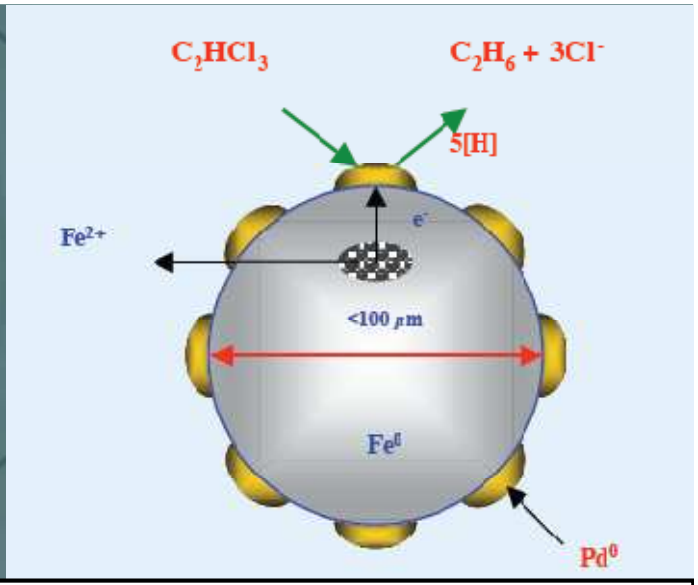

Use of NZVI for ground water remediation

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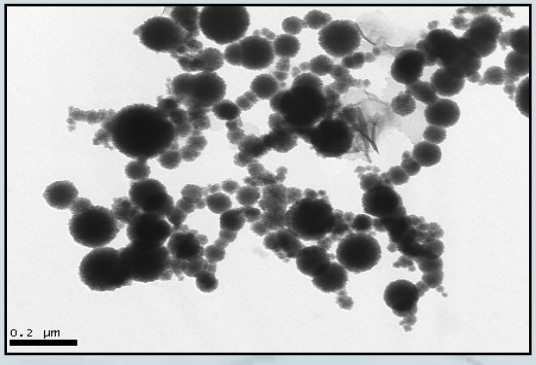
- Introduction to NZVI
  - What is NZVI
  - How does it work
- Case Sammonmäki
  - Site investigations
  - Bench scale tests
  - Remedial action plan



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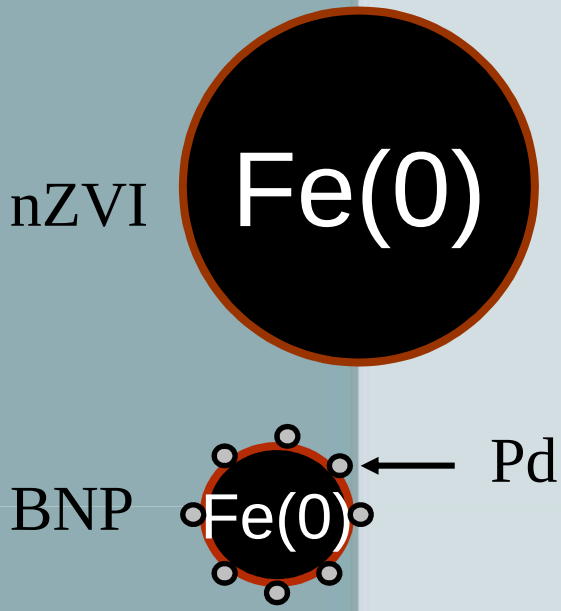
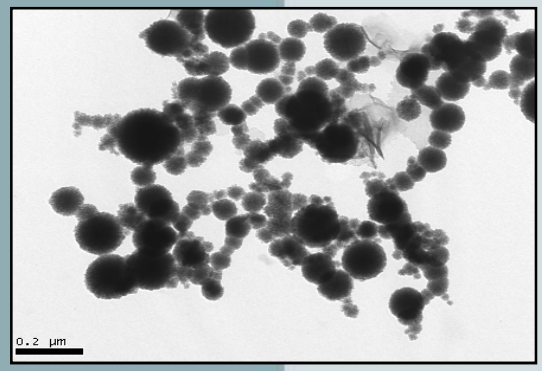
What is NZVI?





- Nano scale particles (in production, not in subsurface)
- Fe^0
- Coated with small amount of noble metal (Pd)
  - Resists corrosion
  - Faster Reaction Rate

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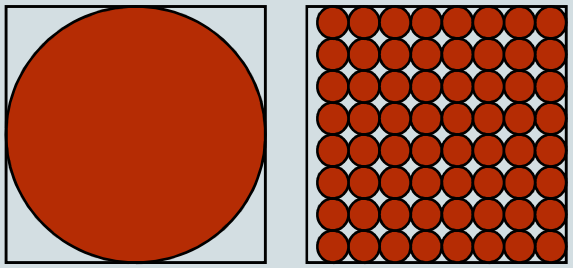
What is NZVI?

- Why go nano?



	Micro ZVI	**Nano ZVI**
Particle size	10 – 100 µm	50 – 75 nm
Surface area	10 m^2/Kg	30,000 m^2/Kg
Cost	~ 1 €/Kg	~ 50 €/Kg
Actual cost	10 m^2/€	600 m^2/€

