Use of the *Conduit Flow Process* for the simulation of passive mitigation measures against the piezometric damming effect at the new underground High Speed railway station of Florence.

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Site location

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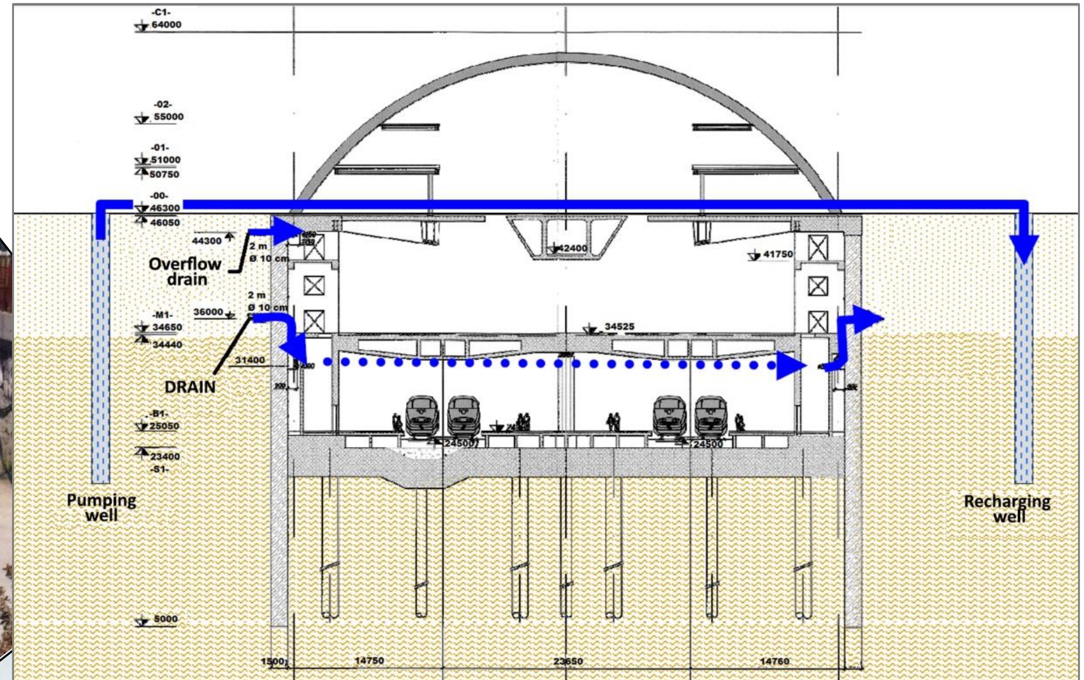
Station pit

The pit in Feb. 2016



Station design

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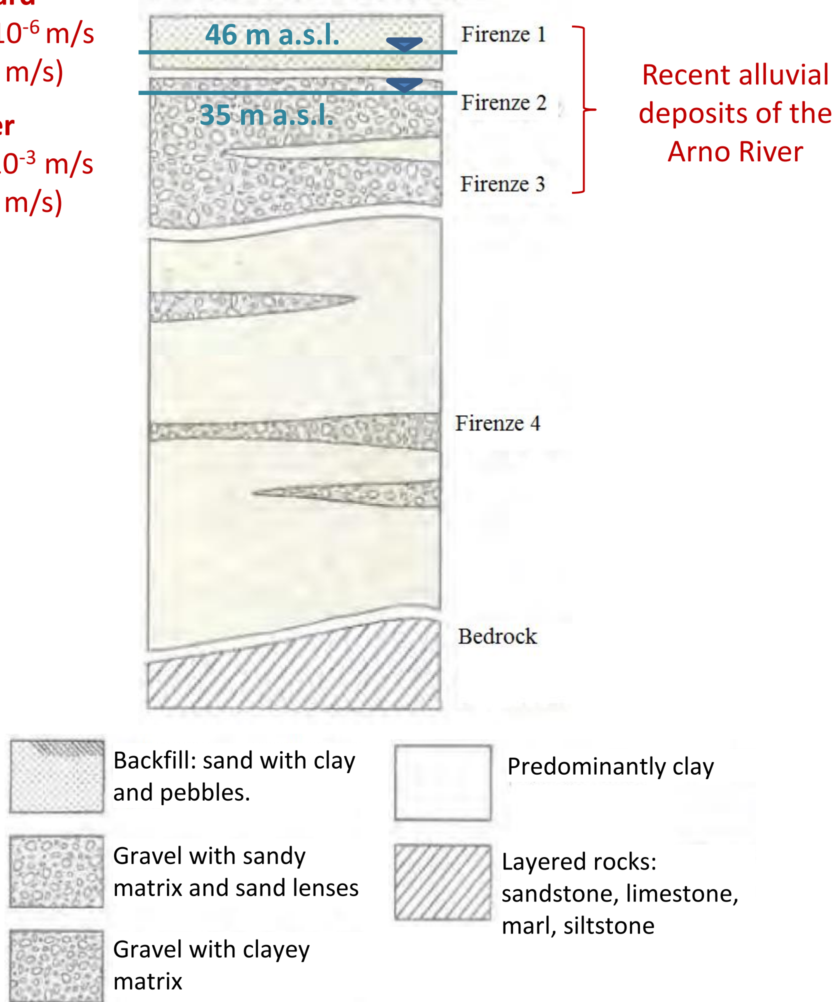
Hydrogeologic outlines

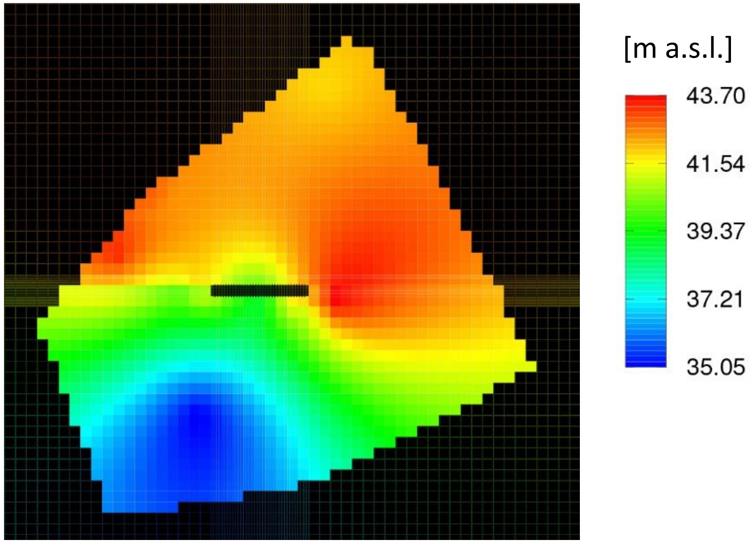
Aquitard
(k: 1×10^{-6} m/s
1×10^{-9} m/s)

Aquifer
(k: 1×10^{-3} m/s
5×10^{-5} m/s)

