DIRECT VELOCITY TOOL : A NEW TOOL FOR GROUNDWATER VELOCITY DETERMINATION

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Laboratory and field experiments

INTERSOL 2018

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GROUNDWATER MEASUREMENT WITH THE DIRECT VELOCITY TOOL

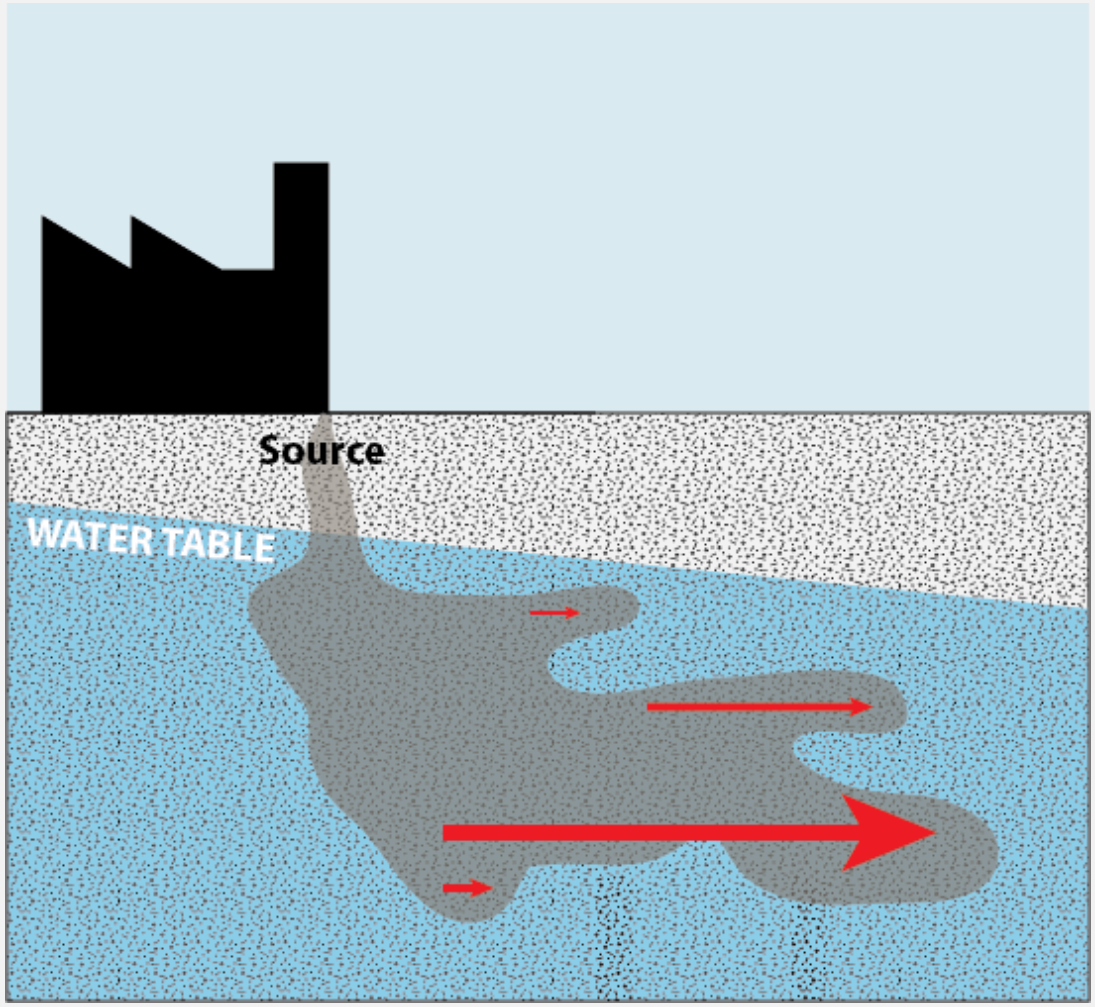
I. BACKGROUND

II. PRESENTATION AND DESCRIPTION OF THE DVT

III. LABORATORY TESTS

IV. FIELD COMPARISON

MASS FLUX MEASUREMENT



- **Heterogeneous plume definition**
- **Mass flux measurement**

⇒ **Risk evaluation**

⇒ **Remediation optimised**

⇒ **Cost benefits**

MASS FLUX MEASUREMENT

Measurement:

