKI-1999-00035) for removing of U from GW

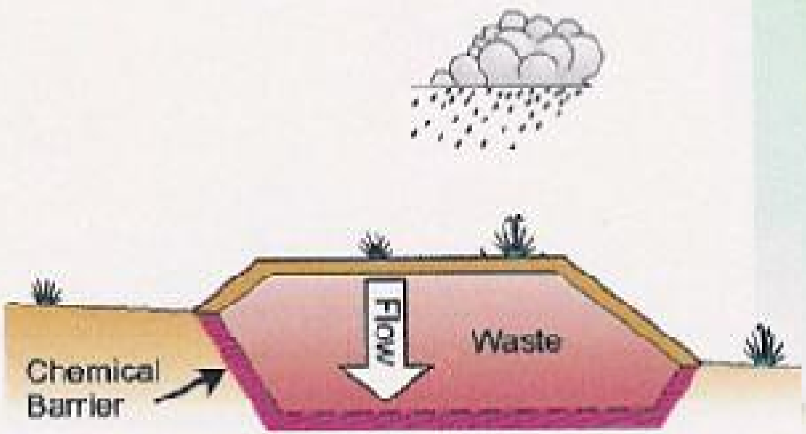
Practical solutions are known in first of all inUSA , but the long-term performance is still under investigation

For field test ZVI+sand mixture was selected, though different reactive materials were tested in laboratory and in columns on the field