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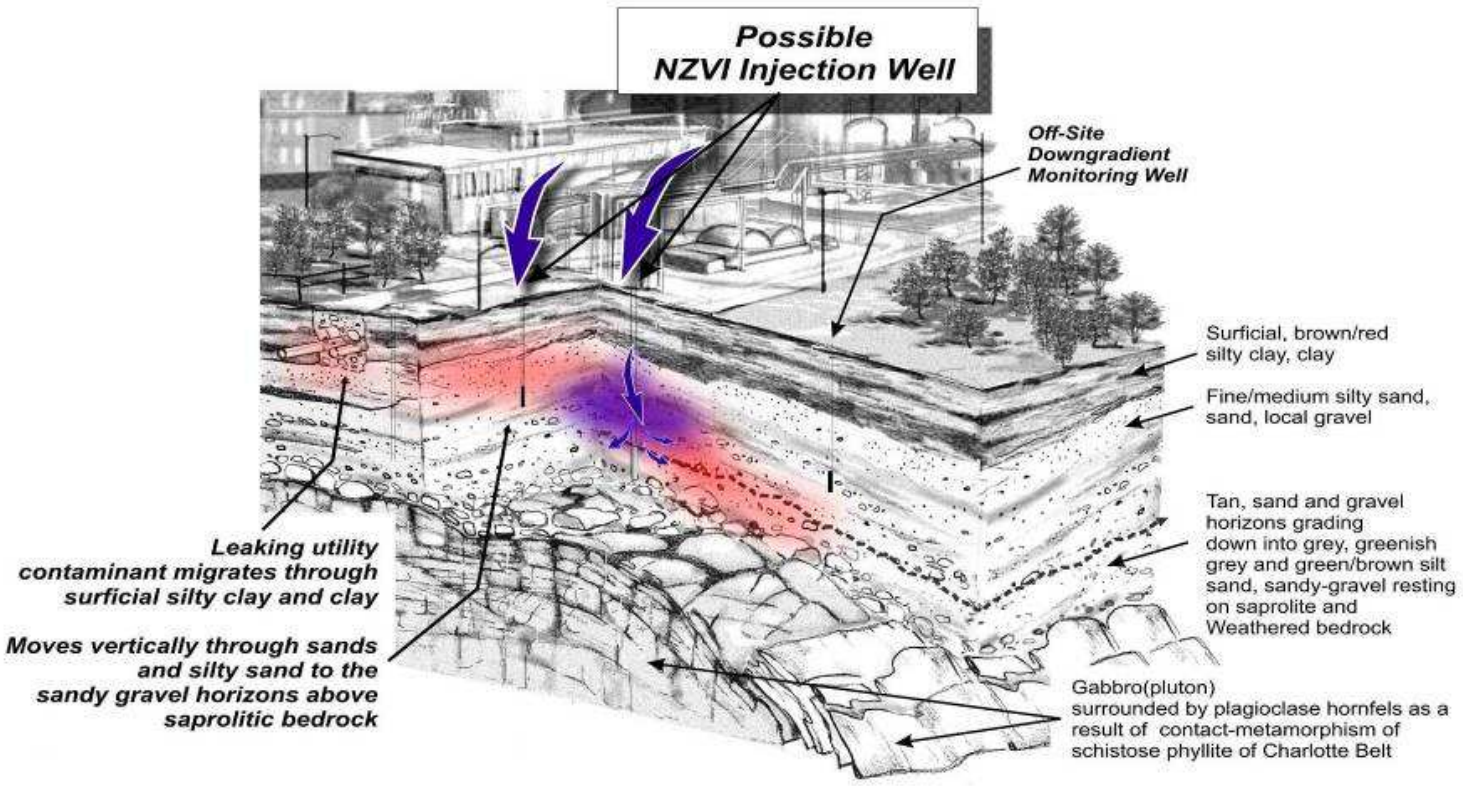
How does it work?

- Groundwater remediation
- Application to contaminated area via groundwater flow
- Dispersant
- Remains active weeks
- Defined treatment area