⇒ **Groundwater velocity: V**

L/T

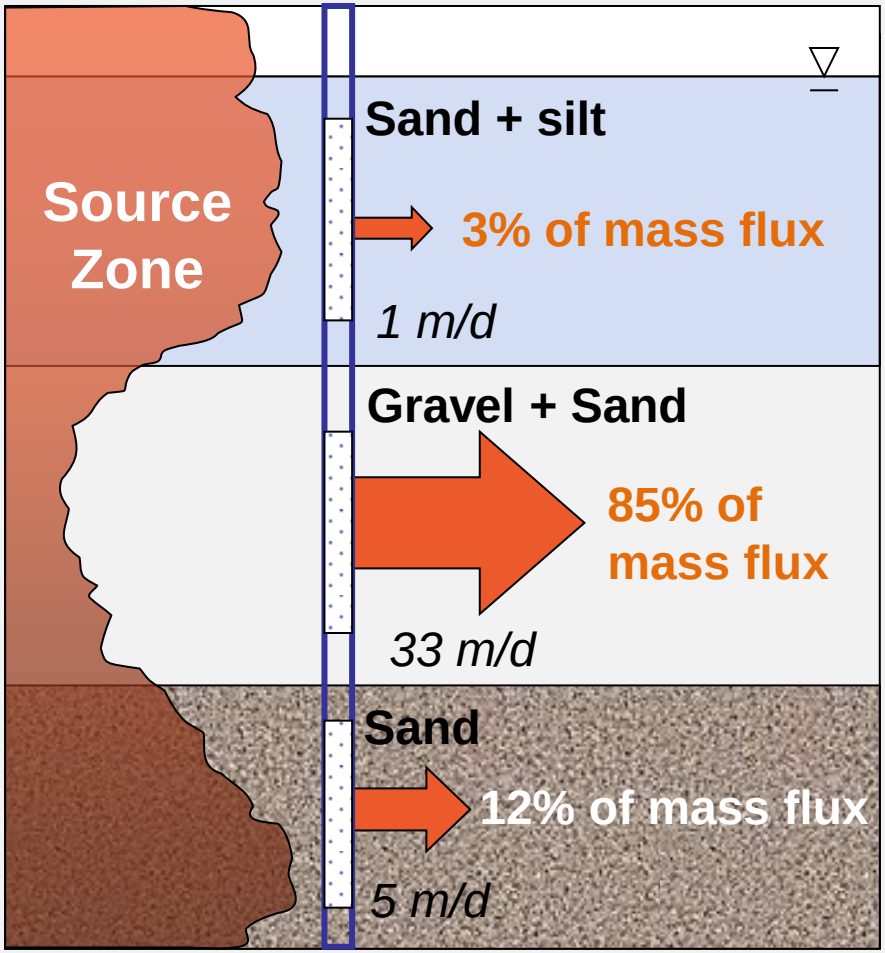
⇒ **Contaminant concentration: C**

M/L^3

CONTAMINANT FLUXES

J = C x V

$M/L^2/T$



RITS Spring 2011: Embracing Mass Flux and Mass Discharge

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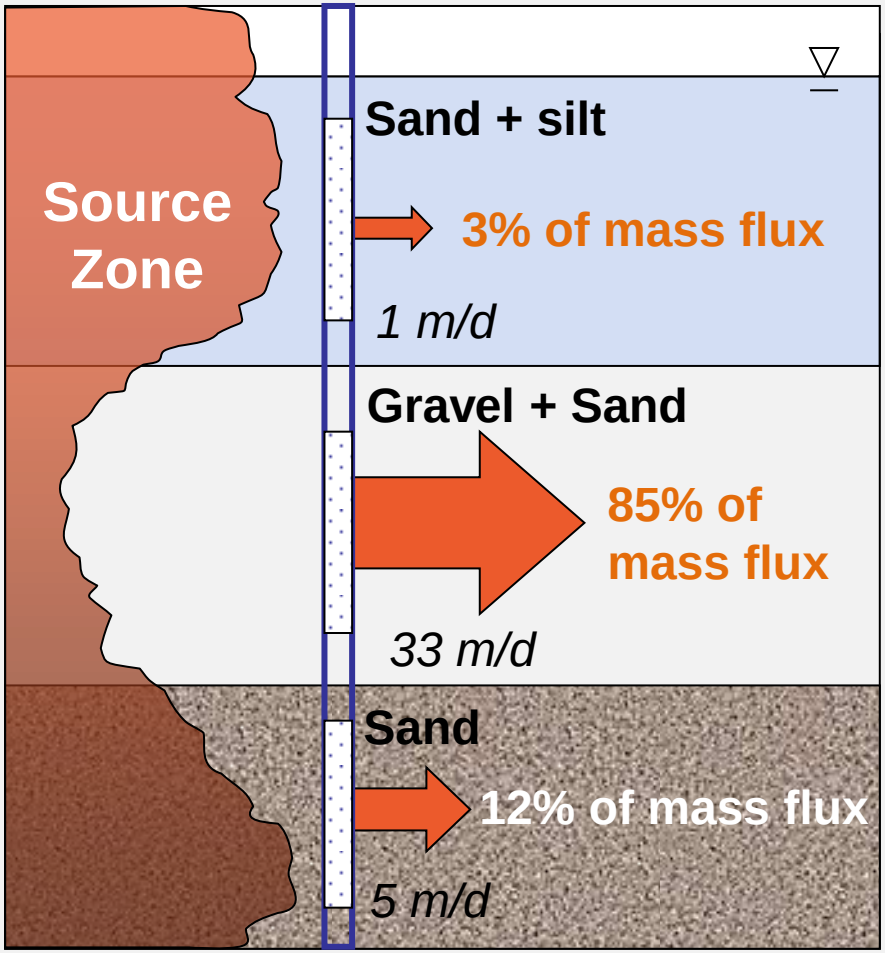