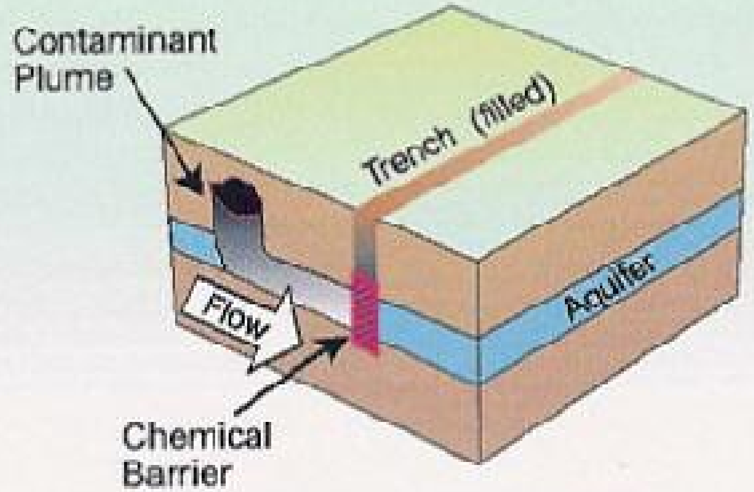
Permeable reactive barriers



Permeable reactive barriers

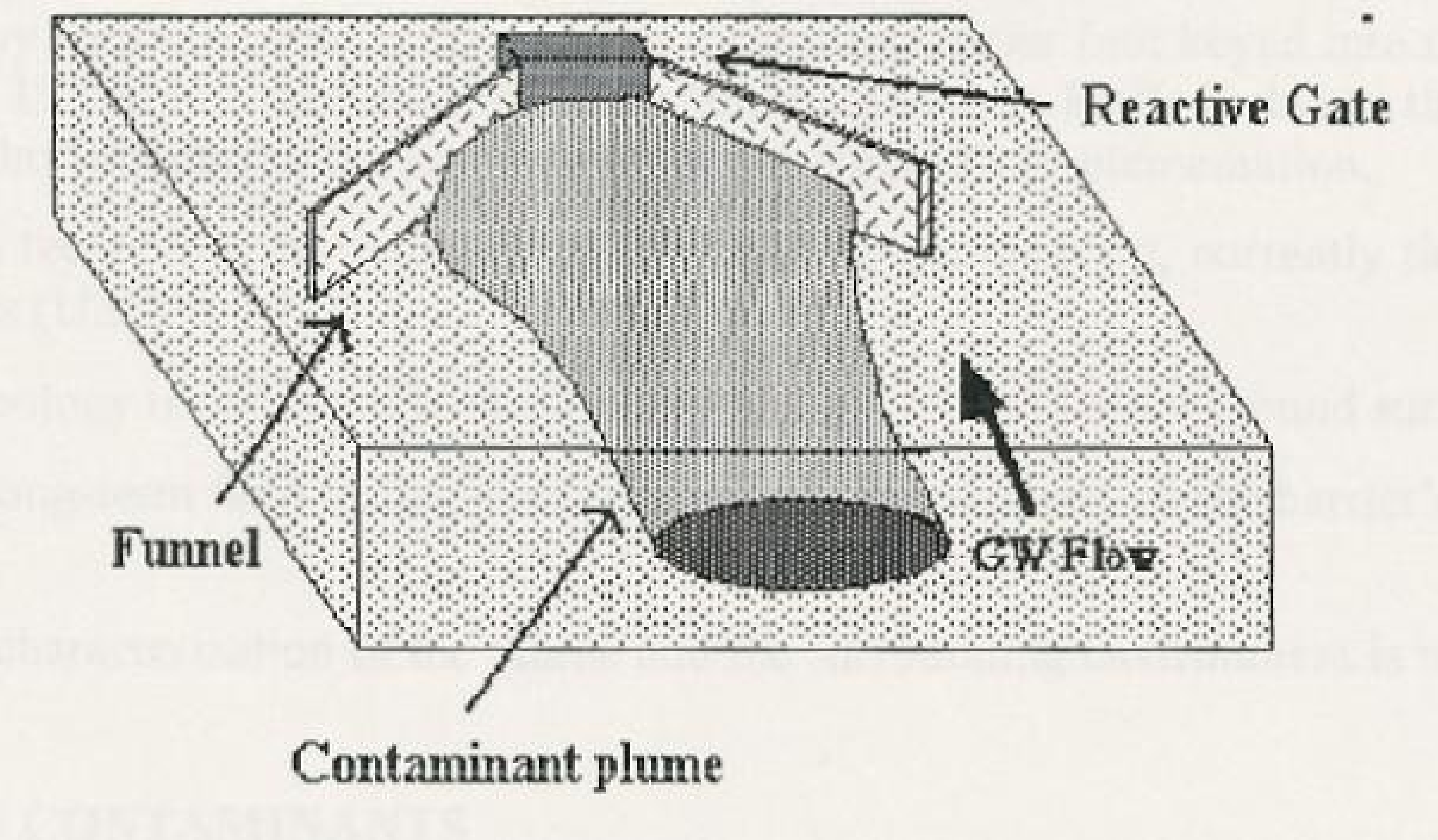


Landfill Liner

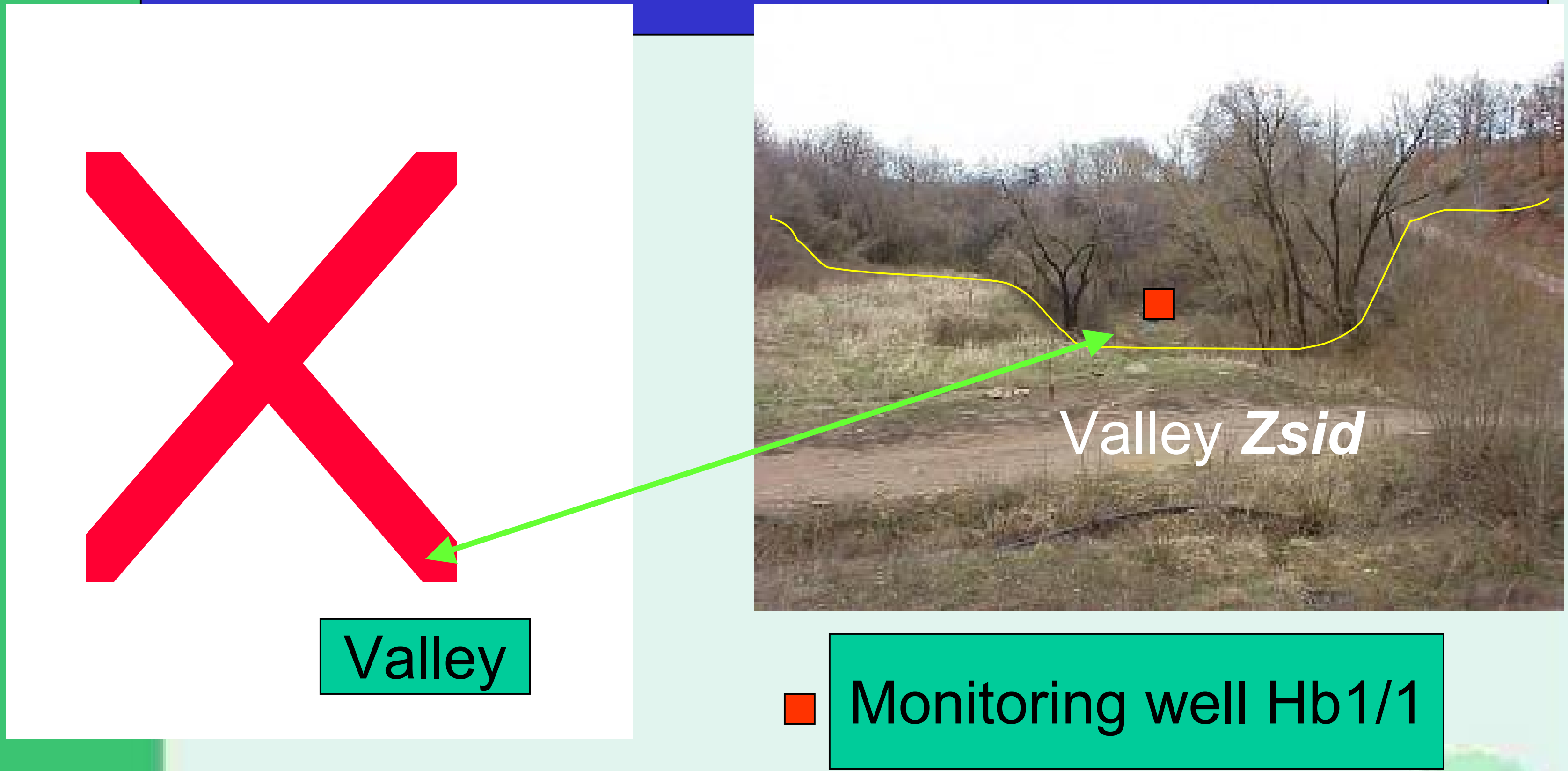


Trench and Fill