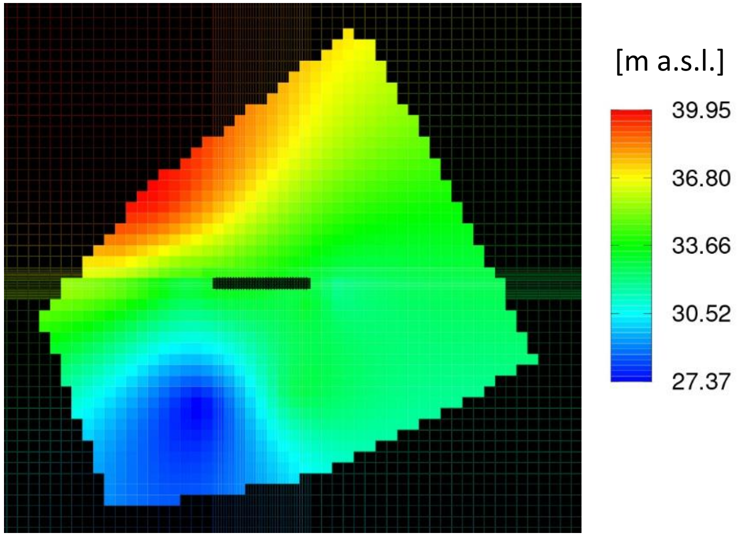


Capecchi et alii, 1975

Aquifer Top elevation:

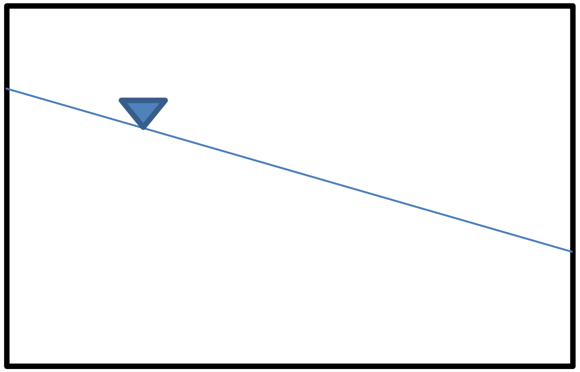


Aquifer Bottom elevation:

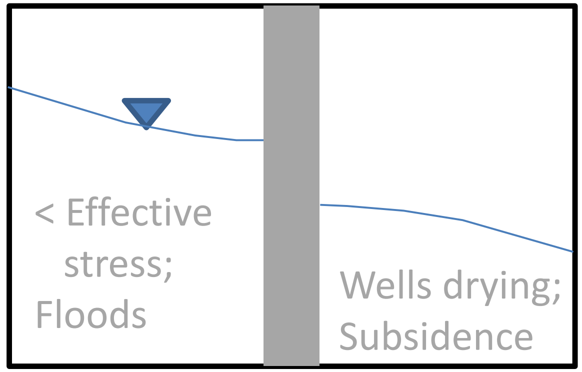


Piezometric damming effect and active mitigation (temporary)