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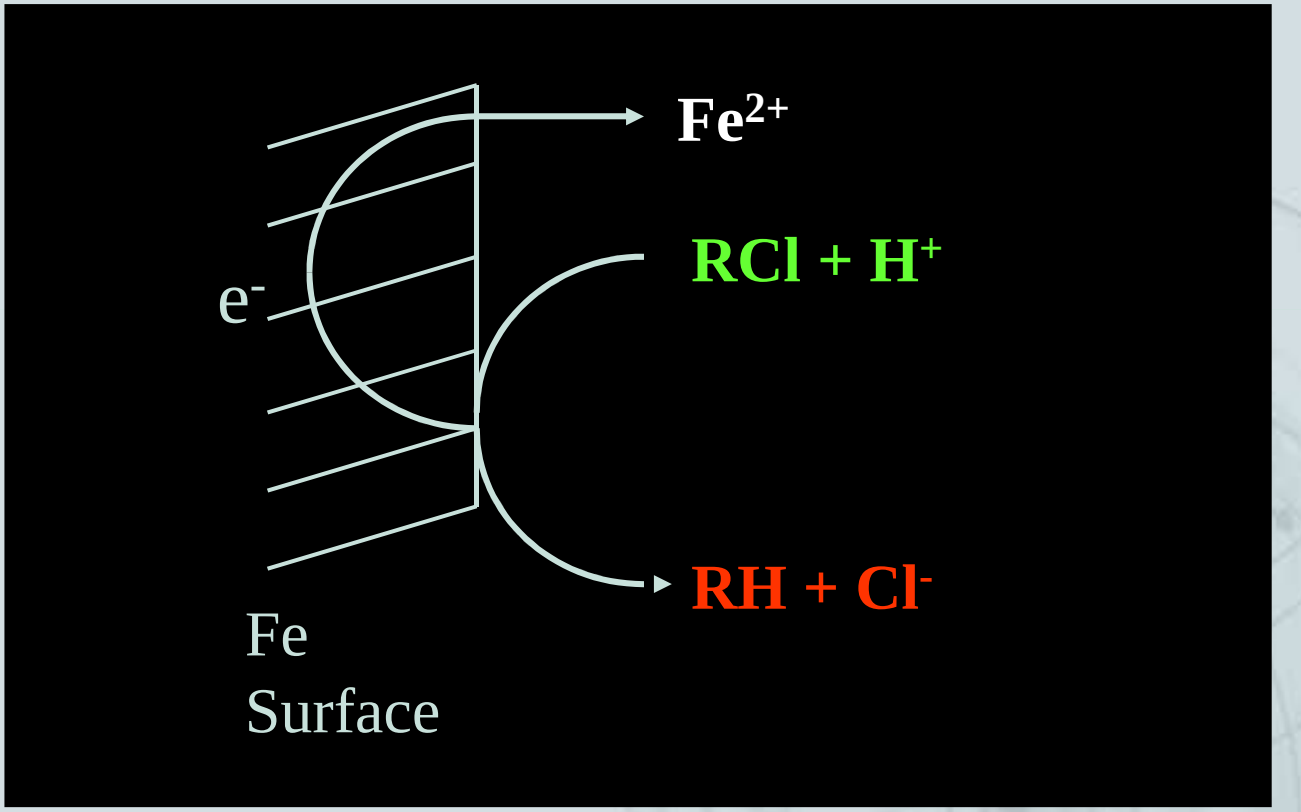
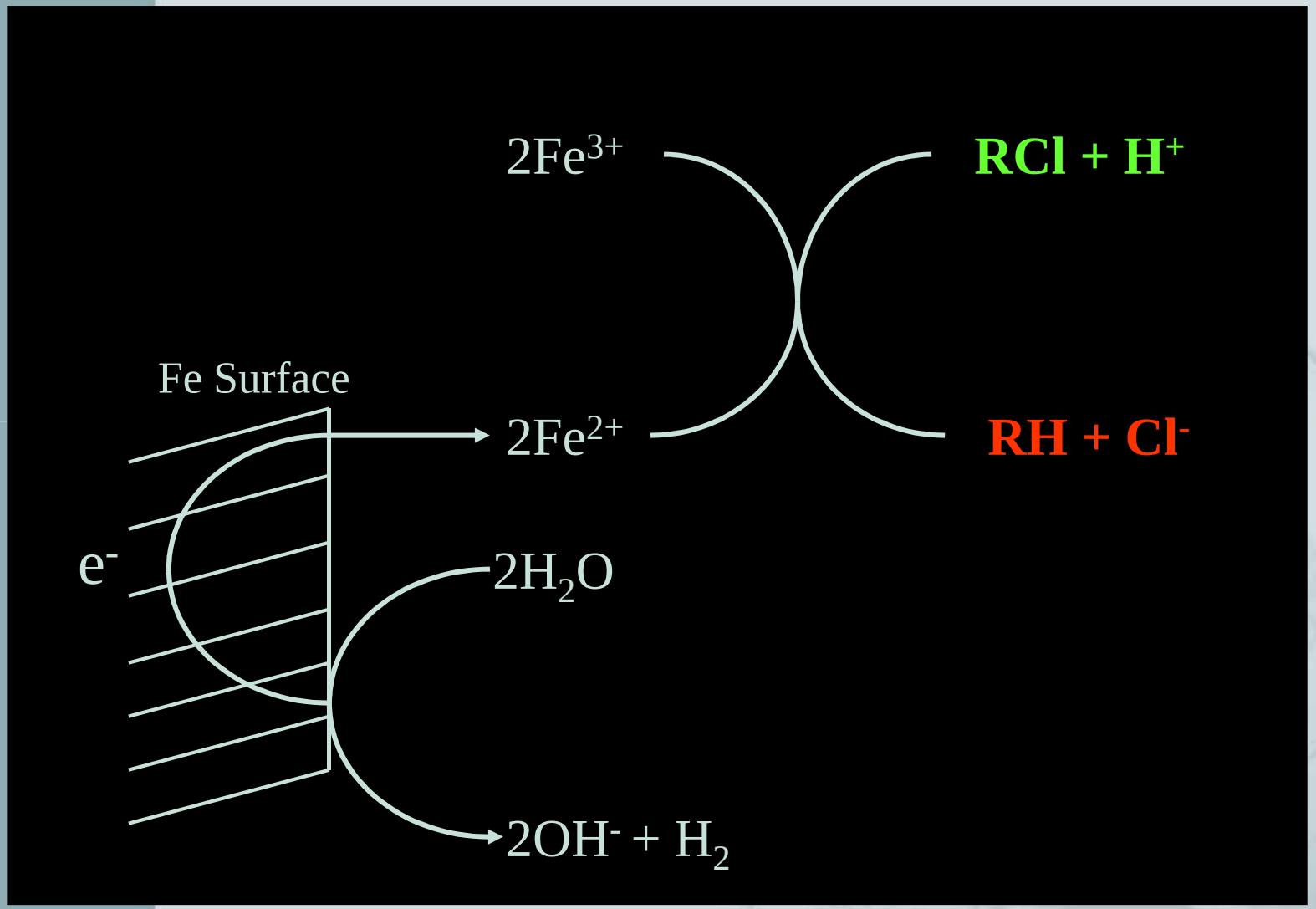
How does it work?

- Fe^0 donates electrons for chlorinated solvent reduction



More on Reaction Mechanism



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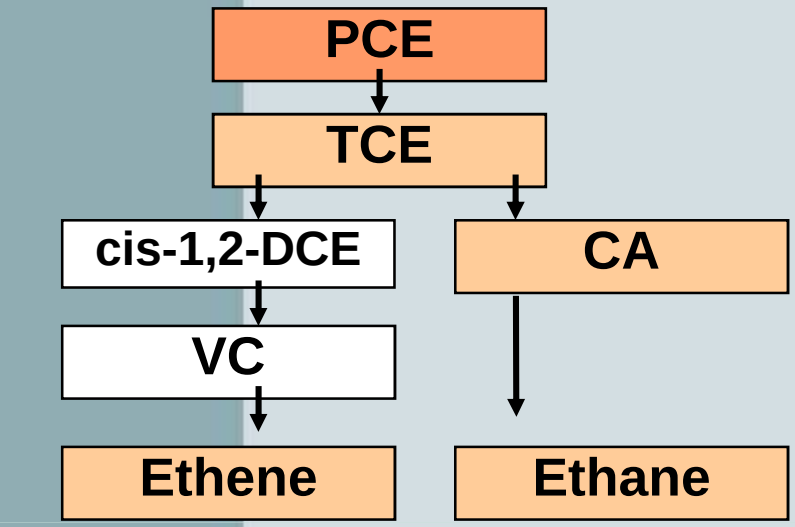
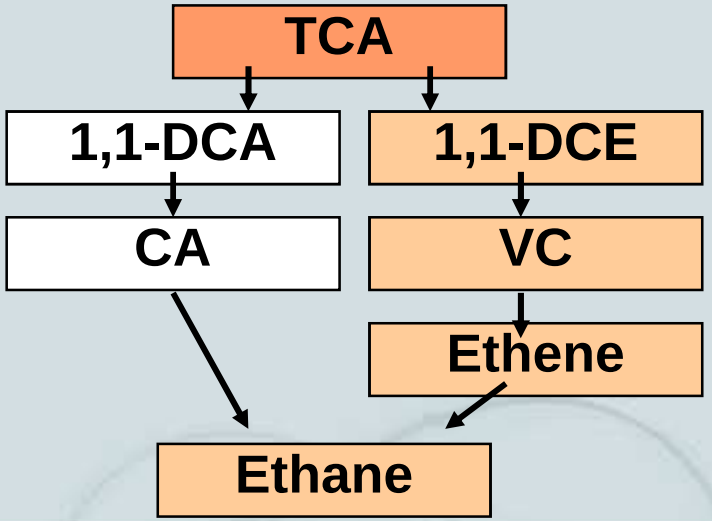
How does it work?