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GROUNDWATER VELOCITY MEASUREMENT

- **EXISTING TOOLS FOR GROUNDWATER VELOCITY**

TOOLS	USING	HOW	TIME OF MEASUREMENT	REFERENCE
PFM (passive flux meter)	In-well	Tracers displaced from the sorbent	1 – 4 weeks	Annable, Hatfield, 2004
Borehole dilution test	In-well	Dilution of a tracer in the isolated-interval	Hours	Drost et al. , 1967
PVP (Point Velocity Probe)	Direct-push	Travel time of a tracer pulse in a cylindrical probe	Hours	Devlin et al. 2009
Colloidal Borescope	In-well	Observation of particle movement	30 min – 1 h	Kearl et al., 1992

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DVT - PRINCIPLE

- **Principle**

- **Tool maintained against the screen**

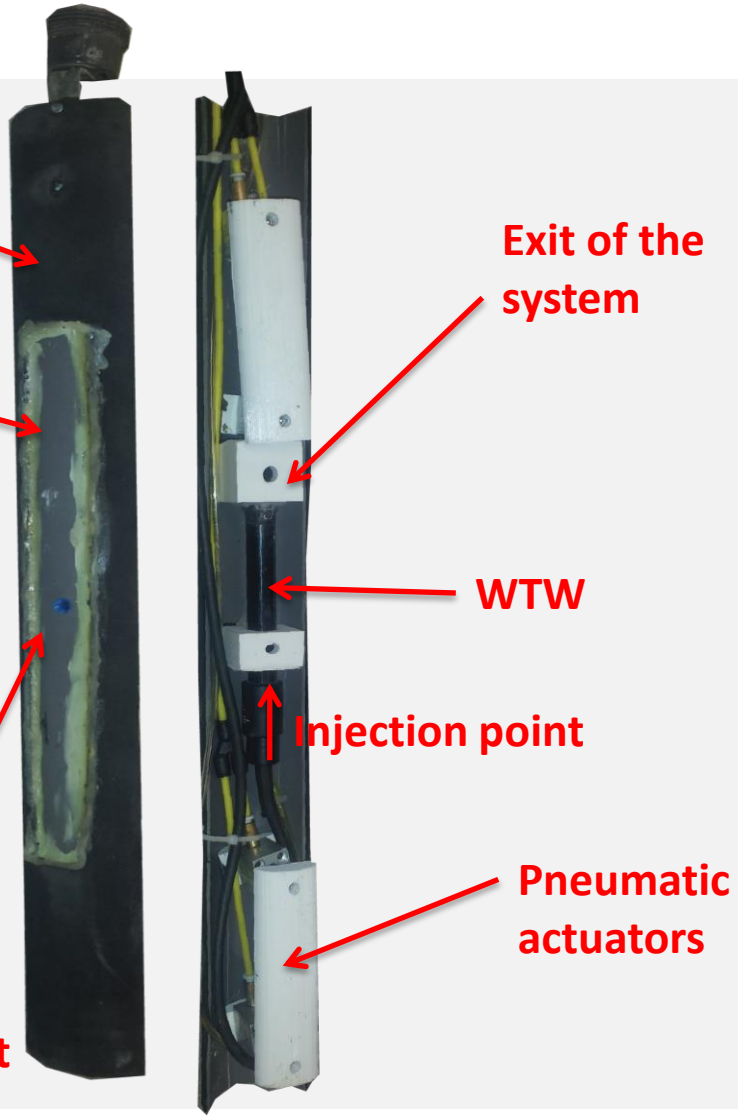
- **Continuous injection**

- **Homogeneous mixure measurement**

  (Groundwater + solution)