Funel anf gate system

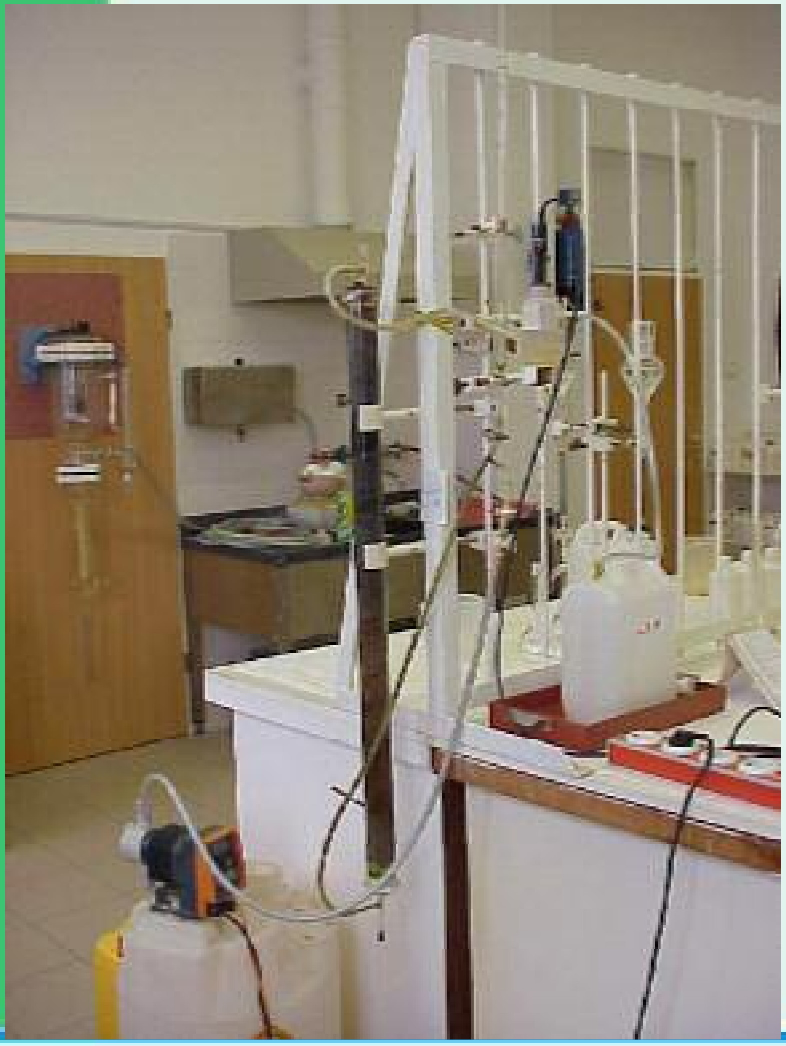


Uranium contaminated groundwater In valley *Zsid*



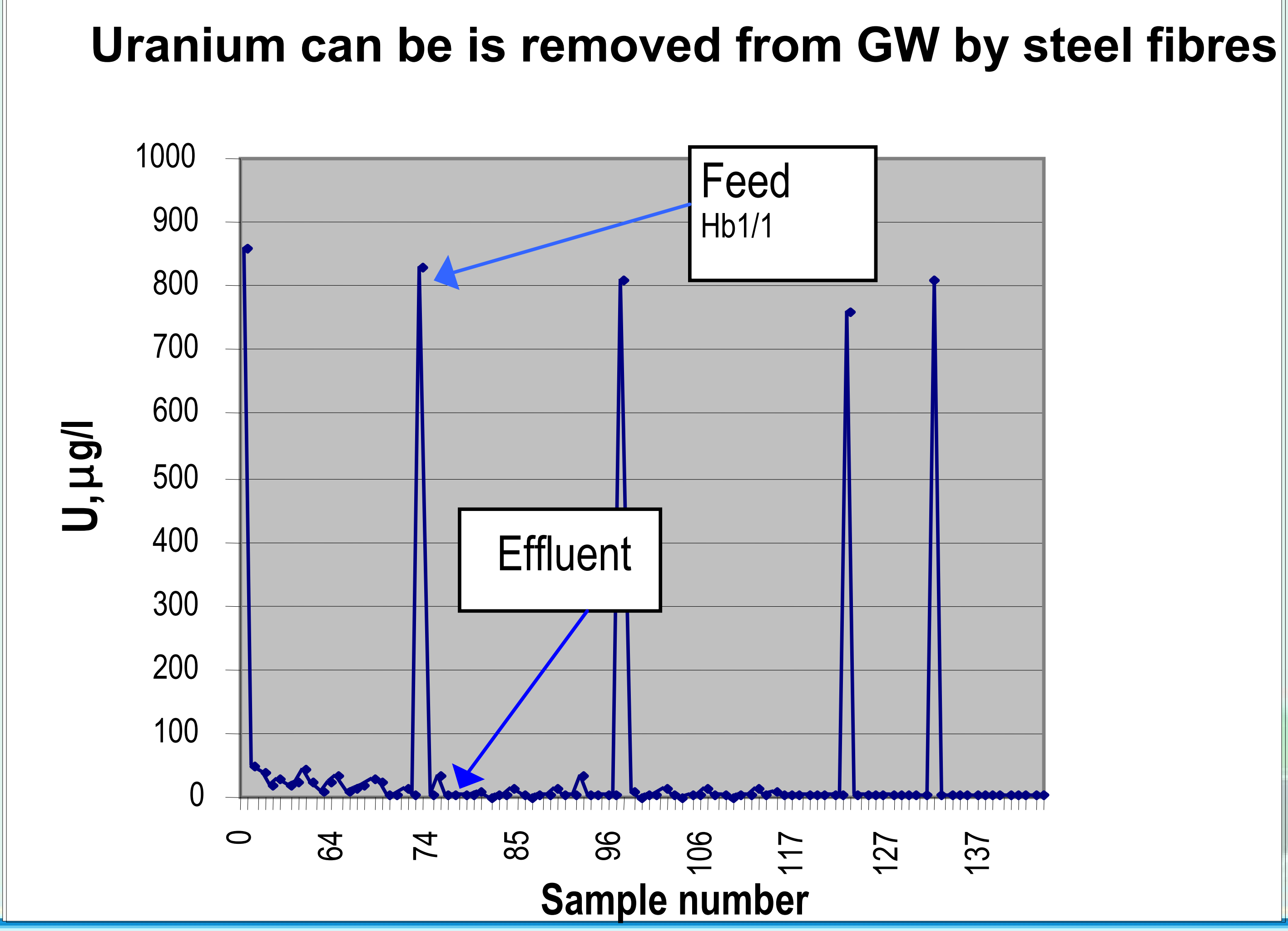
Slite contamination of GW was detected in GW on the site