Biological dechlorination β-elimination



Biological dechlorination β-elimination

- Production of ethene/ethane
- Natural biodegradation and use of NZVI support each other

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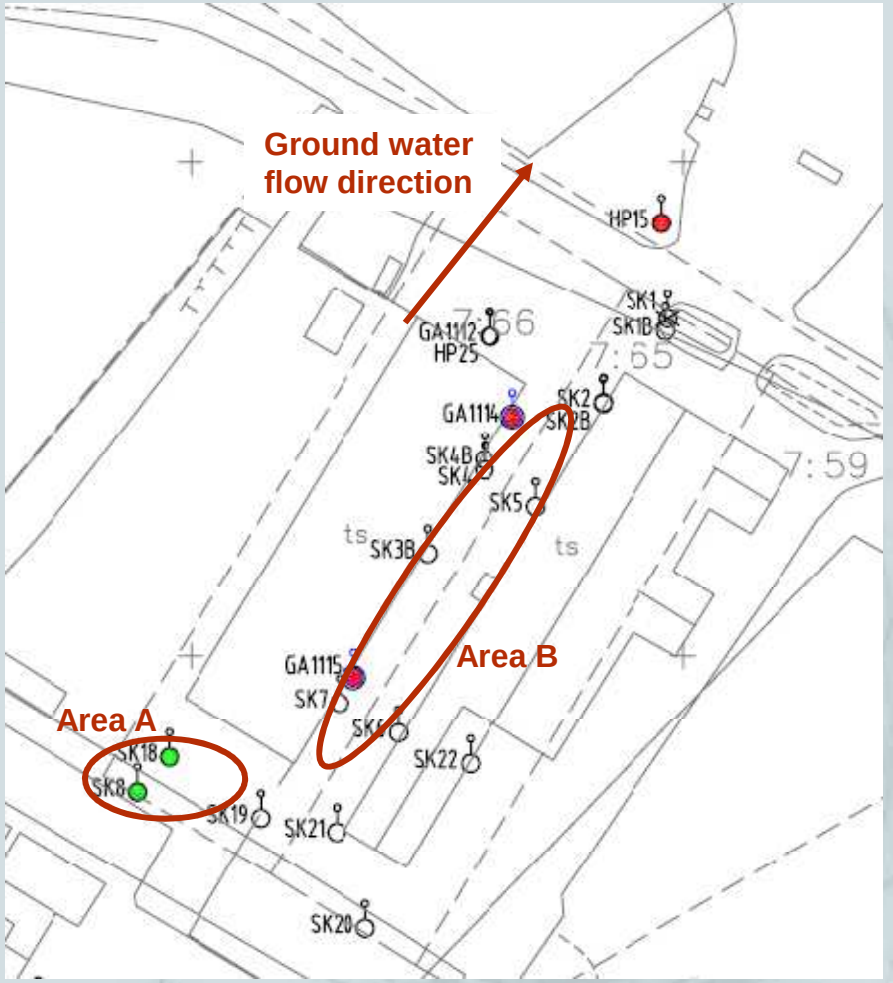
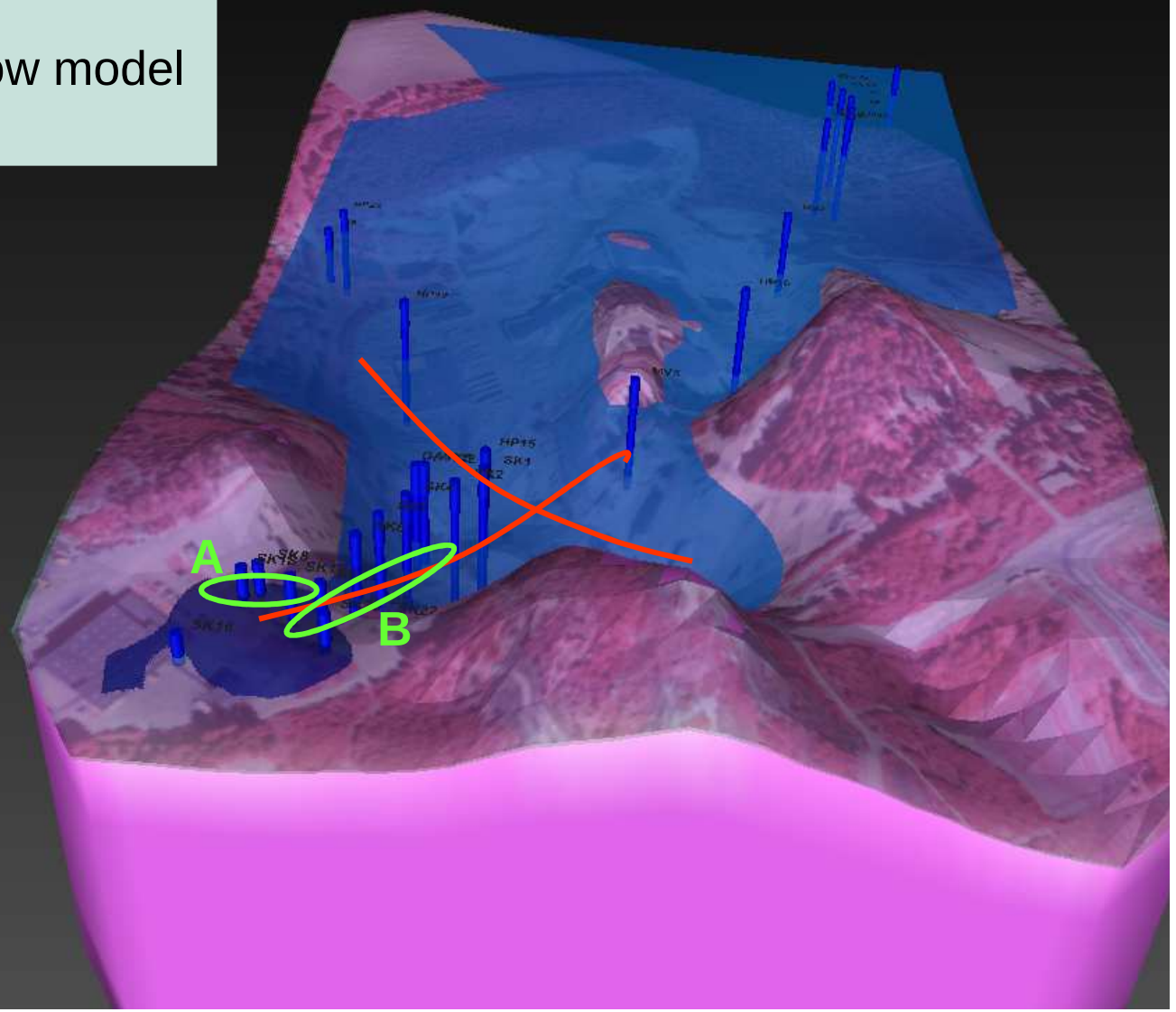
Case Sammonmäki