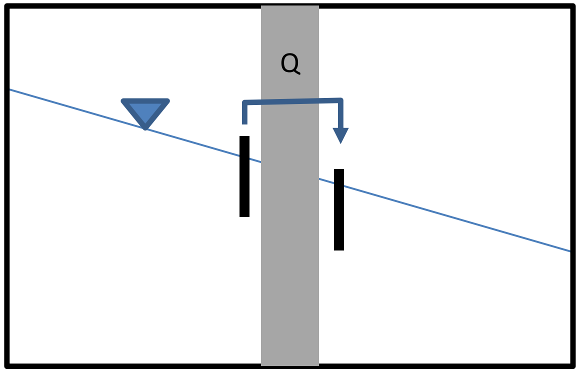
Undisturbed water level

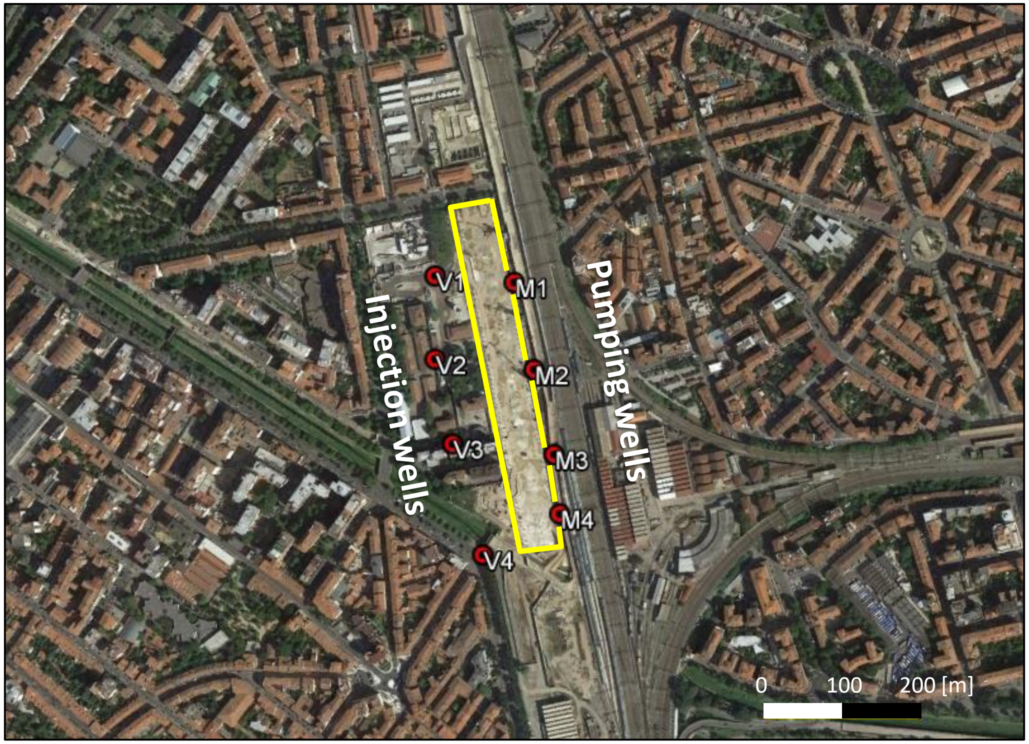


Damming effect

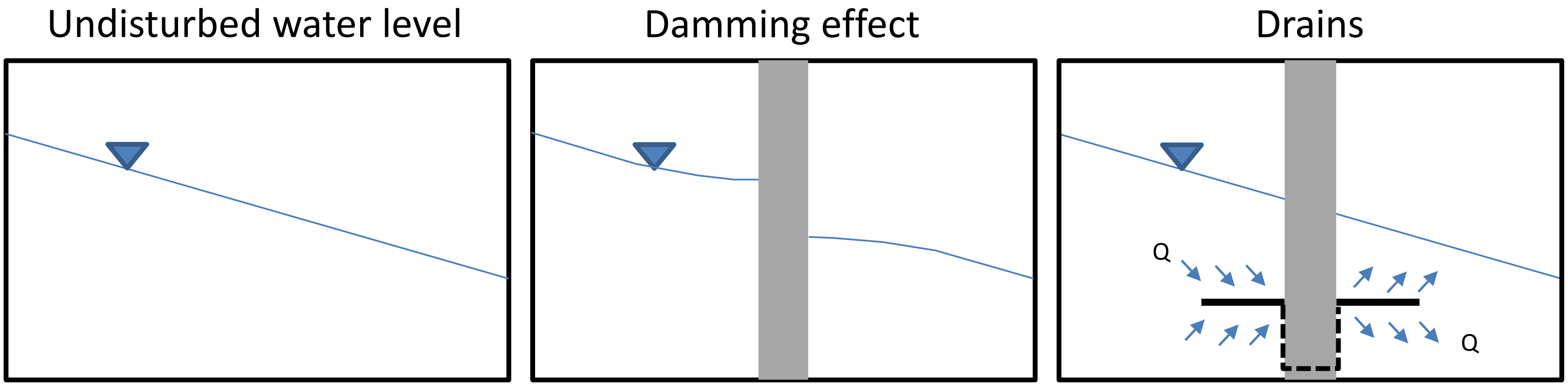


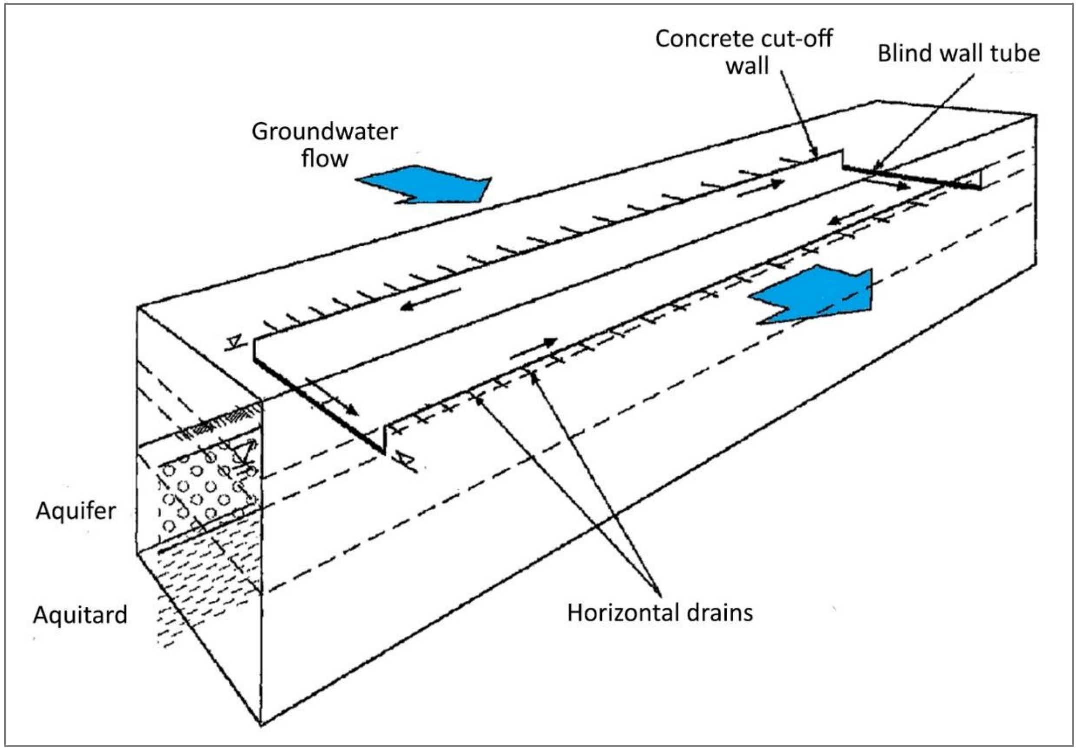
Wells





Piezometric damming effect and passive mitigation (permanent)





Objective:
Hydraulic transparency

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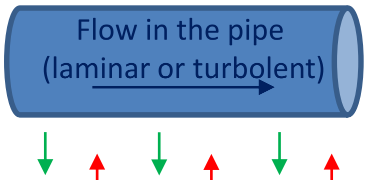
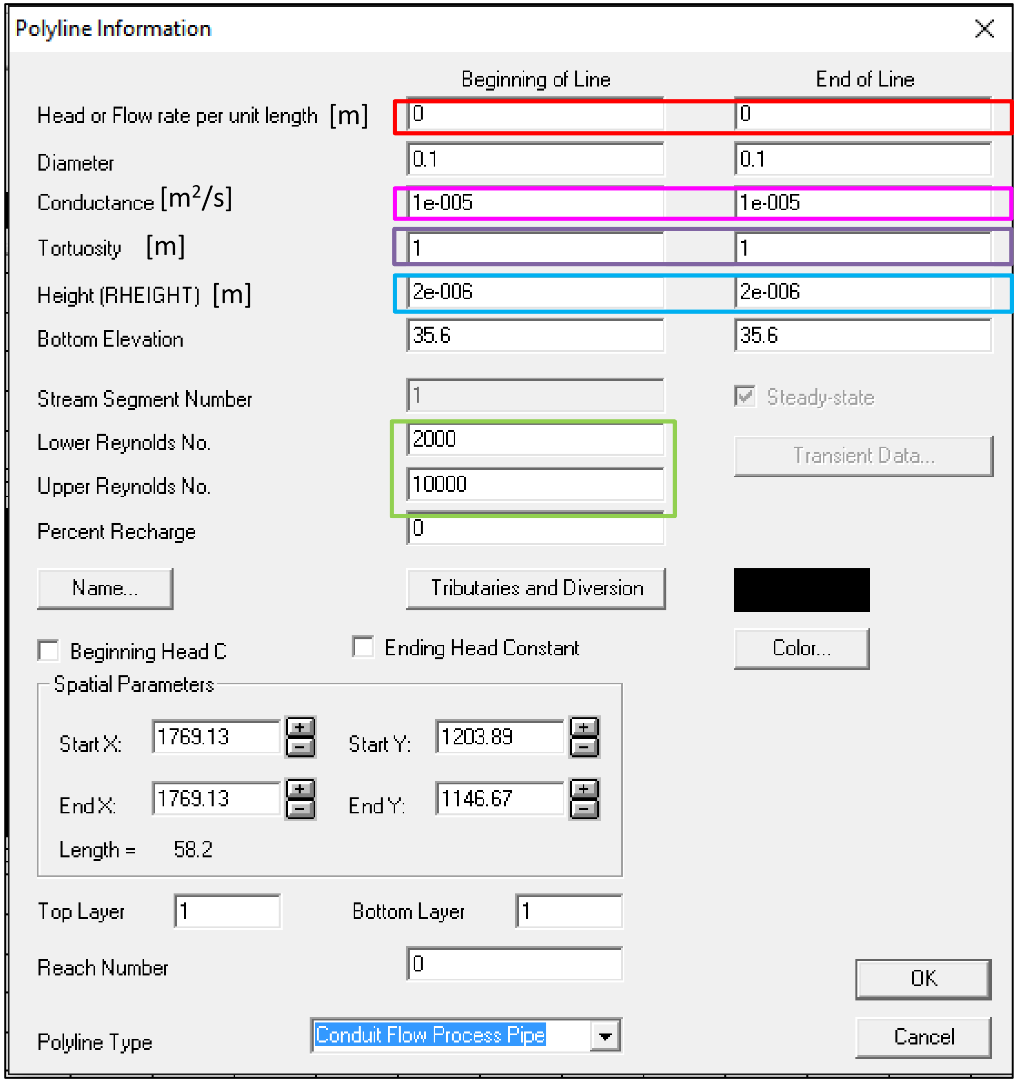
Conduit Flow Process (MODFLOW)

Shoemaker, W.B., Kuniansky, E.L., Birk, Steffen, Bauer, Sebastian, and Swain, E.D., 2008, **Documentation of a Conduit Flow Process (CFP) for MODFLOW-2005**: U.S. Geological Survey Techniques and Methods 6-A24, 50 p.