Laboratory experiments in columns

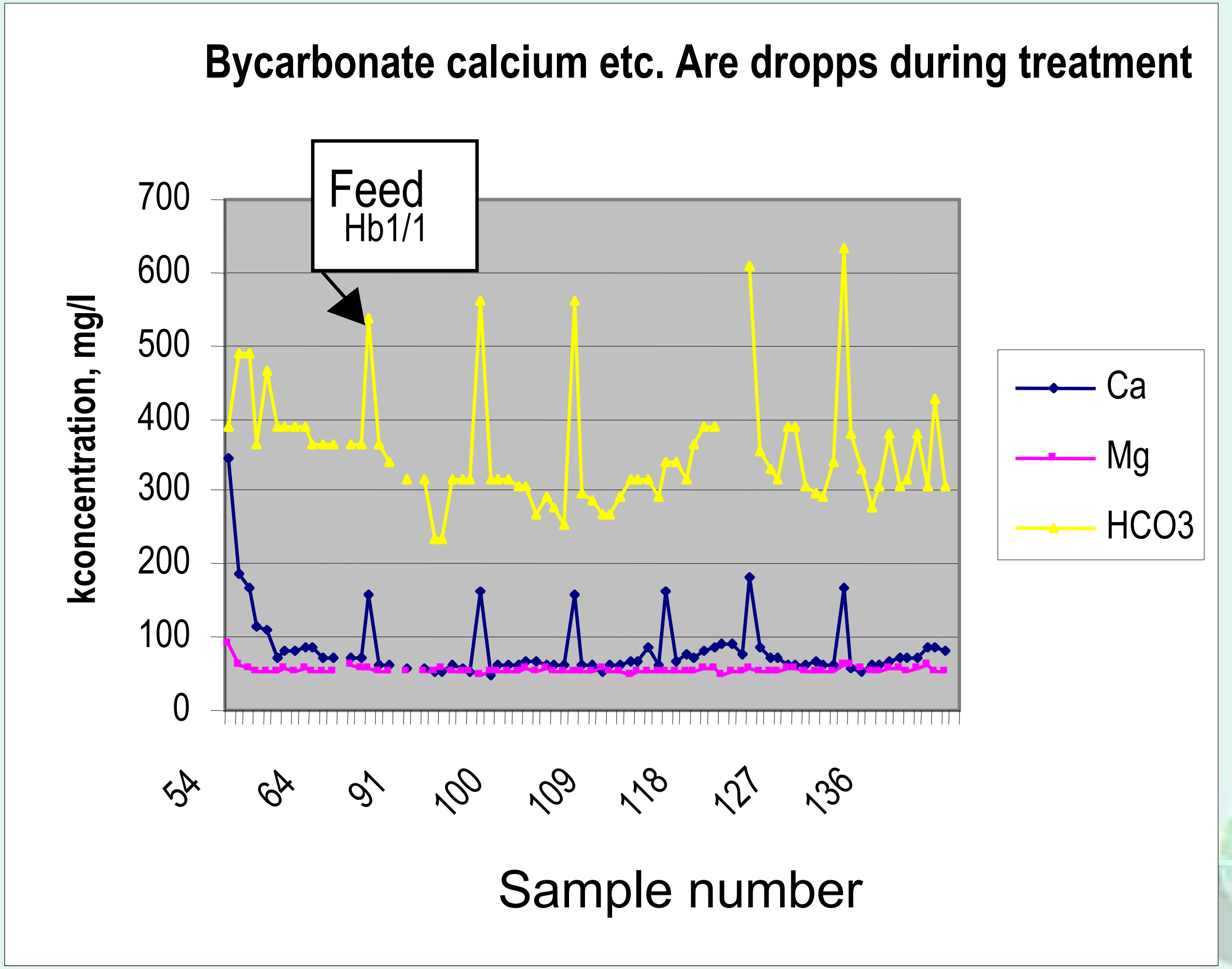


Iron, hydroxiapatite, anion exhange resin, etc. were tested

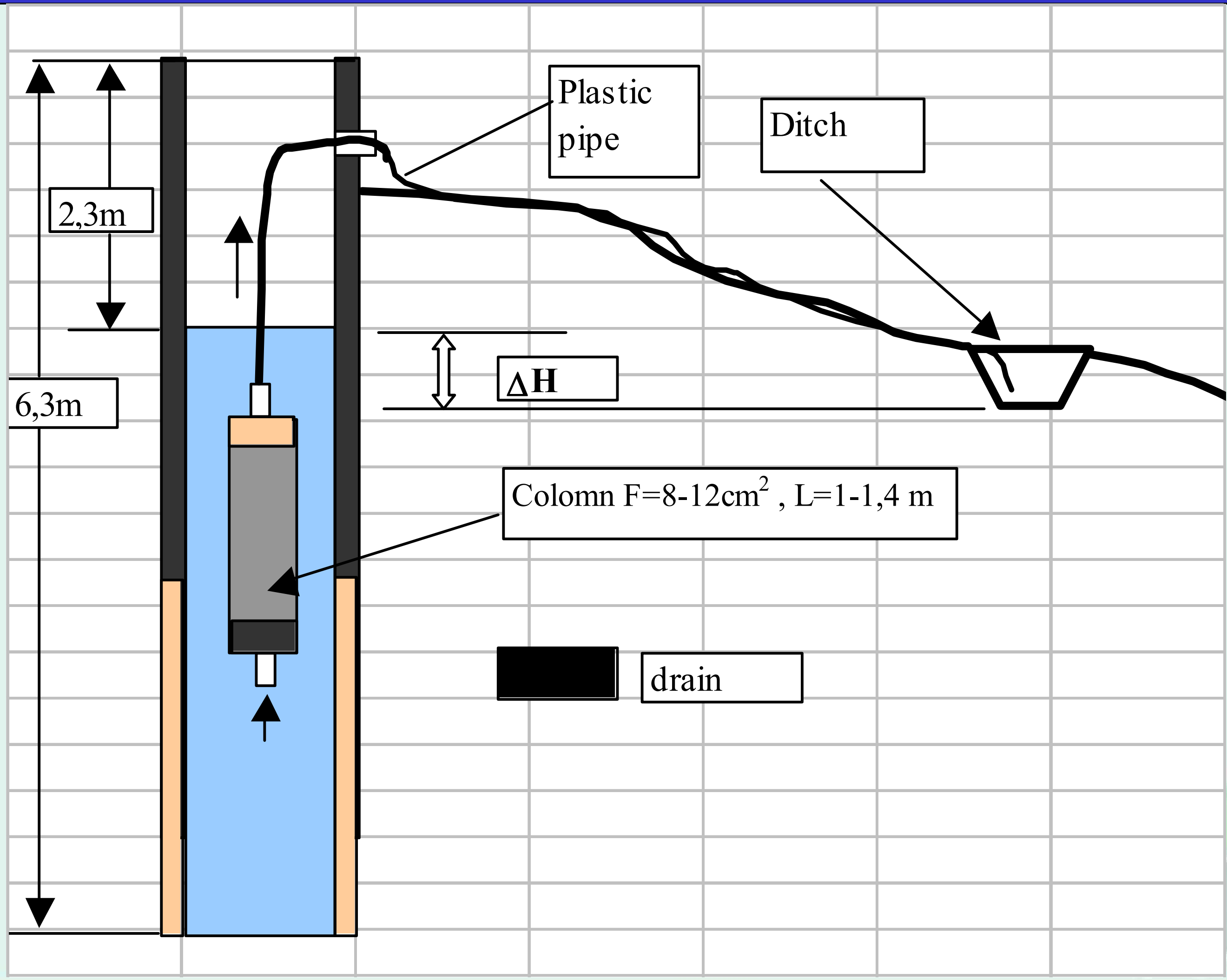
Removal of uranium from contaminated GW



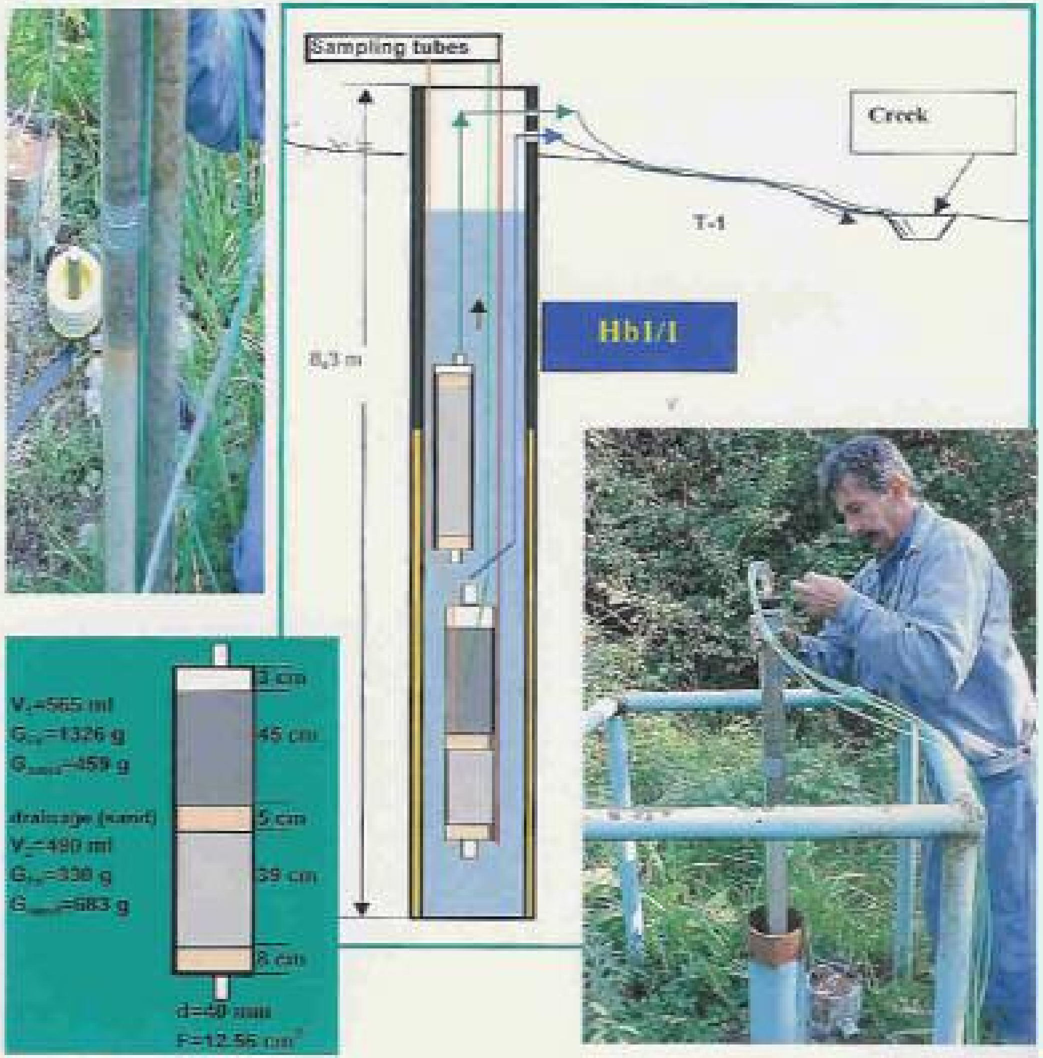
Changing the general chemistry of water



Colomns in monitoring wells



Field column experiments



Geochemical processes controlling GW chemistry

$H_2CO_3 = HCO_3^- + H^+$

$K=10^{-6,3}$

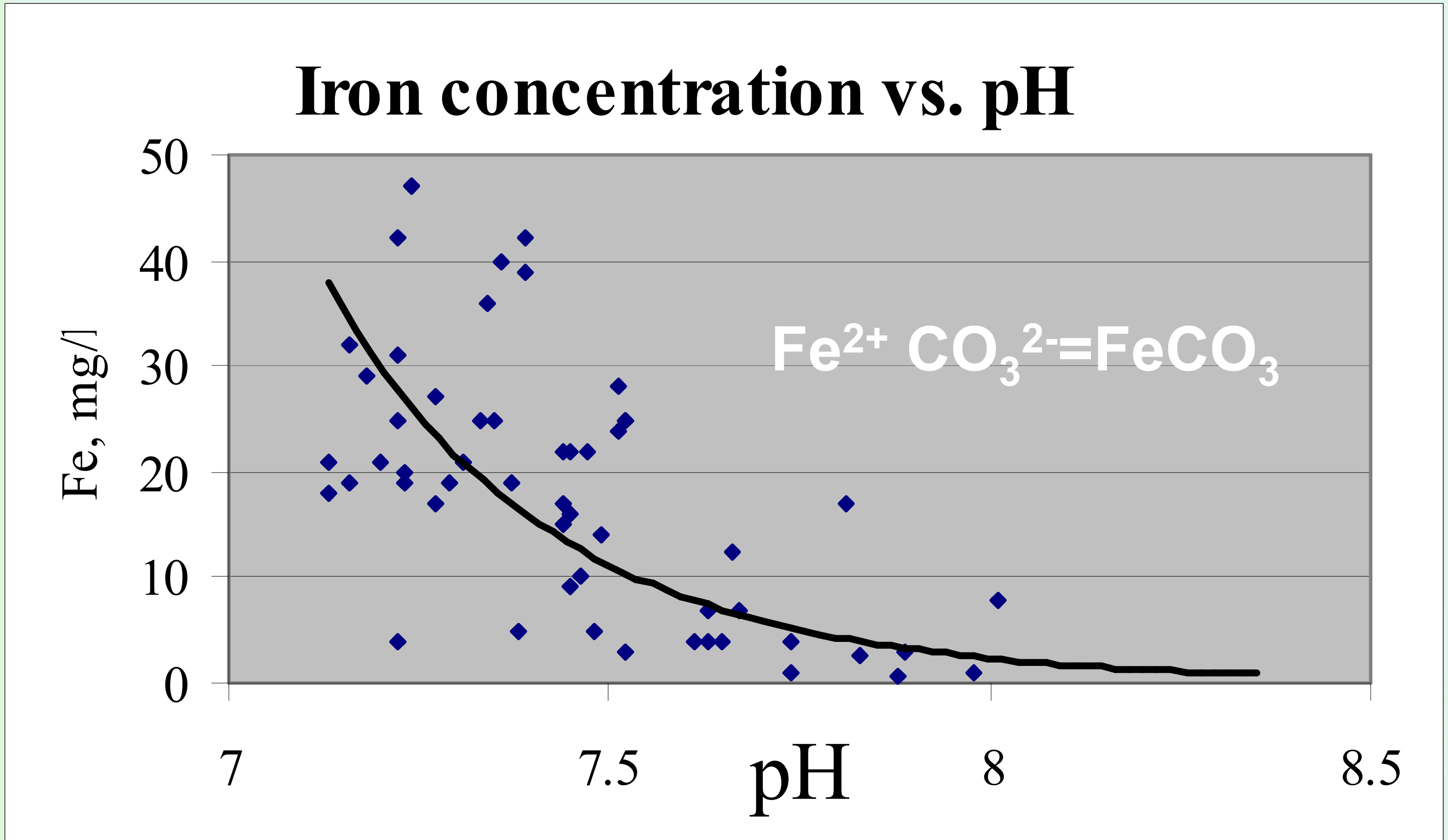
$HCO_3^- = CO_3^{2-} + H^+ \quad K=10^{-10,25}$