- Ground water contaminated with chlorinated ethanes (area A) and ethenes (area B)
- Two source zones

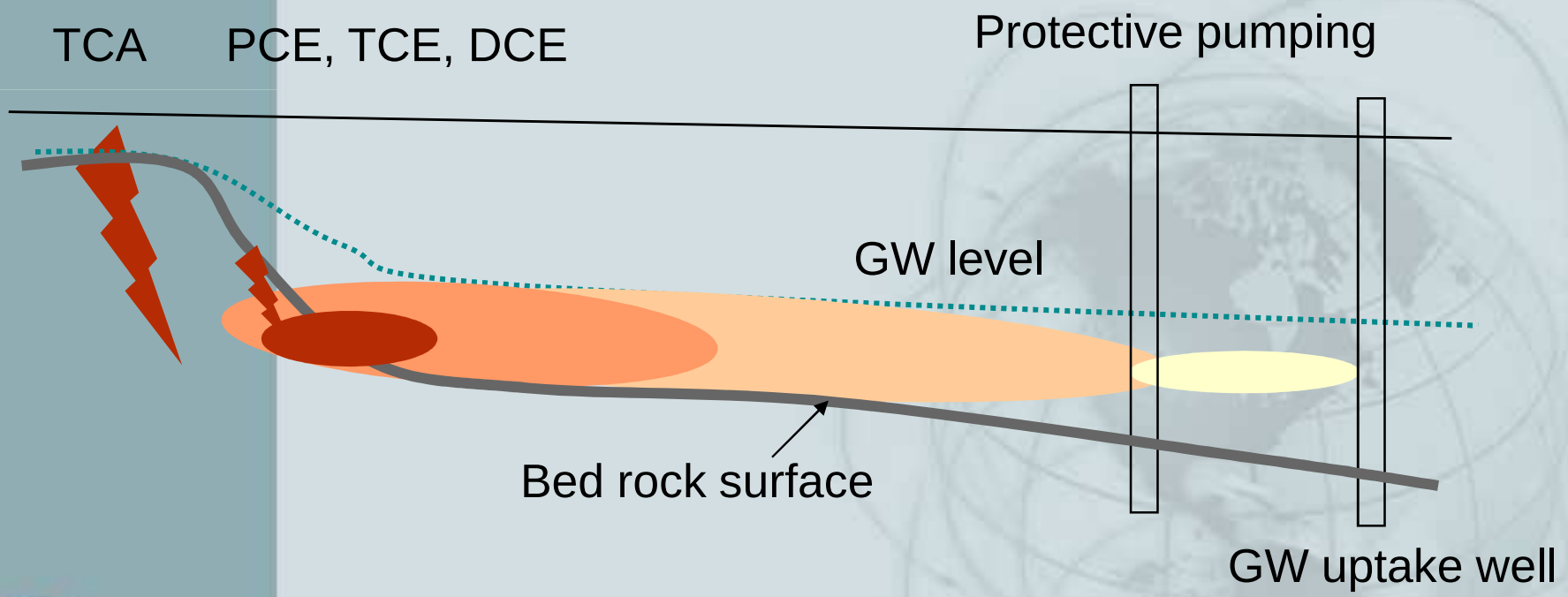


- Site investigations
  - Contaminant chemistry
  - Geology
  - Ground water flow model
  - Geochemistry



Case Sammonmäki

- Groundwater concentrations 1-2 mg/l at highest (2004-2007)
- Groundwater uptake well downstream



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Case Sammonmäki

- Selection of remediation technique
  - MNA
    - No strong signs of natural attenuation
    - Slow
    - Risk for ground water uptake well need to be managed by protective pumping for unknown time
  - ENA, ISCO, NZVI
    - All feasible
    - All required bench scale and/or pilot scale testing
    - Site low in oxygen but not strong signs of biodegradation