CFP:



Flow from the pipe to the aquifer
Flow from the aquifer to the pipe



"0" = head not fixed

??? (e.g. k of pipe wall)

"1" = straight pipe

Roughness: very low value assumed

from Moody diagram

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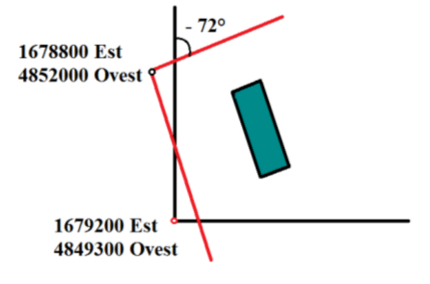
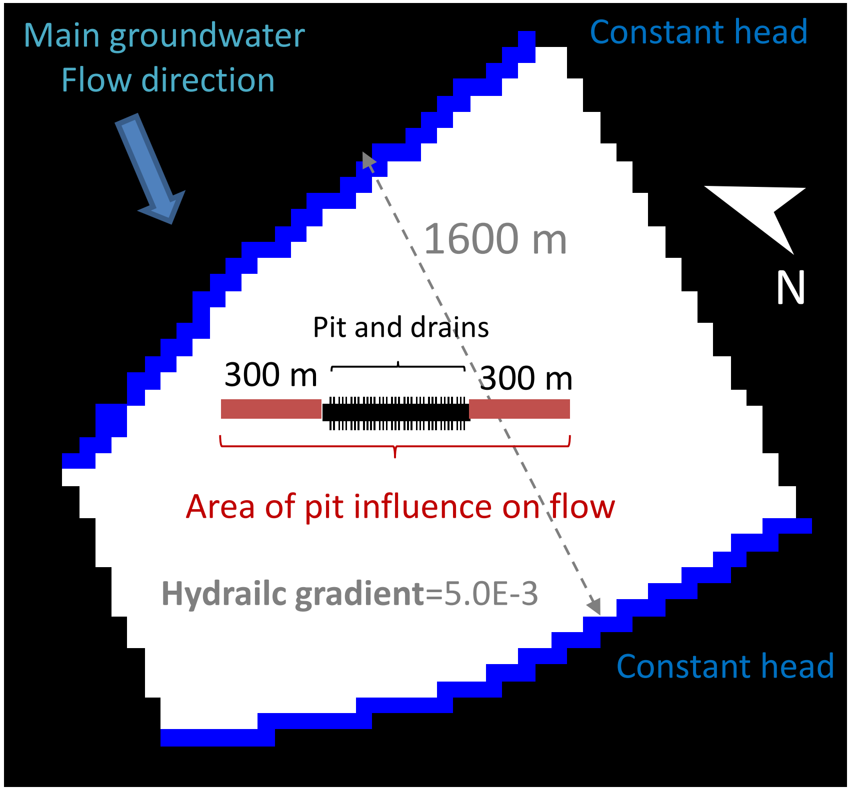
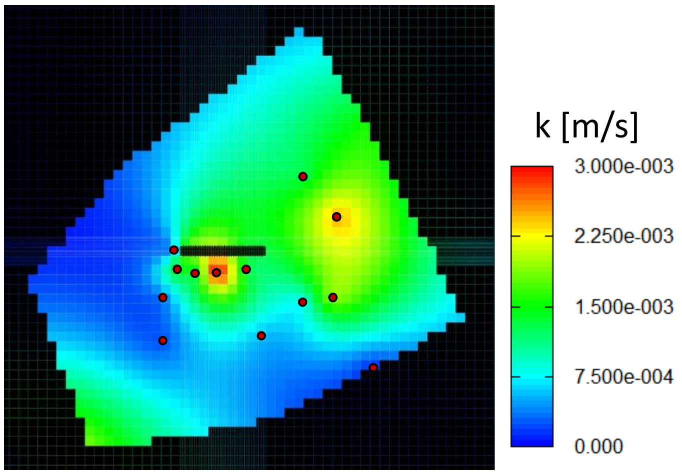
Numerical model – averaged head distribution