$[Fe][CO_3] = 2,50E\text{-}11 \quad 20^0C$

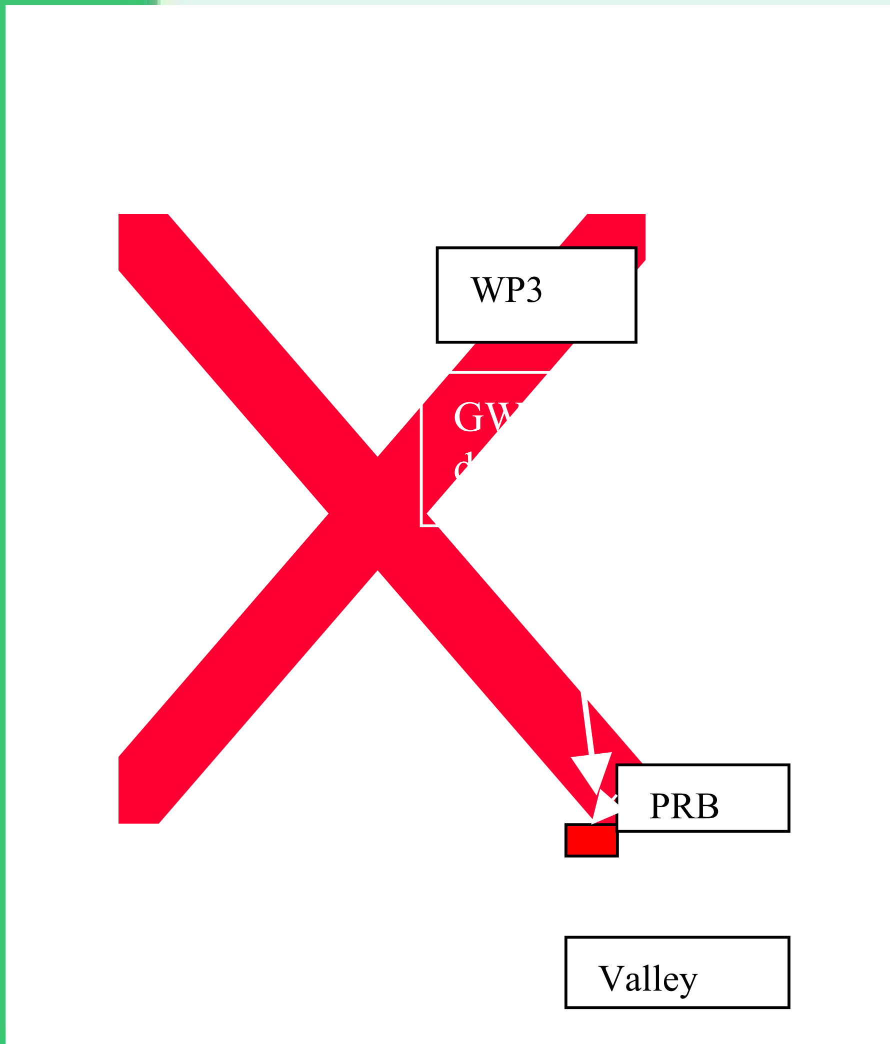
$[Fe][OH]^2 = 1,64E\text{-}14 \quad 18^0C$

$[Ca^{2+}]\,[CO_3^{2-}]=1.20E\text{-}08 \quad 20^0C$

Geochemical processes in GW

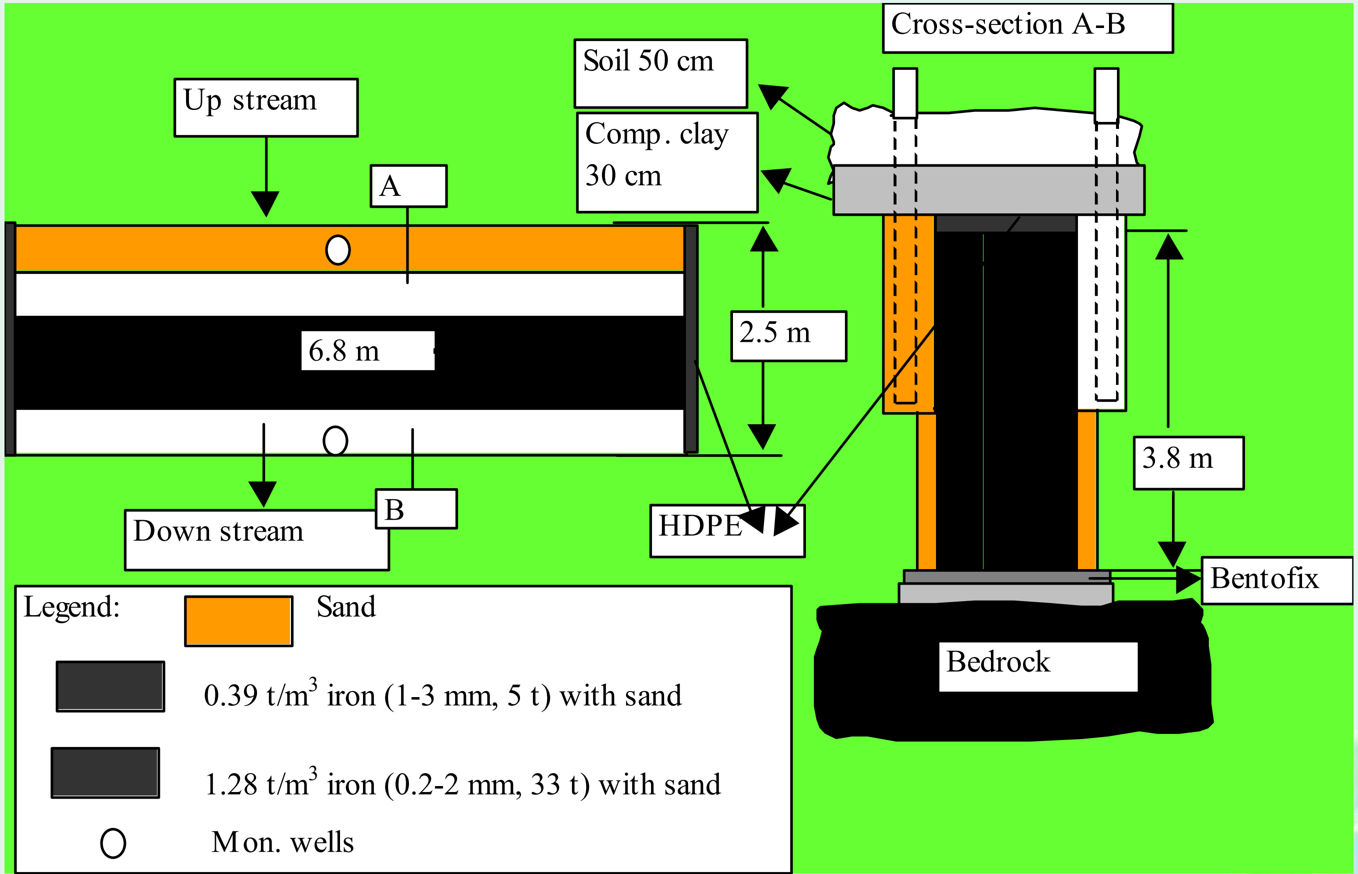


Location of the PRB



The installation is located in a narrow valley at the foot of WPIII, linking the mining area with drinking water aquifer (*Zsid-valley*)