- *Bench scale tests for NZVI*
  - *If feasible, remediation using NZVI*

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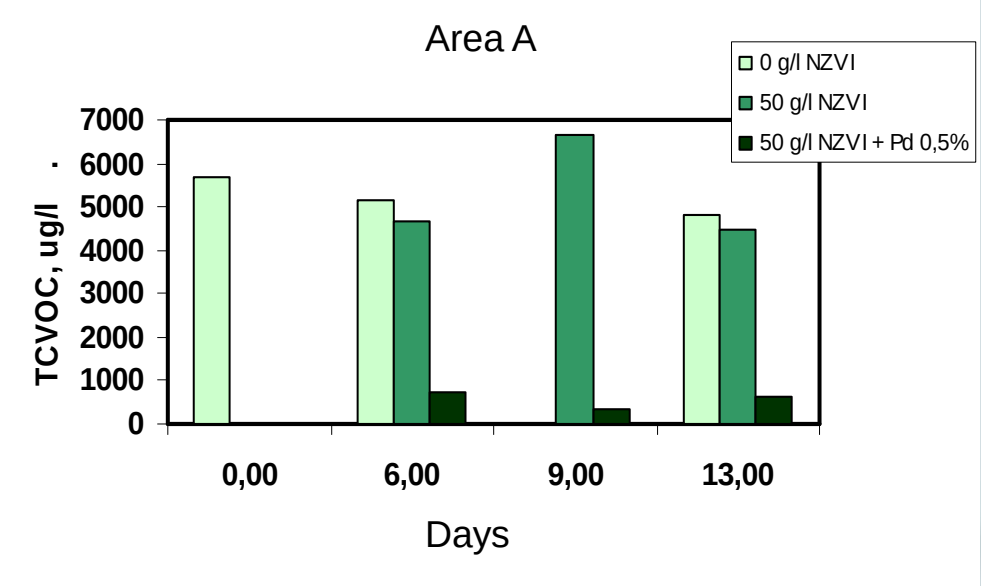
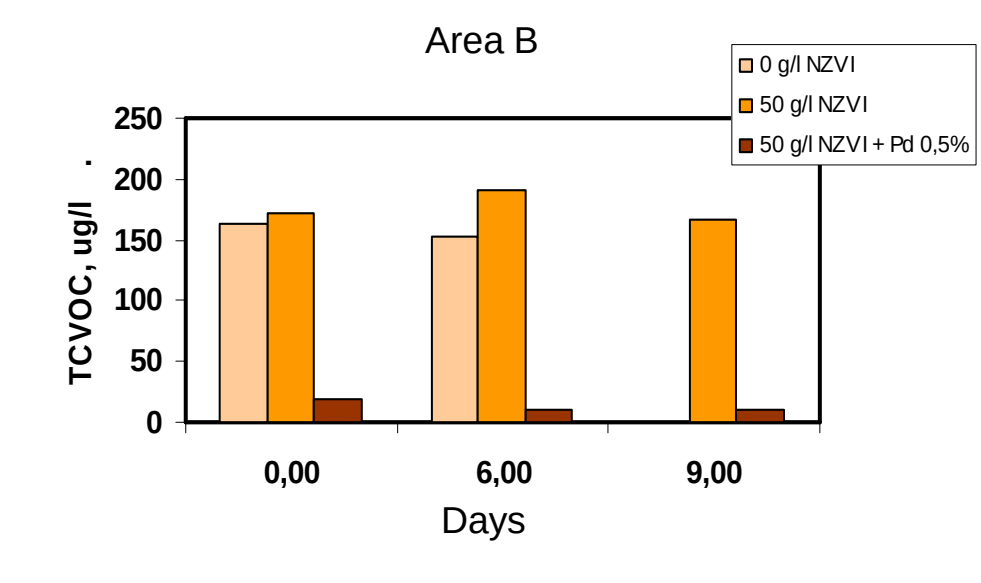
BS tests

- Bench scale tests
- Water + soil slurries

- Does NZVI work at all?
- Do we need to add Pd?