$$C_{aquifer} \times Q_{aquifer} + C_{solution} \times Q_{solution}$$

$$= C_{mélange} \times (Q_{aquifer} + Q_{solution})$$



DVT - AVANTAGES

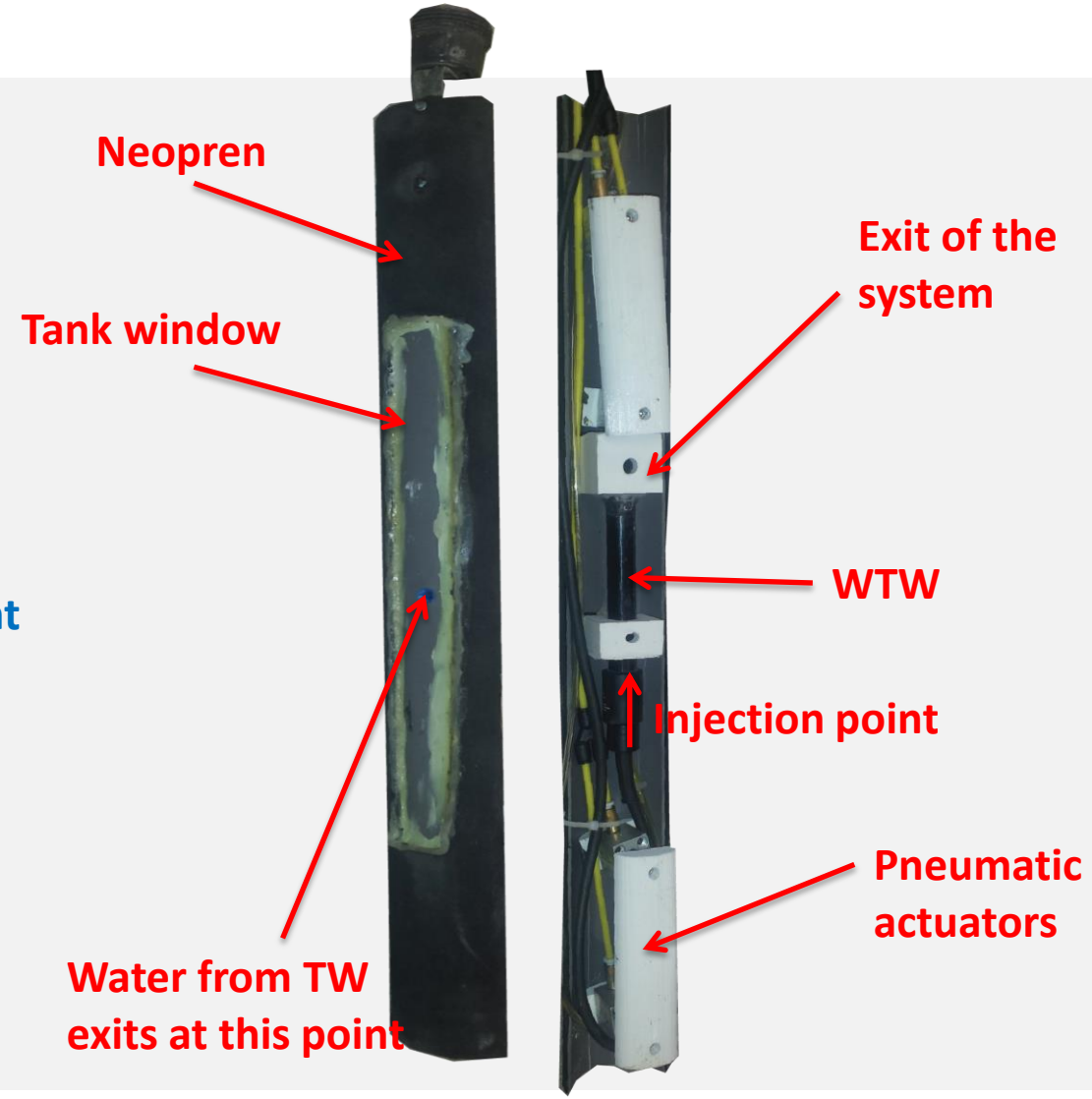
⇒ Time = 5 – 10 min

⇒ Adapted for low velocities

0 – 40 cm/day

⇒ Isolated interval of measurement

⇒ Vertical distribution