Principal design of the experimental PRB



Elemental iron mixed with sand

Spec. Surface: 0.7 m²/g

0.2-3 mm

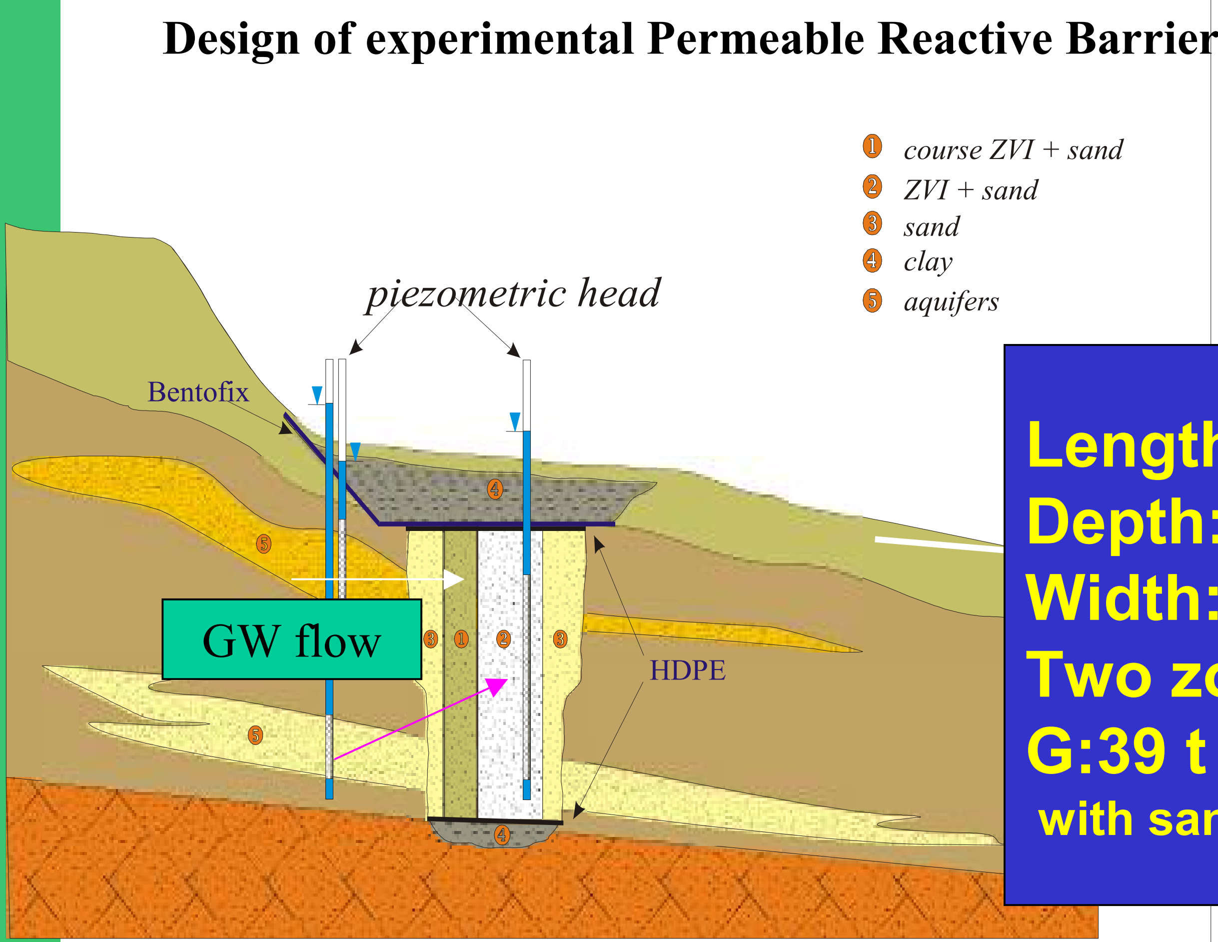
Construction of the PRB

Permian sandstone with sediments

Two layers of Fe+sand mixture

Monitoring wells placed in reactive zones

Construction of the PRB

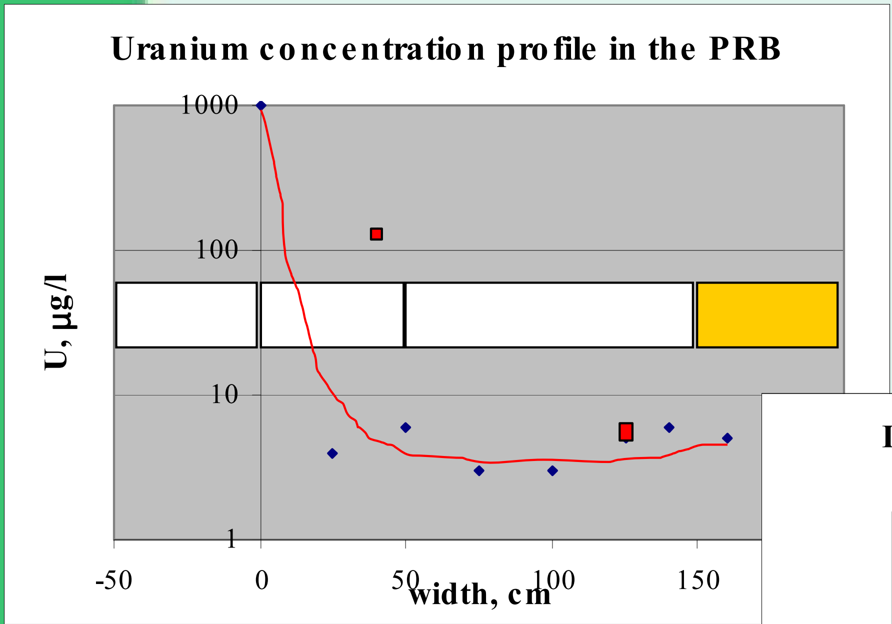


Length:6.8 m;
Depth:3.9 m
Width: 1.5m;
Two zones;
G:39 t ZVI (mixed with sand)