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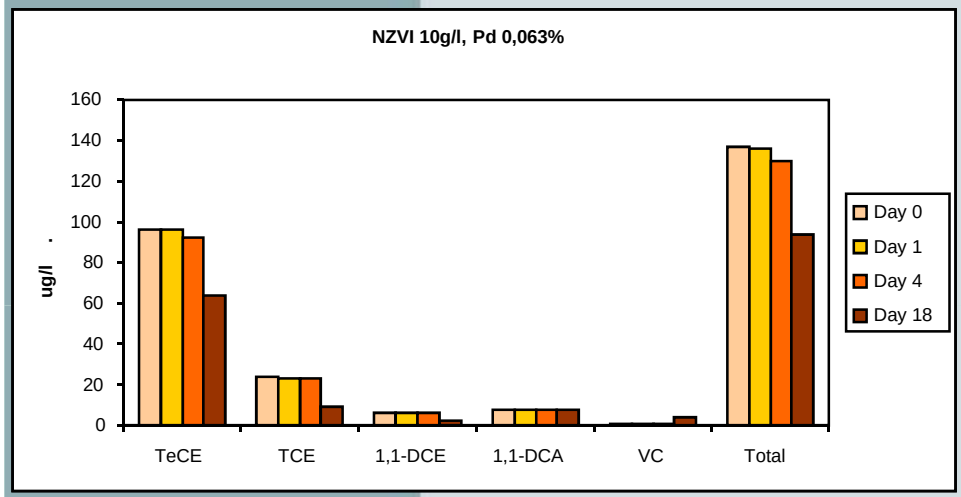
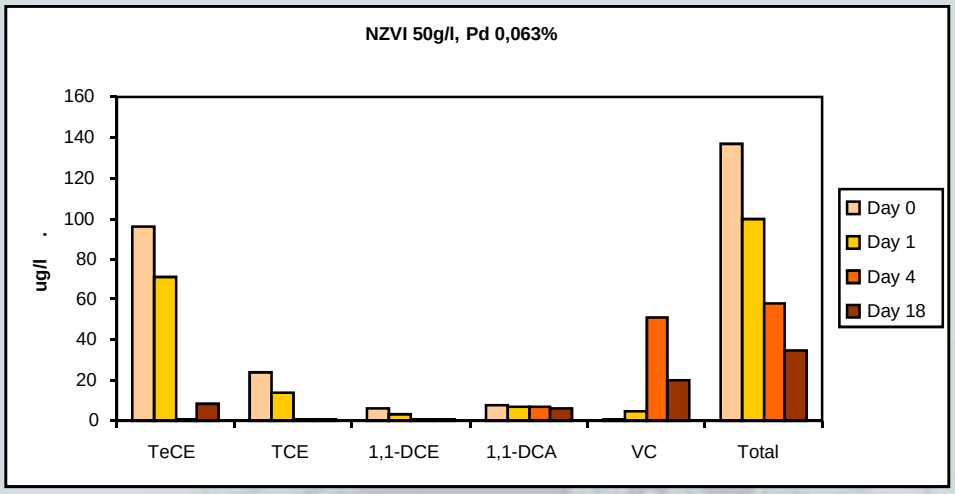
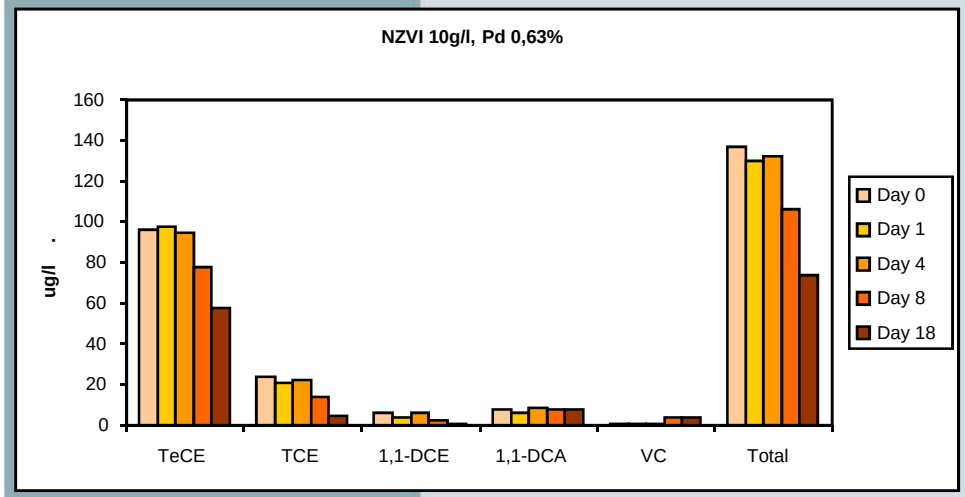
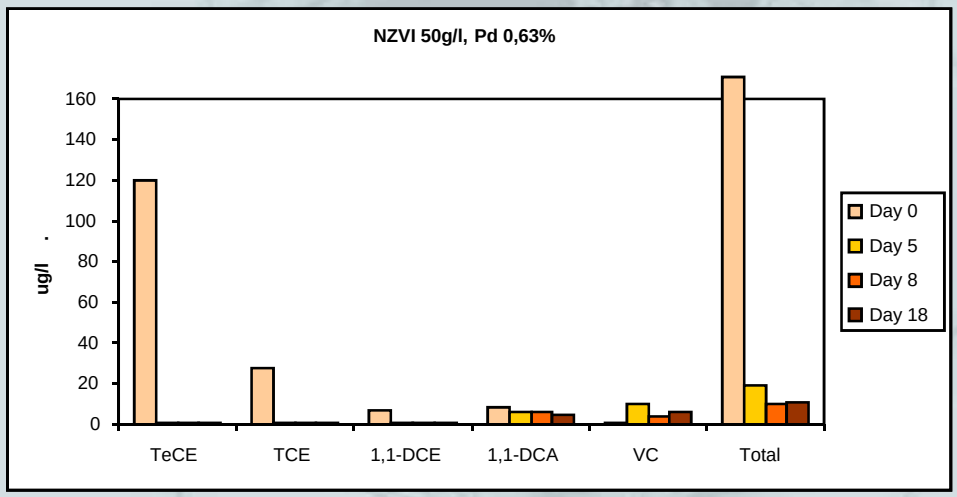
BS tests

- How much NZVI?
- How much Pd?