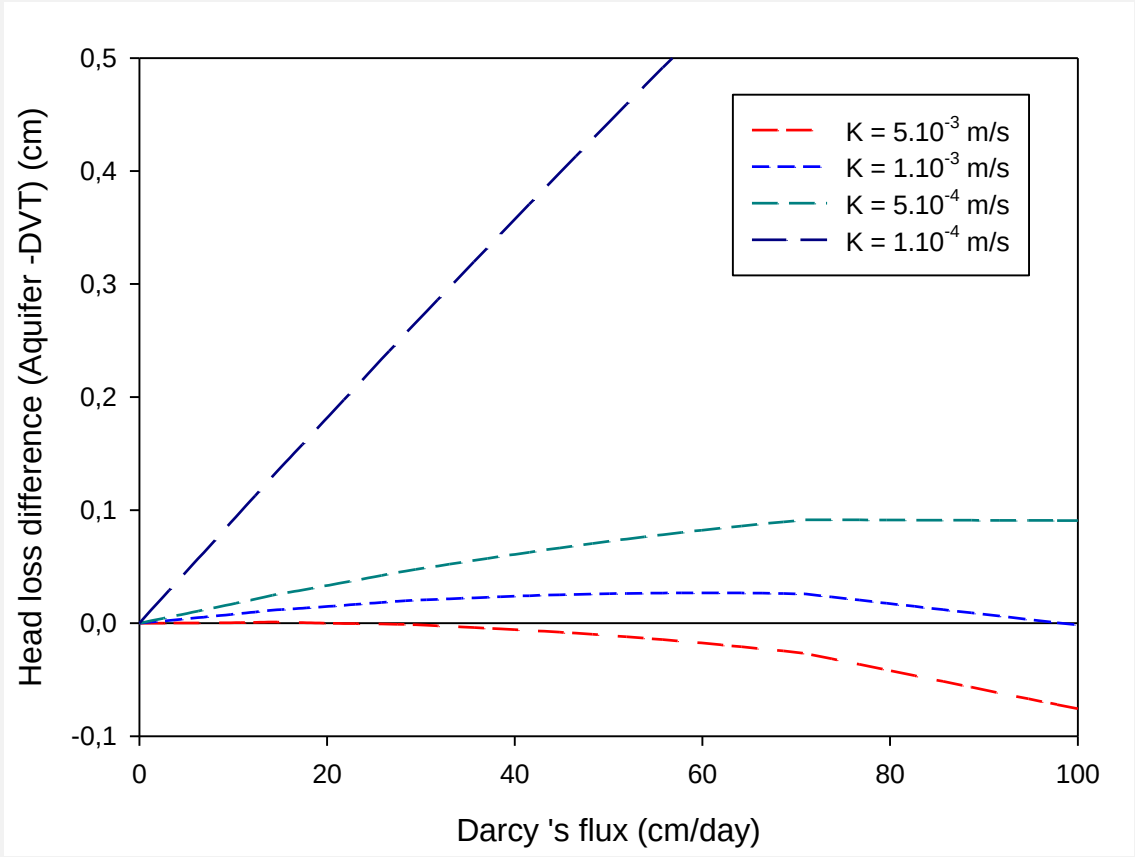
LABORATORY TEST

DVT Limitation

If Head loss difference ≤ 0

⇒ Measurement is not possible

⇒ Head loss depending on Inlet System geometry



LABORATORY TEST

Sand tank measurement

- **Caracteristic :**

- **Gravel pack (75 mm)**

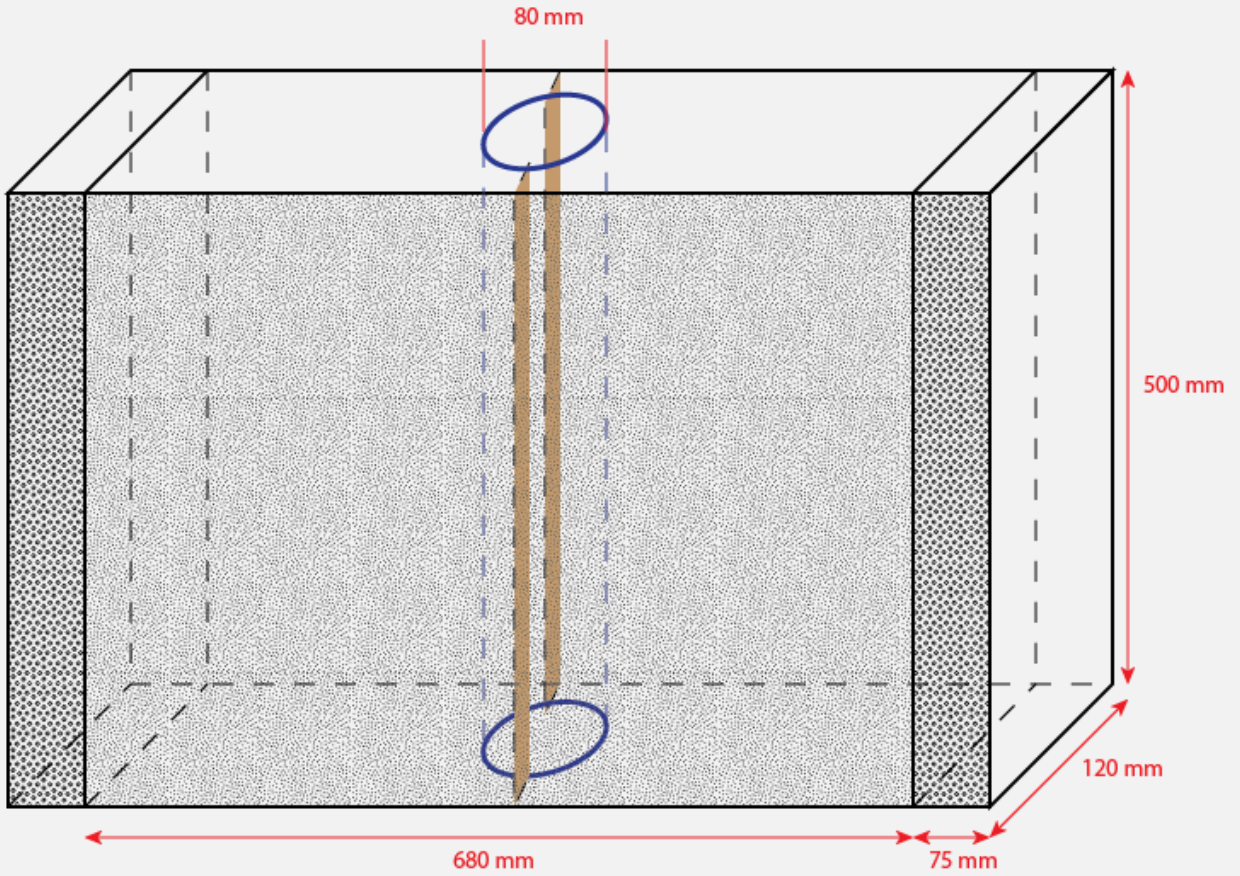
(upstream and downstream)

