Considerations about the Positioning of Monitoring Wells in Fractured Soil and Rock Aquifers

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Overview

• Importance
• Positioning wells
• Examples
• Conclusions
Scale of Plumes

Fractured Media vs. Porous Media
(complexity and velocities)
Distribution and Use

Fractured Rock Aquifers in Sao Paulo
Fractured Media Includes Soils (dual porosity media)

Sedimentary Deposited Organic Clay (neotectonics?)
Deeply Weathered Rock

(Taylor, R. pers. com.)
Fractured Soil in East of Sao Paulo

Weathered bedrock thickness
- <5m
- 5 to 30m
- >30m

(DAEE/IG/IPT/CPRM, 2005)
Investigating Fractured Media

- Objectives vary from case to case (e.g. more scale limitations than porous media). Typical they include (one or more):
  - Investigating an impacted receptor
  - Investigating impacts of a contaminant source
  - Investigating flow paths (almost always required)
Conceptual Site Model
Wells for Abstraction: Flow, Flow... and Flow

Wells located near lineament with screen in rock
Wells located far from lineament with screen in rock
Wells located near lineament with screen in rock and soil
Wells located far from lineament with screen in rock and soil

Fonte: Fernandes & Rudolph (2001)
Tools Available for Fractured Media Investigation

- **Qualitative**
  - Mathematical Model
  - Surface geophysics
  - Geological Surveys
  - Desktop studies

- **Quantitative**
  - FLUTe wells
  - NAPL FLUTe
  - Angled wells
  - Multilevel wells
  - Packer Tests
  - Pumping Tests
  - Borehole geophysics
  - Laboratory Core Testing
  - Transducers

- **Not intrusive**
  - Rock coring boreholes
  - Air rotary boreholes

- **Cost**

- **Groundwater sampling**

No silver bullet. Use multiple lines of evidence.
Investigating Fractured Media (High Complexity)

• Fractured media is typically highly anisotropic and heterogeneous

• Limited amount of case studies fully investigated

• Risk of plume/DNAPL mobilization
Uncertainty

- For fractured media investigations, certainty is typically more dependant on quality than quantity or cost
Positioning Monitoring Wells in Fractured Media

Not all fractures are useful (e.g. several are closed; several are not connected).

Monitoring wells positioning can be optimized by using multiple lines of evidence to target representative fractures related to key areas:

- Impacted receptor
- Impacts of a contaminant source
- Preferential flow paths

Update Conceptual Model
Example 1

• Investigating an impacted receptor

2 main exposure routes confirmed with packer sampling and targeted monitoring wells
Example 2

- Investigating preferential flow paths

Pathways intercepted with targeted monitoring wells
Example 3

• Investigating impacts of a shallow DNAPL source

Contaminant distribution and chemical signature confirmed with targeted monitoring wells
Conclusions

• Not all fractures matter. Monitoring wells shall target key areas based on multiple lines of evidence. No silver bullet.
• Non intrusive studies and existing wells can provide highly useful data (such as existence of high angle fractures)
• Care for plume/DNAPL mobilization
• Assess importance of fractures in soils
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