PRB with monitoring wells

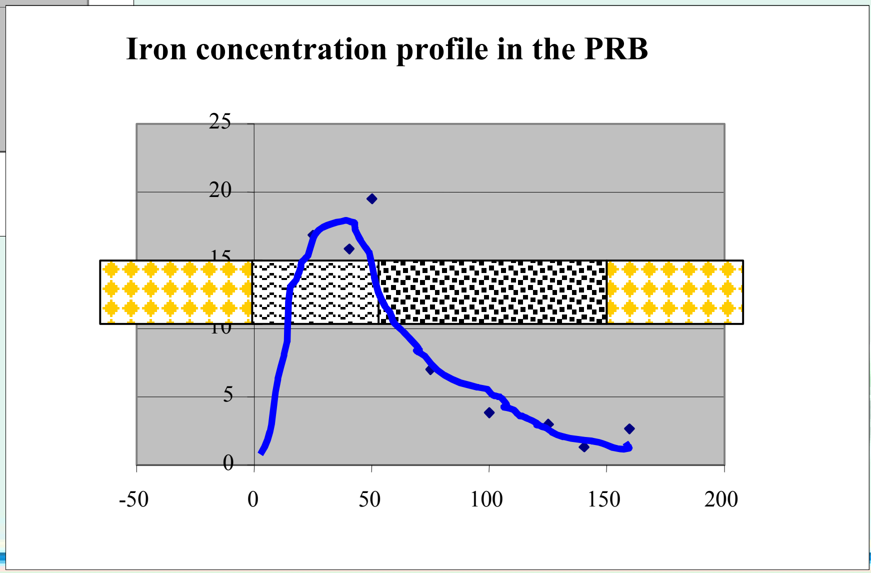
28 monitoring wells

Precipitation of uranium and dissolution of iron

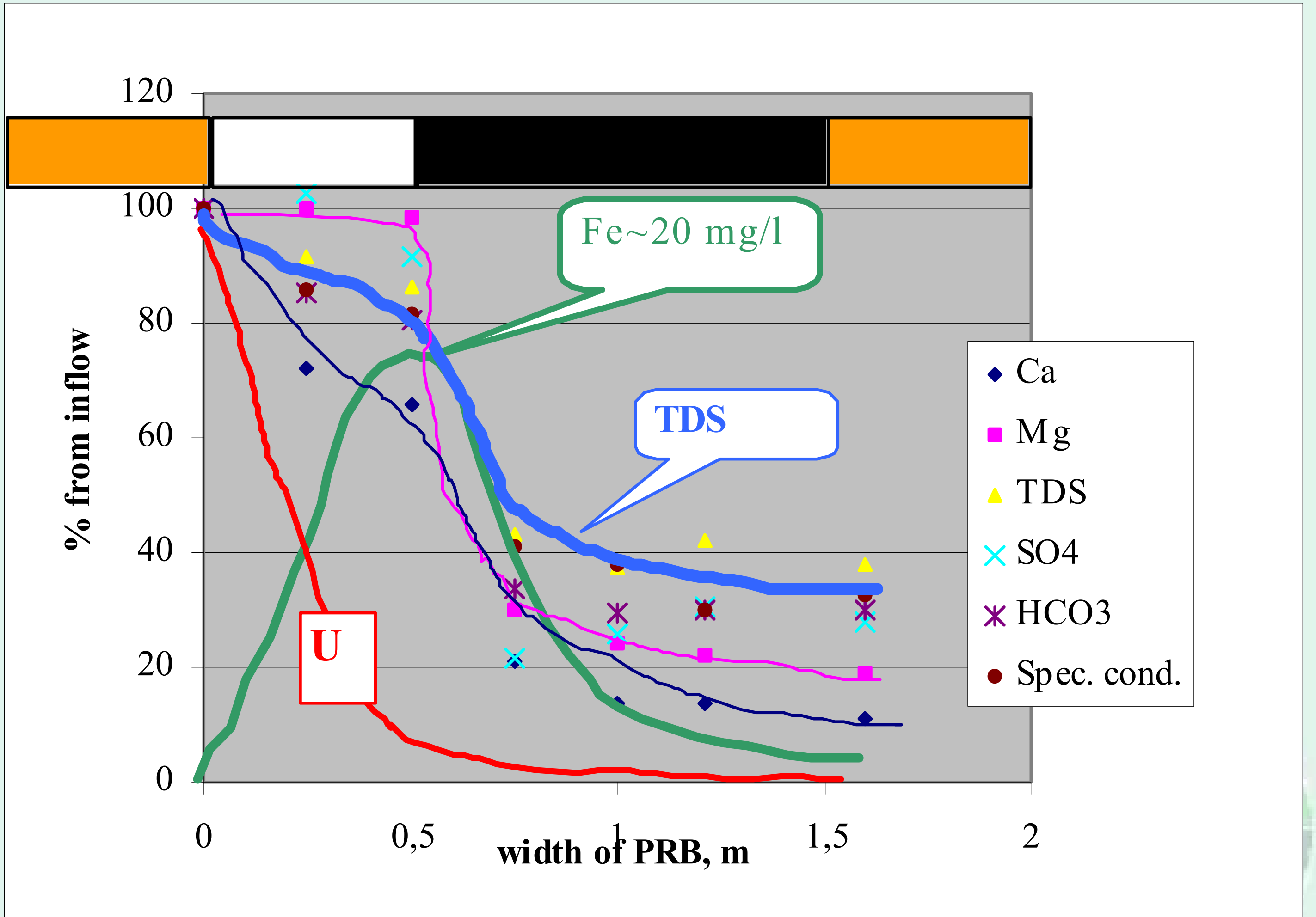


Iron first dissolves in first zone than precipitates in the 2nd zone

Uranium conc. drops in the first zone

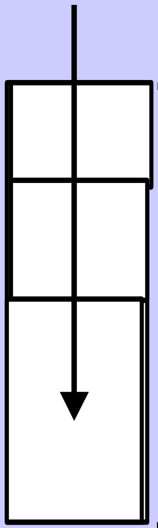


Concentration profiles in zones of PRB



PRB performance (August 2002-April 2005)

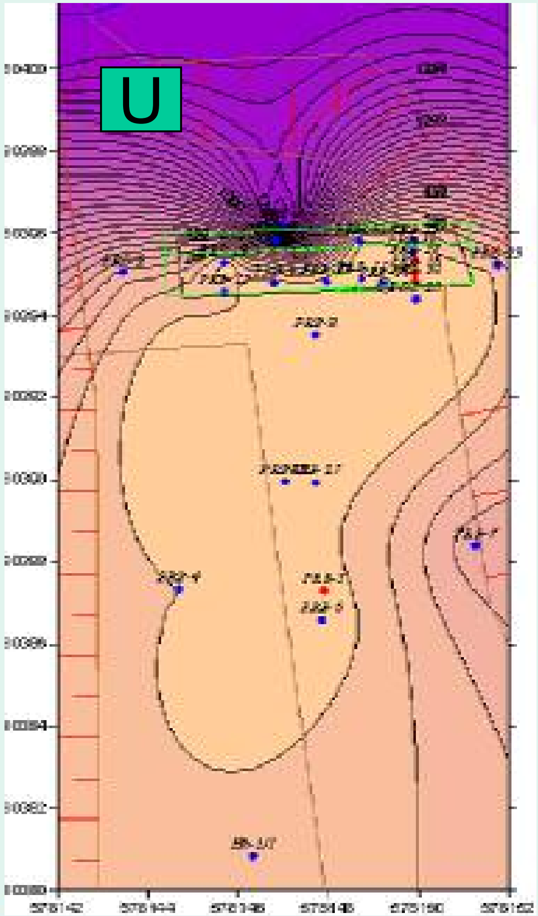
GW flow direction

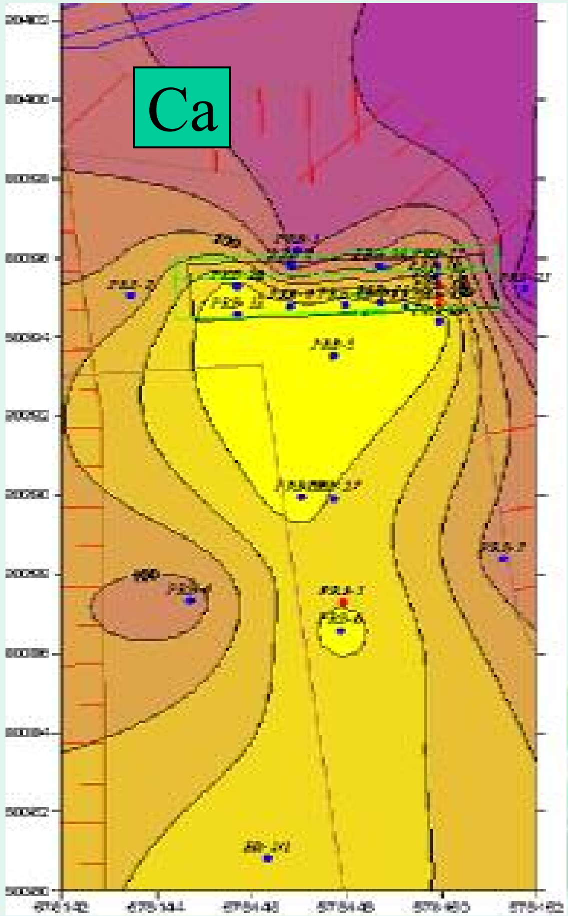


	pH	EC	U(VI)	TDS	Ca	SO_4	HCO_3	Fe
		µS/cm	µg/l	mg/l				
Inflow	6.9	1400	940	1010	150	320	525	0.002
Zone I	7.3	1330	37	937	125	300	275	5.5
Zone II	8.7	865	10	550	10	185	299	0.03