- **Coarse sand**

=> K = 3,9.10^{-3} m/s and

=> Porosity = 38%

- **Screen well (80 mm)**



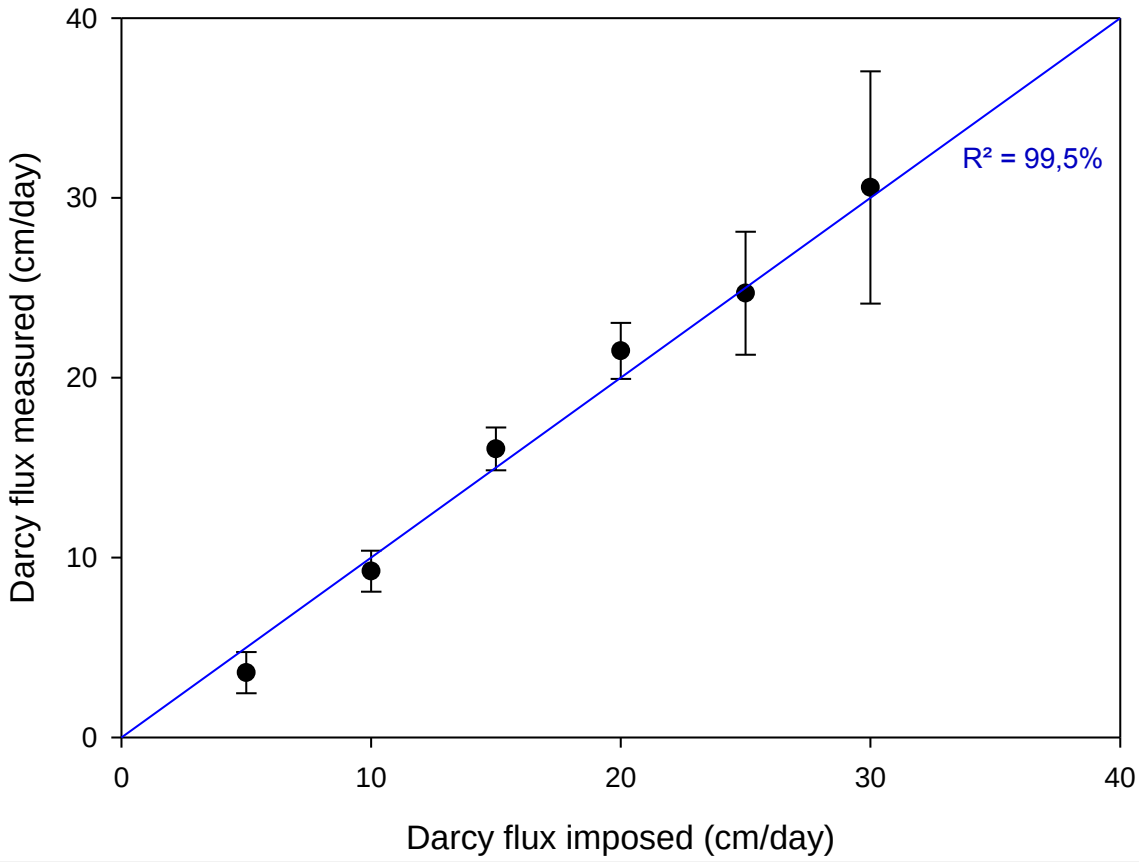
- **2 clay zones to avoid water deviation outside the well**