Steady- state flow



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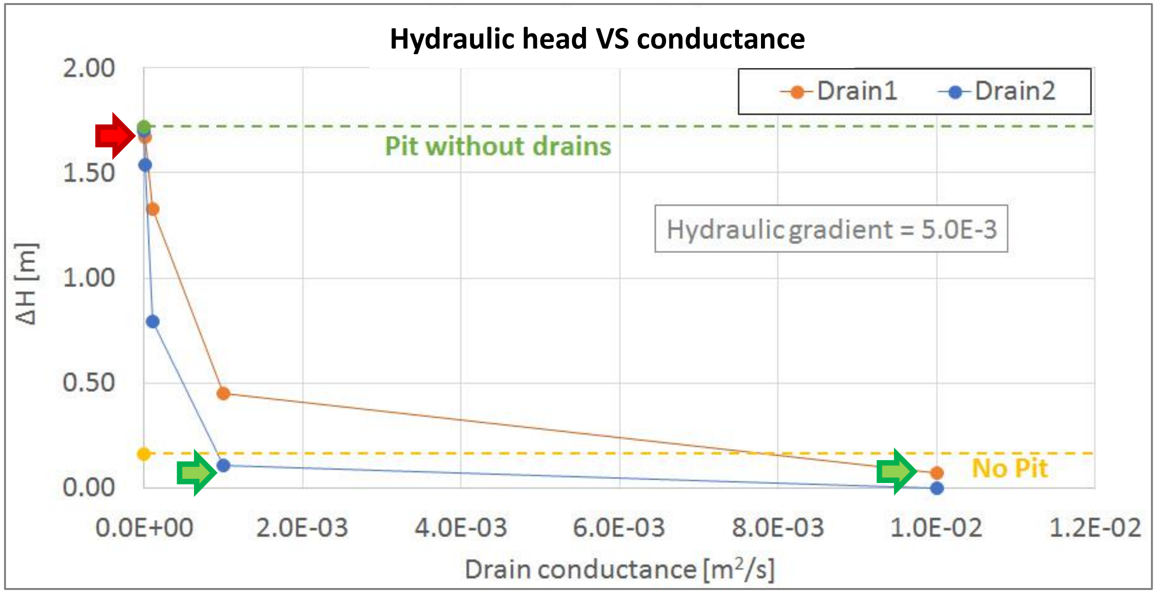
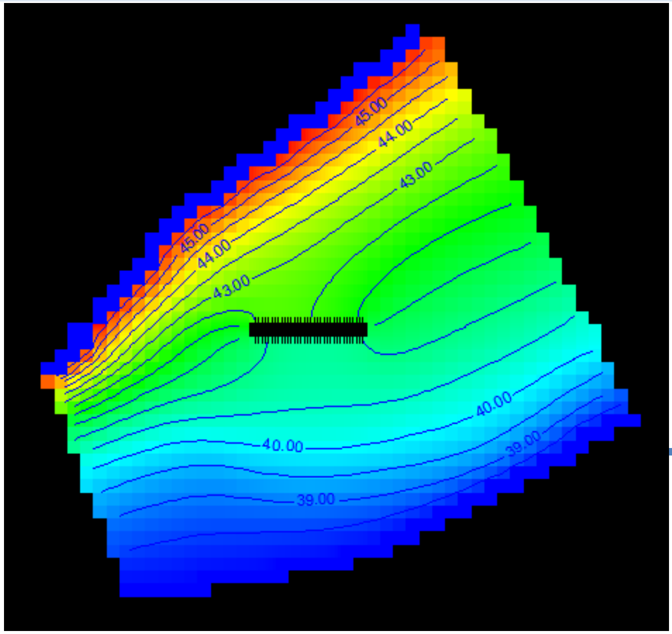
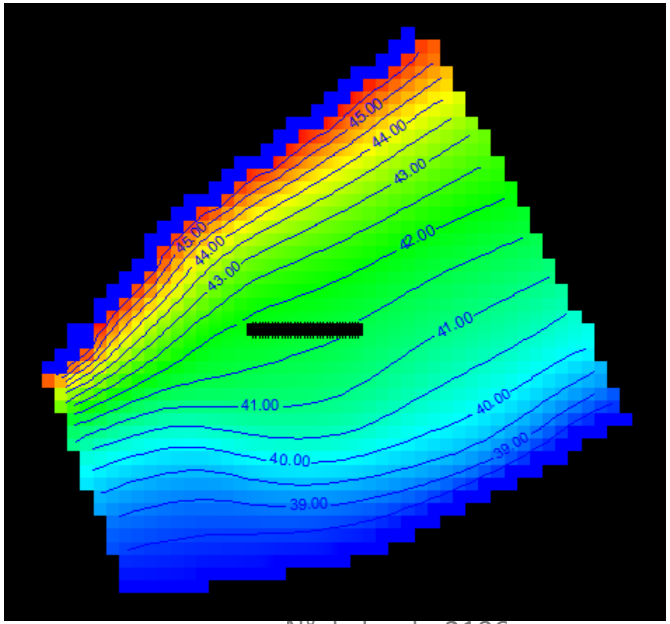
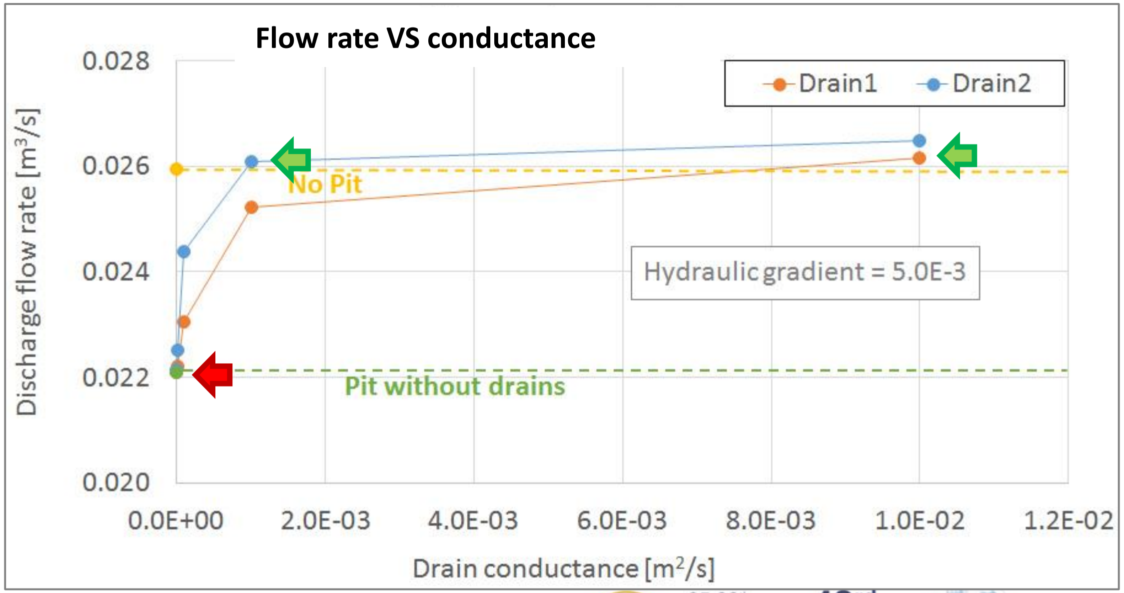
Numerical model – averaged head distribution - Results