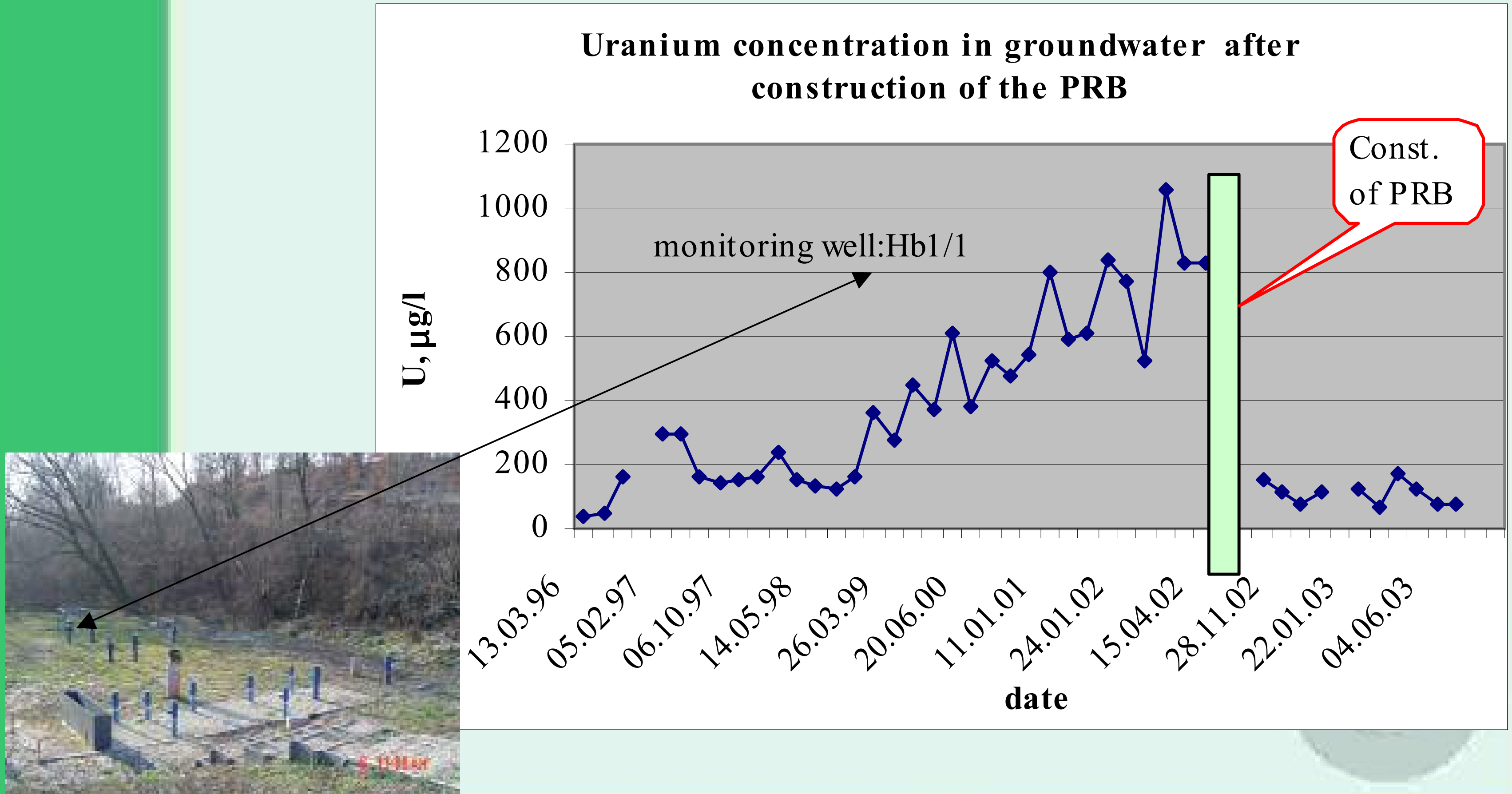
Uranium is removed with high efficiency but huge volume of inert compounds ($CaCO_3$, $MgCO_3$ etc.) is precipitated

Isolines of uranium and calcium concentrations on the test field





V.7 Development of uranium concentration in downstream monitoring well



Performance change

Water passed through the PRB: ~700 m^3/a
Formed precipitate: ~0.5 kg/m3~ 350 kg/a
Free porosity in PRB (original) ~11 m^3
Annual losses:~ 0.35x2.7~0.094 m^3
in persentage:~1-1.5%

Iron dissolution:~20-30 mg/l Fe(II)
G=~700x0.03=21 kg/a

Performance monitoring is continued

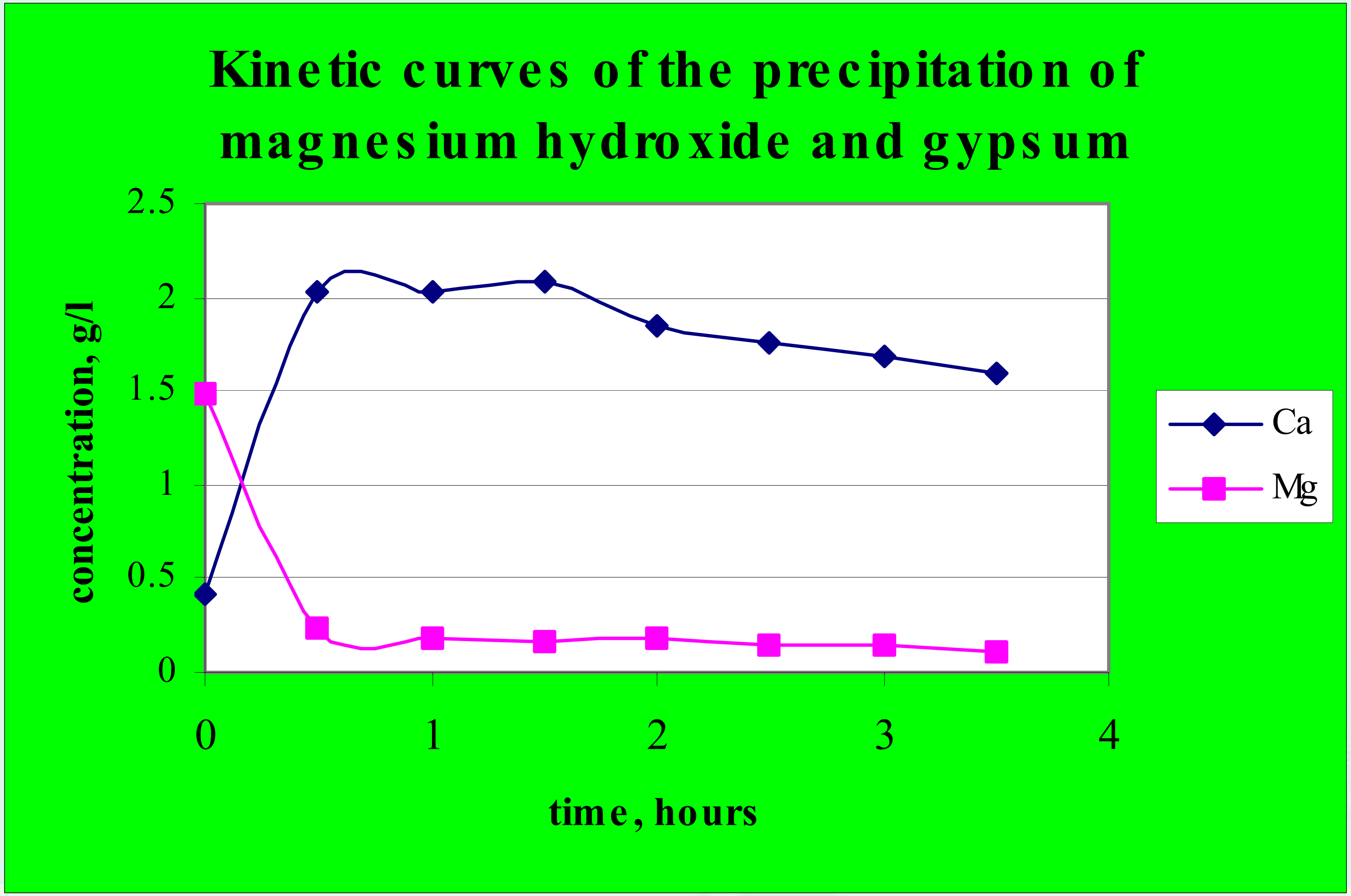
- by regular water sampling
- by planned drillings
- by hydrogeological evaluation

Acknoledgement

The research works related to the GW treatment was suported by the IAEA (Contract: N^0 9114).

The research related to the PRB and dispersion of contaminants under TPs was partially suppotred by EU (Contract: EVIKI-1999-00186 andEVGI-CT-2002-00035)

Precipitation of gypsum and magnesium



I.3 Project cost distribution