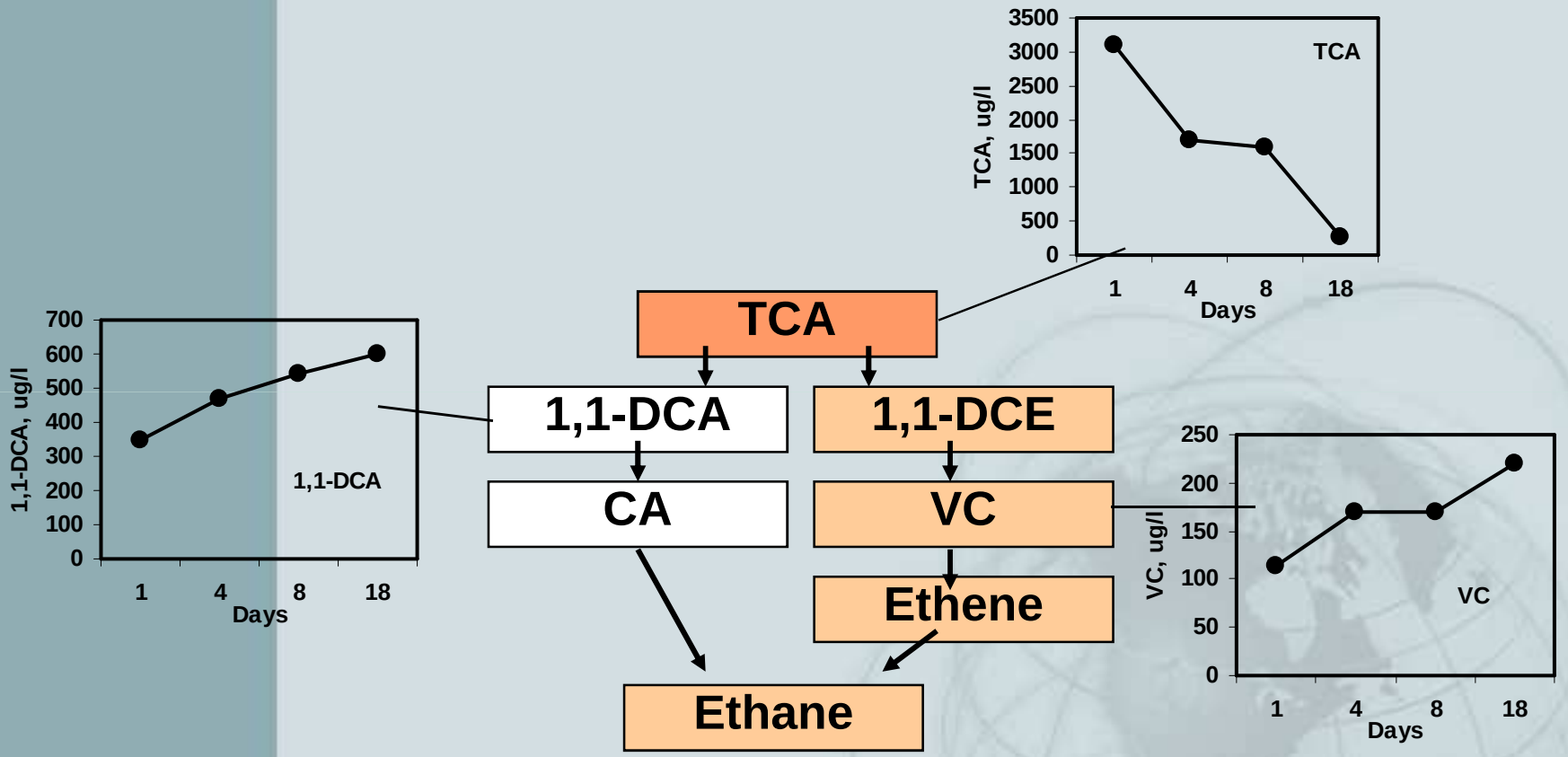






BS tests

- **Degradation pathways?**



Biological dechlorination **β-elimination**

Conclusions from BS tests

- Based on BS tests
  - Contaminants in Sammonmäki can be degraded by means of Pd-NZVI (BNP)
  - Without Pd, no degradation took place
  - NZVI concentration needed 50 g/l, Pd 0,1-0,6 % for area A and 0,06-0,1% for area B
  - Signs of both chemical and biological degradation
  - 1,1-DCA and VC can be temporally accumulated
  - No increase in pH
  - No metal release from minerals
  - Soy milk can be used as dispersant

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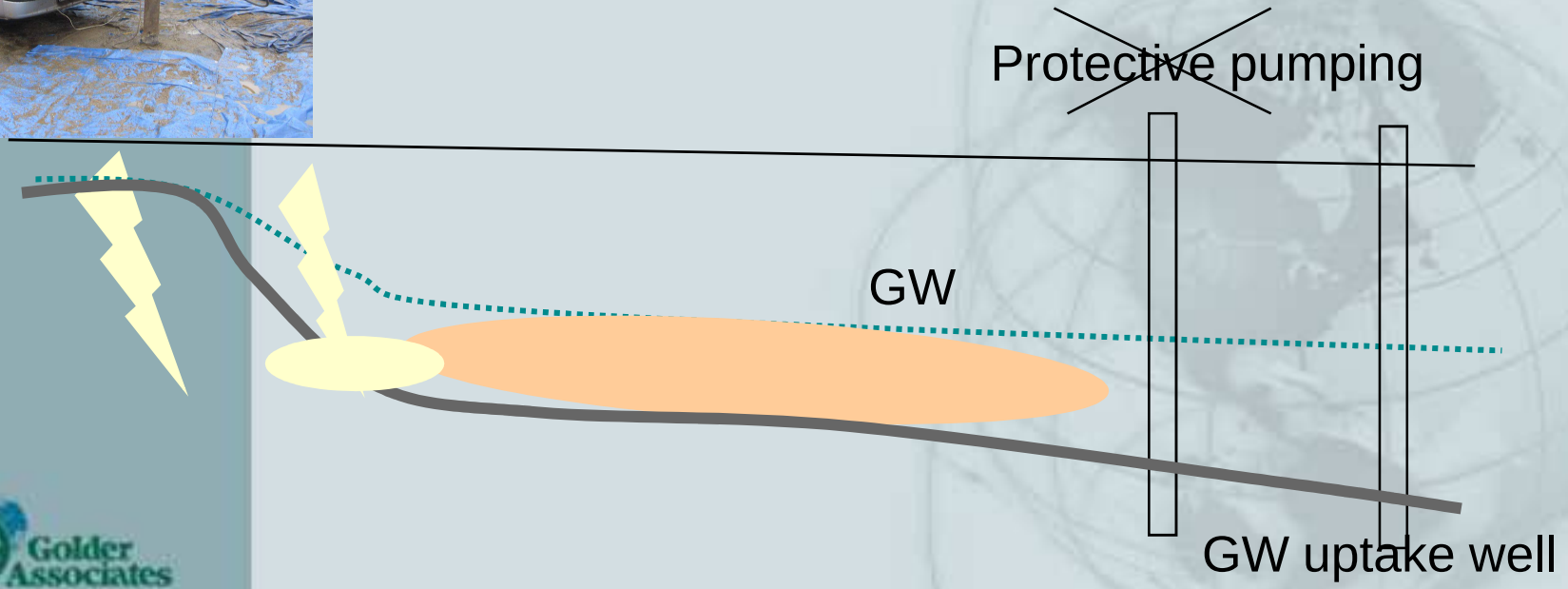
Remedial action plan

- Based on BS tests, remediation of the site was designed
  - Amount of NZVI, Pd, soy milk
  - Injection points and schedule
  - Target levels at source zone were set using Bioscreen
  - Monitoring
- Permit for experimental remediation applied
- Source zone remediation during 2 years of injections



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