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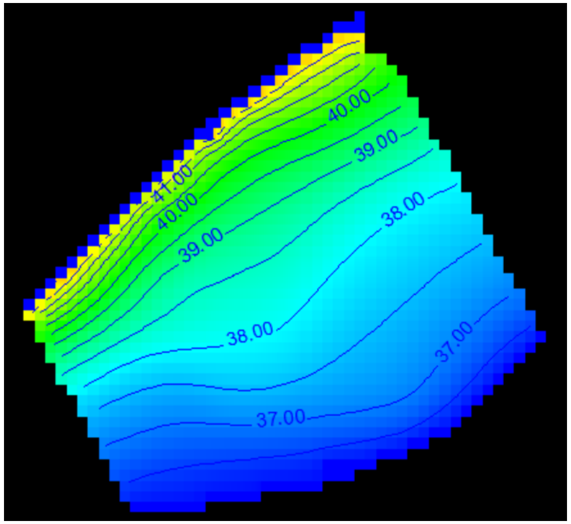
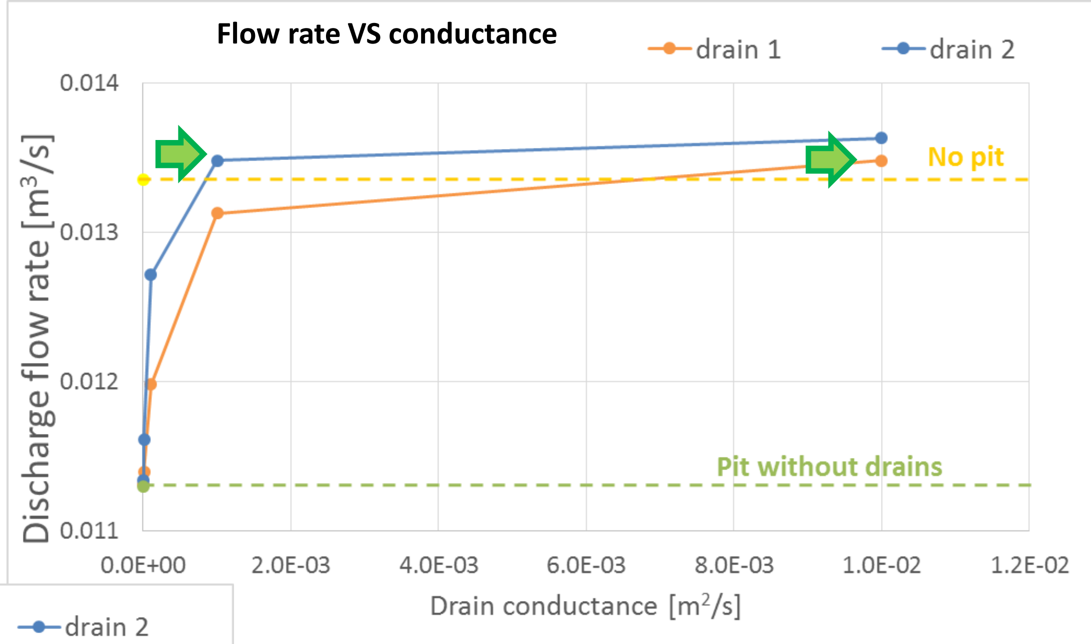
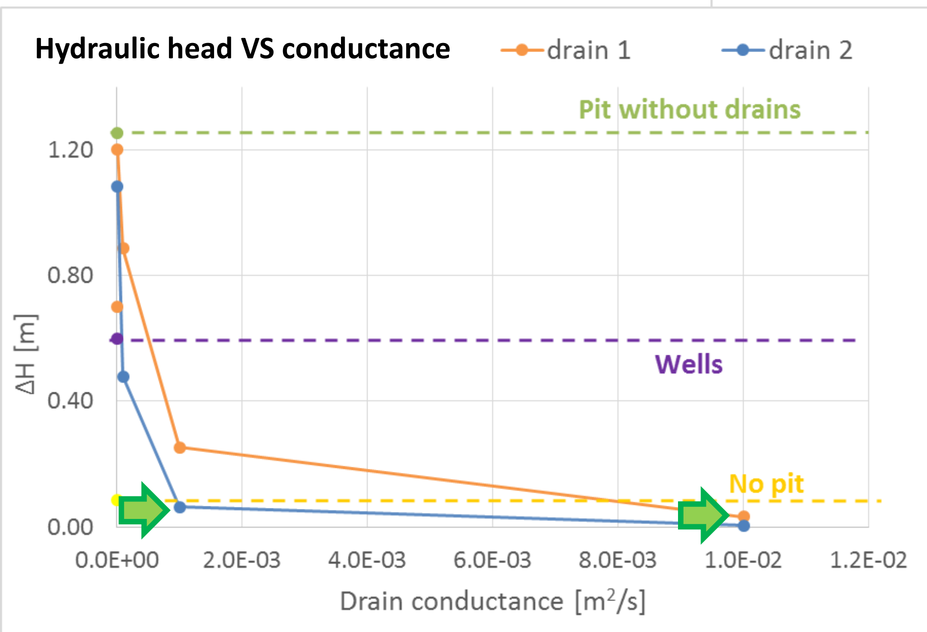
Seasonal variations – dry season







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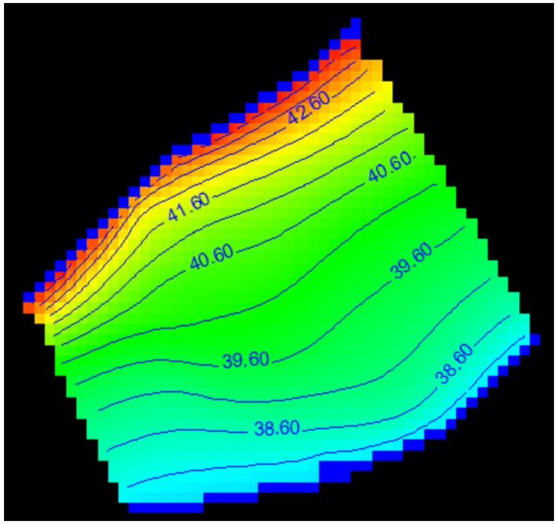
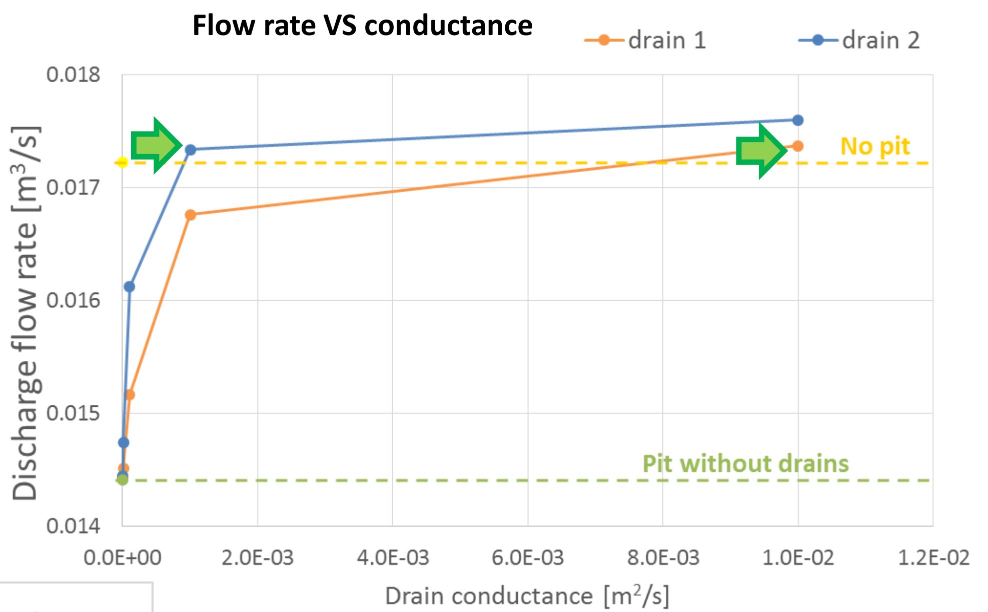
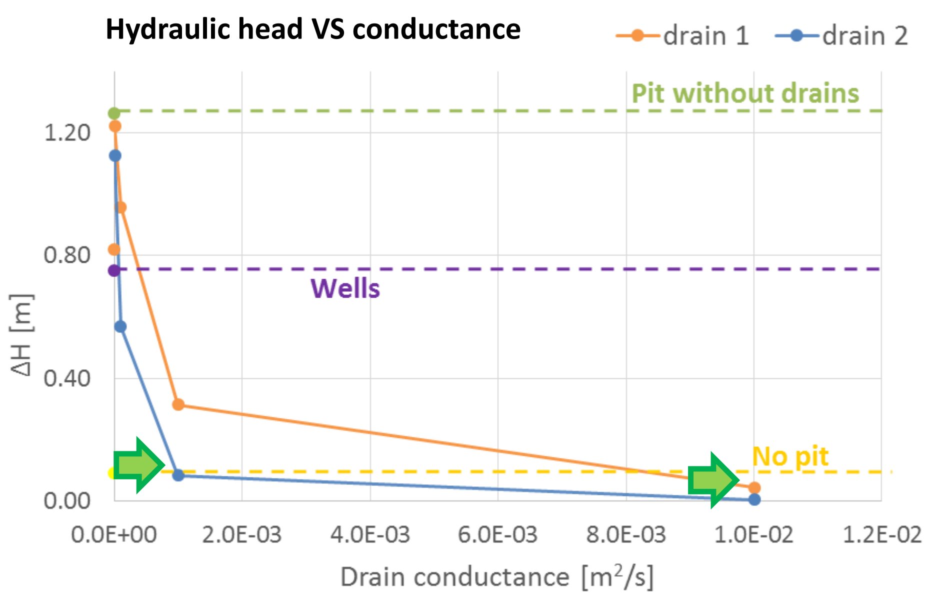
Seasonal variations – recharge season