LABORATORY TEST

Sand tank measurement

⇒ **Proportional to the rate flow**

⇒ **Repeatable measurement**



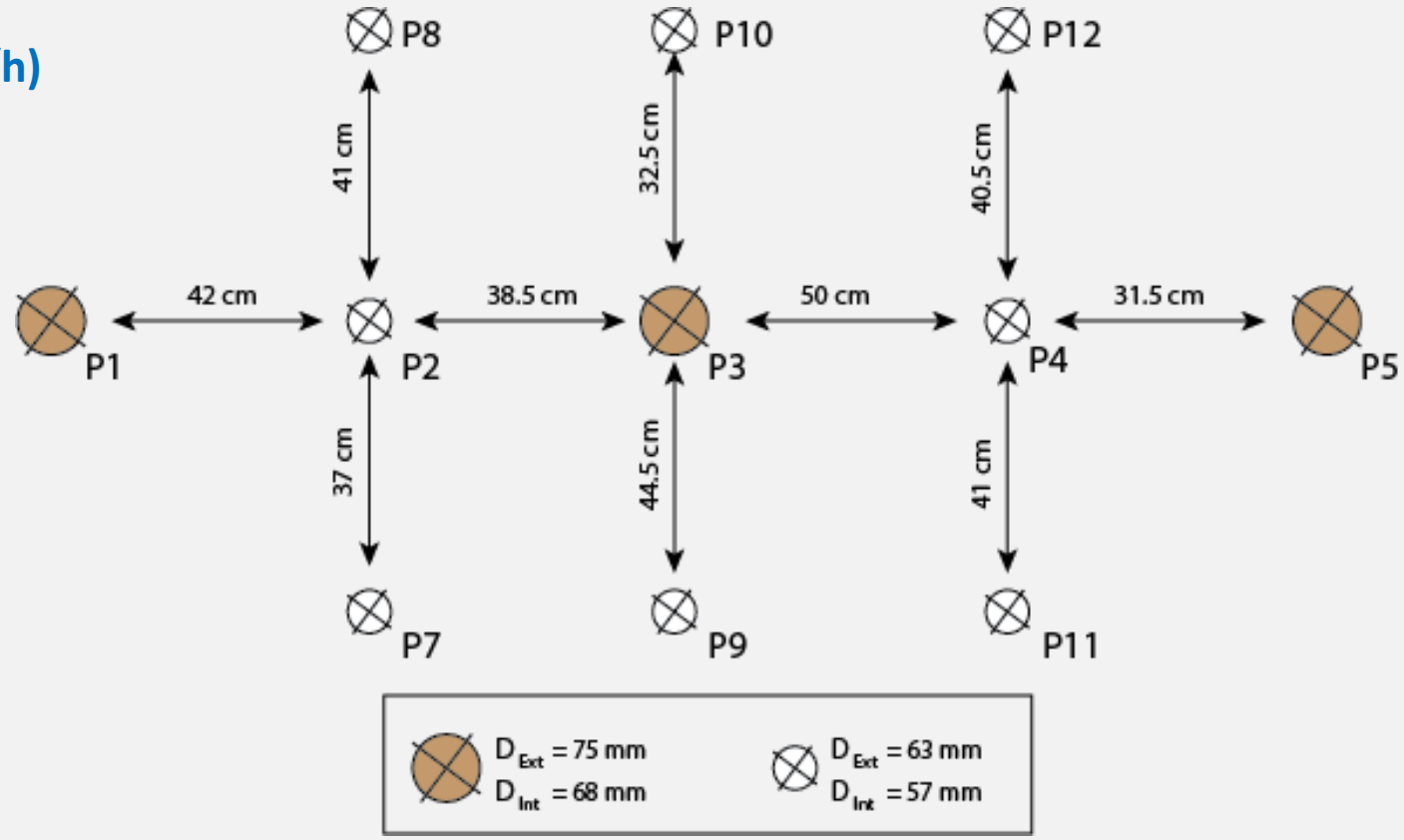
FIELD TEST A – CONTROLLED FIELD

Context

⇒ **P5 : Pumping (75L/h)**

⇒ **P1 : Injection**

⇒ **P3 : Measurement**



FIELD TEST A – CONTROLLED FIELD

Comparison of velocity measurement

TOOLS USED

⇒ **Direct Velocity Tool**

⇒ **Tracer Test**

⇒ **Passive Flux Meter**

⇒ **Borehole Dilution Test**

FIELD TEST A – CONTROLLED FIELD

Comparison of velocity measurement

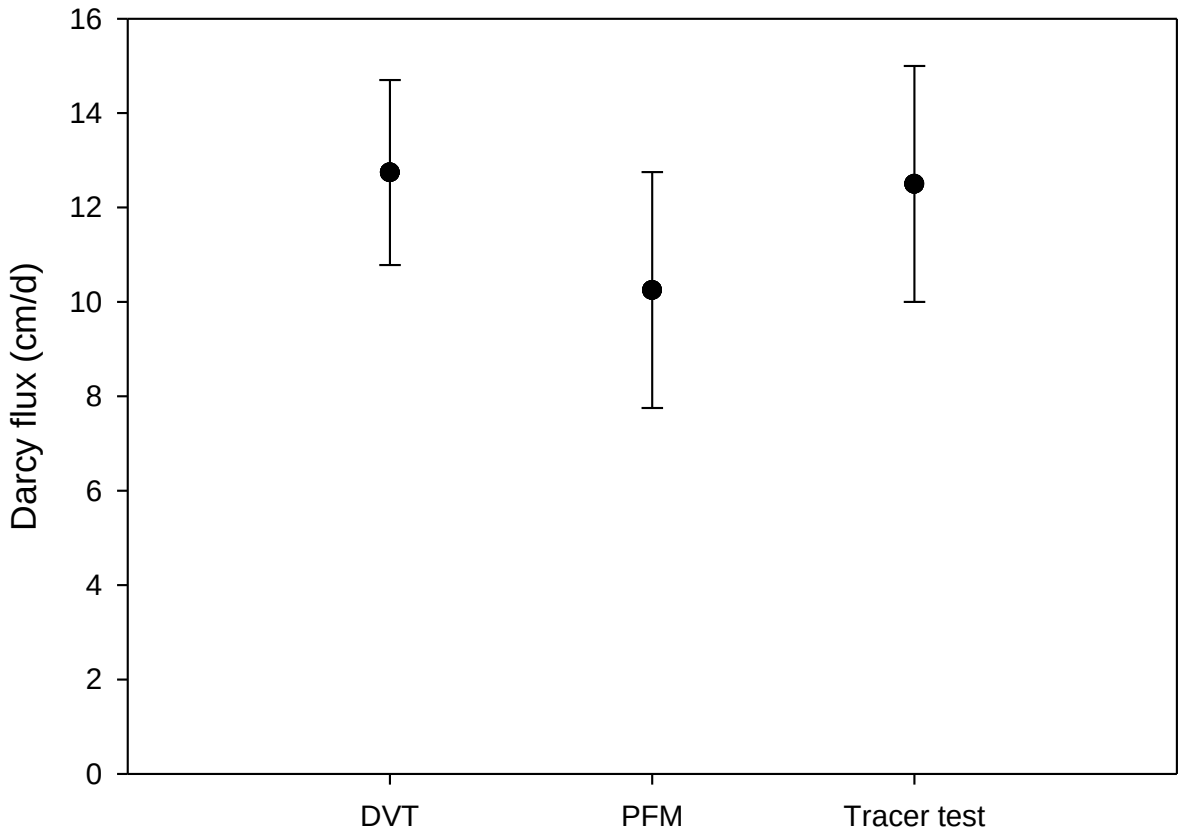
⇒ **DVT / PFM / Tracer test**

Same order of magnitude

⇒ **Borehole dilution test**

Gave a higher value

125 cm/day

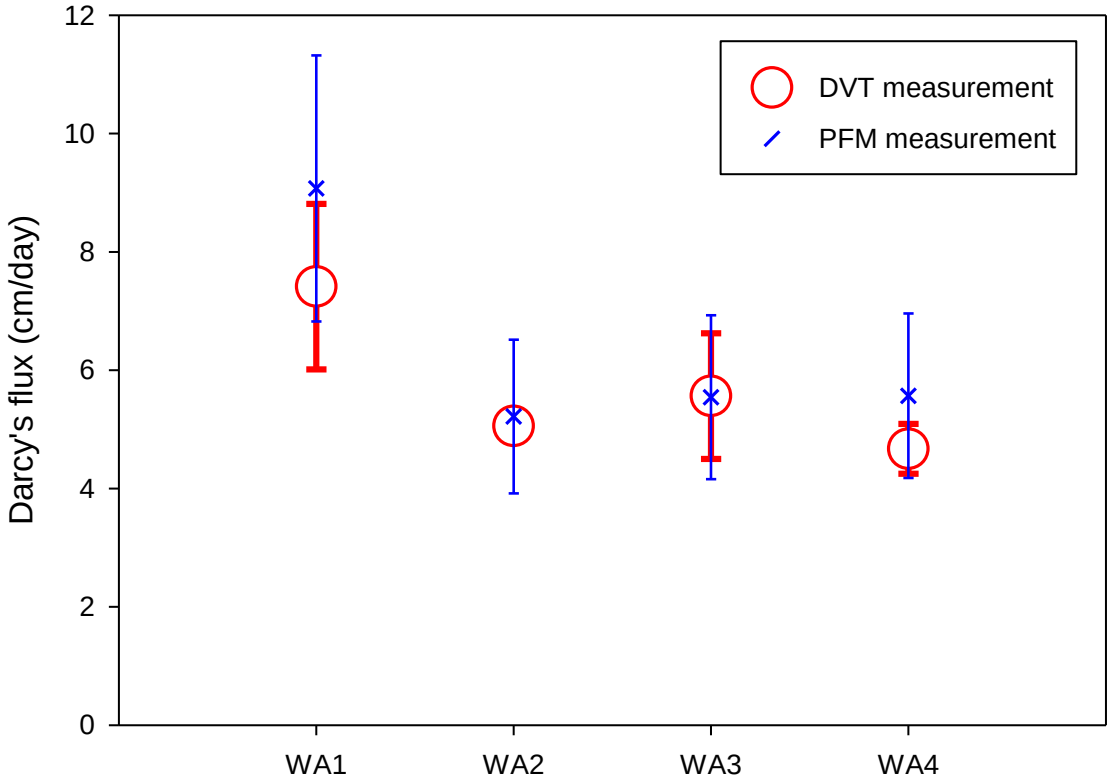


FIELD TEST B - CONTAMINATED SITE

Comparison DVT and PFM

⇒ **Four wells**

⇒ **Same order of magnitude**



CONCLUSION

	CONTROLLED FIELD				CONTAMINATED SITE	
	Tracer test	Borehole dilution test	PFM	DVT	PFM	DVT
Darcy flux measured cm.day^{-1}	10 - 15	145	10,25	12,74	5 - 9	4 - 8
Uncertainties cm.day^{-1}	± 2,5	UNKNOWN	± 2,5	± 1,97	± 1,75	± 0,76

CONCLUSION

⇒ **DVT : INNOVATIVE SOLUTION FOR GROUNDWATER MEASUREMENT**

⇒ **EASILY DEPLOYED AND VELOCITY IS MEASURED RAPIDLY (5 – 10 minutes)**

⇒ **VERTICAL DISTRIBUTION OF HORIZONTAL VELOCITY**

⇒ **SOLEAU DEPOSED IN JUNE 2017**

⇒ **TRANSFER OF TECHNOLOGY VIA G&E TRANSFERT - PoCible**

THANK YOU FOR YOUR ATTENTION