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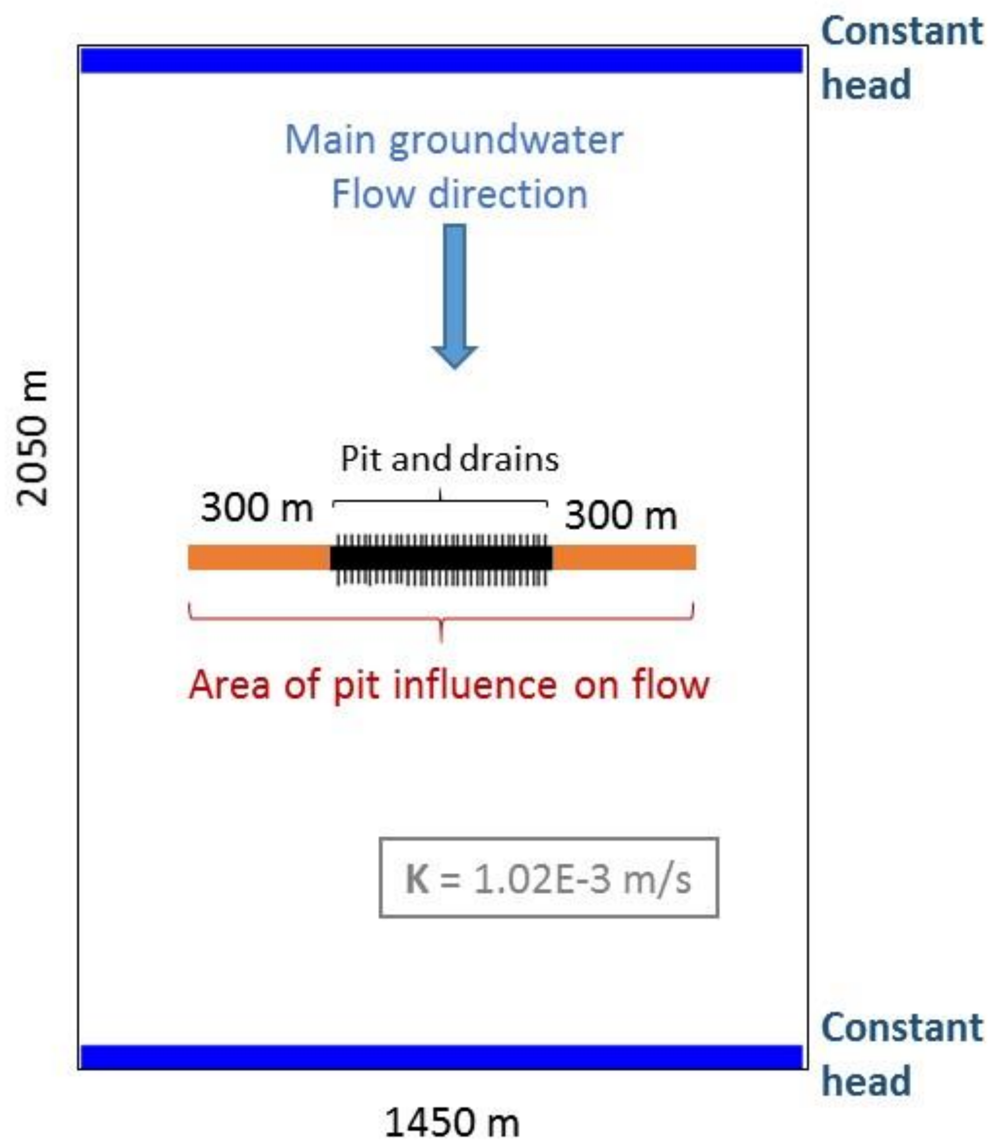
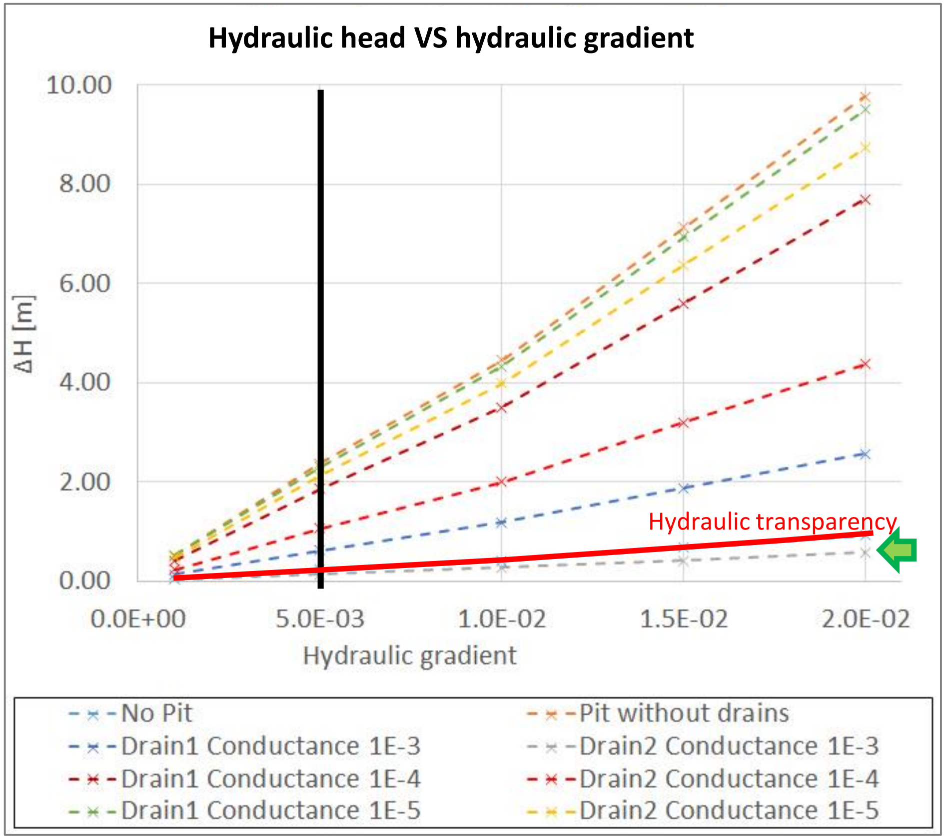
Hydraulic gradient variation

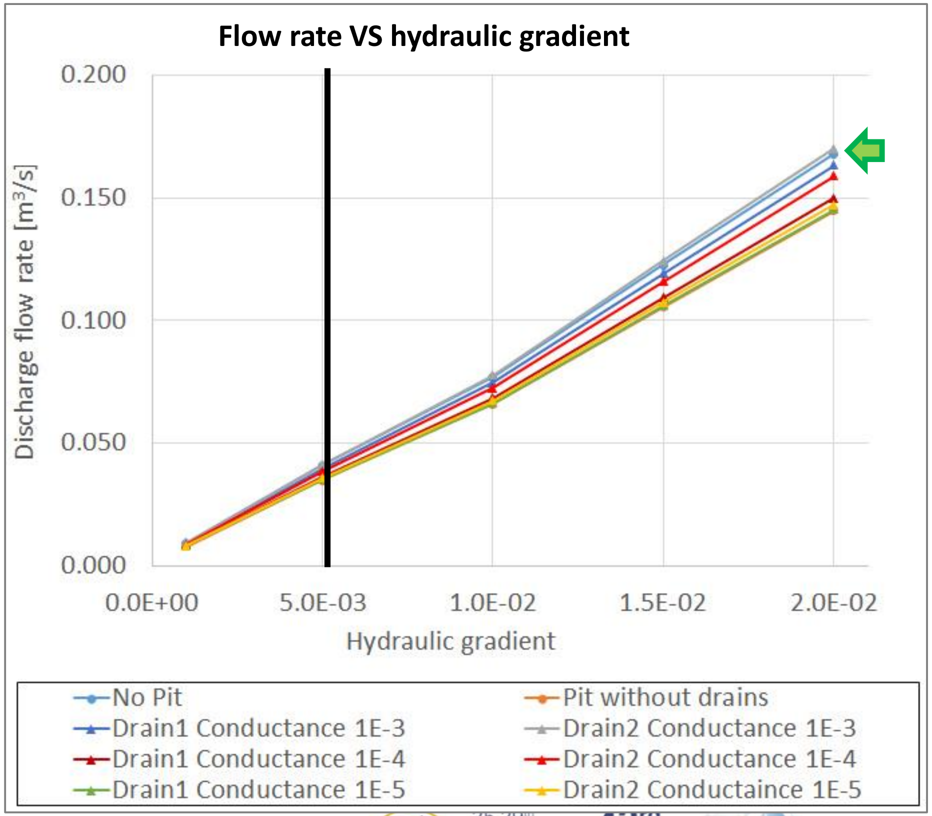


Hydraulic gradient variation – Results



Drain 1: 2 m length
10 cm diameter

Drain 2: 18 m length
20 cm diameter



Drain Conductance [m²/s]	Hydraulic gradient
$1x10^{-3}$	$1x10^{-3}$
$1x10^{-4}$	$5x10^{-3}$
$1x10^{-5}$	$1x10^{-2}$
	$1.5x10^{-2}$
	$2x10^{-2}$

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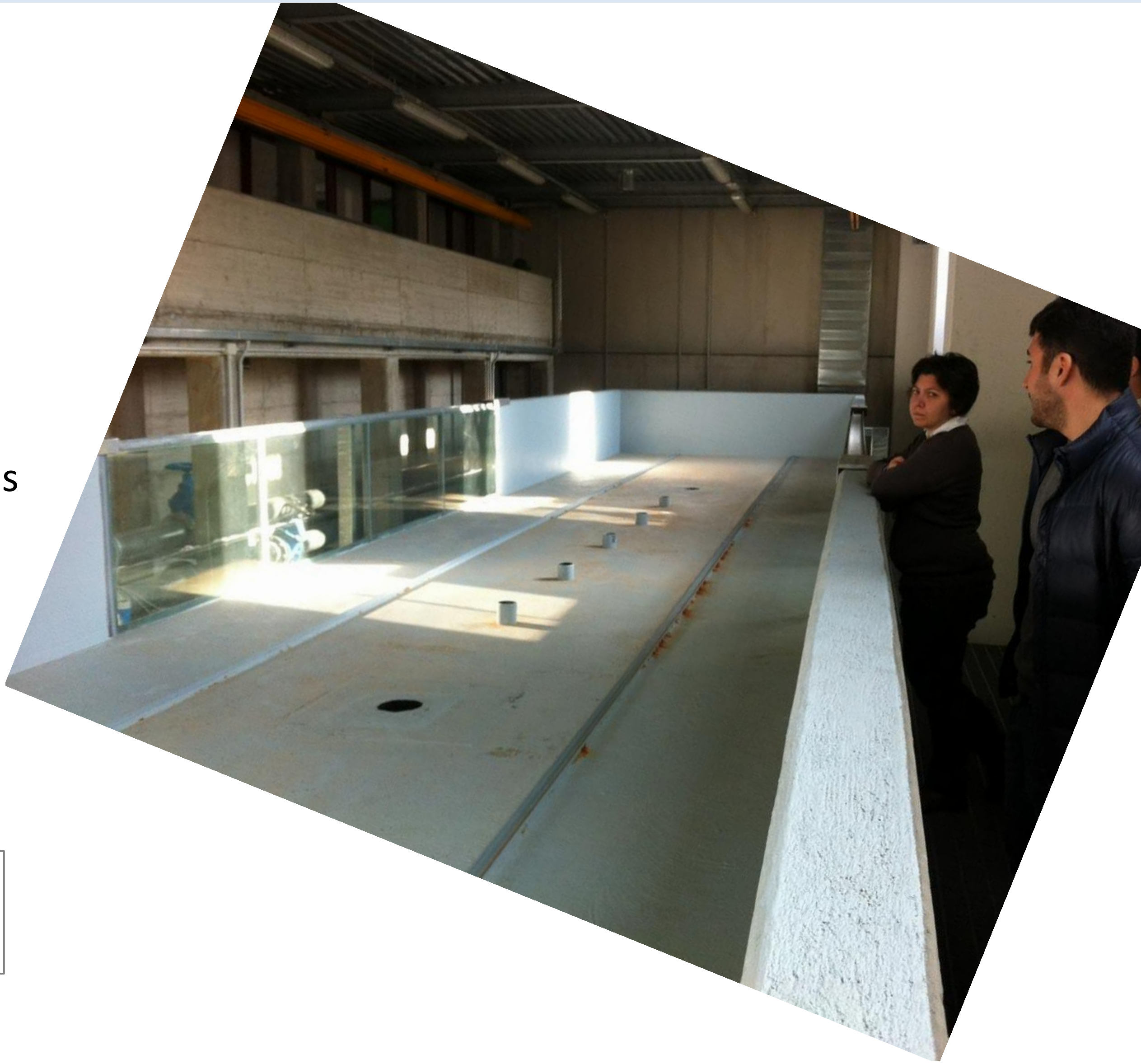
Conductance issue

- 1:1 physical model:

Single-drain (~ 15 m)

Different drain wall porosities
Different grain size distributions



-Field test on a section of the actual station pit

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Conclusions

-Drains 18 m long, 20 cm diameter with conductance of $1e^{-3}$ m^2/s would allow achieving the hydraulic transparency at the Belfiore underground station

-Conductance is the most critical parameter for the numeric assessment of the drain system effectiveness

-The Conduit Flow Process is an effective numeric tool for the simulation of man-made drains and pipes located below the water table

Open questions:

How could we determine drain conductance?

Is the achievement of hydraulic transparency essential at the Belfiore station?

Thanks!