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Impact assessment of hydrologic and operational factors on the efficiency of managed aquifer recharge scheme

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Contents

- Introduction (Managed aquifer recharge and study area)
- Objective
- Model
- Results
- Prospective

Water resources management and managed aquifer recharge

Water Resoures Problems

Shortage of available water resources in semi-arid and arid regions

Groundwater level decline due to over exploitation

Groundwater quality degradation as a result of

- Over-exploitation
- Seawater intrusion
- Pollution

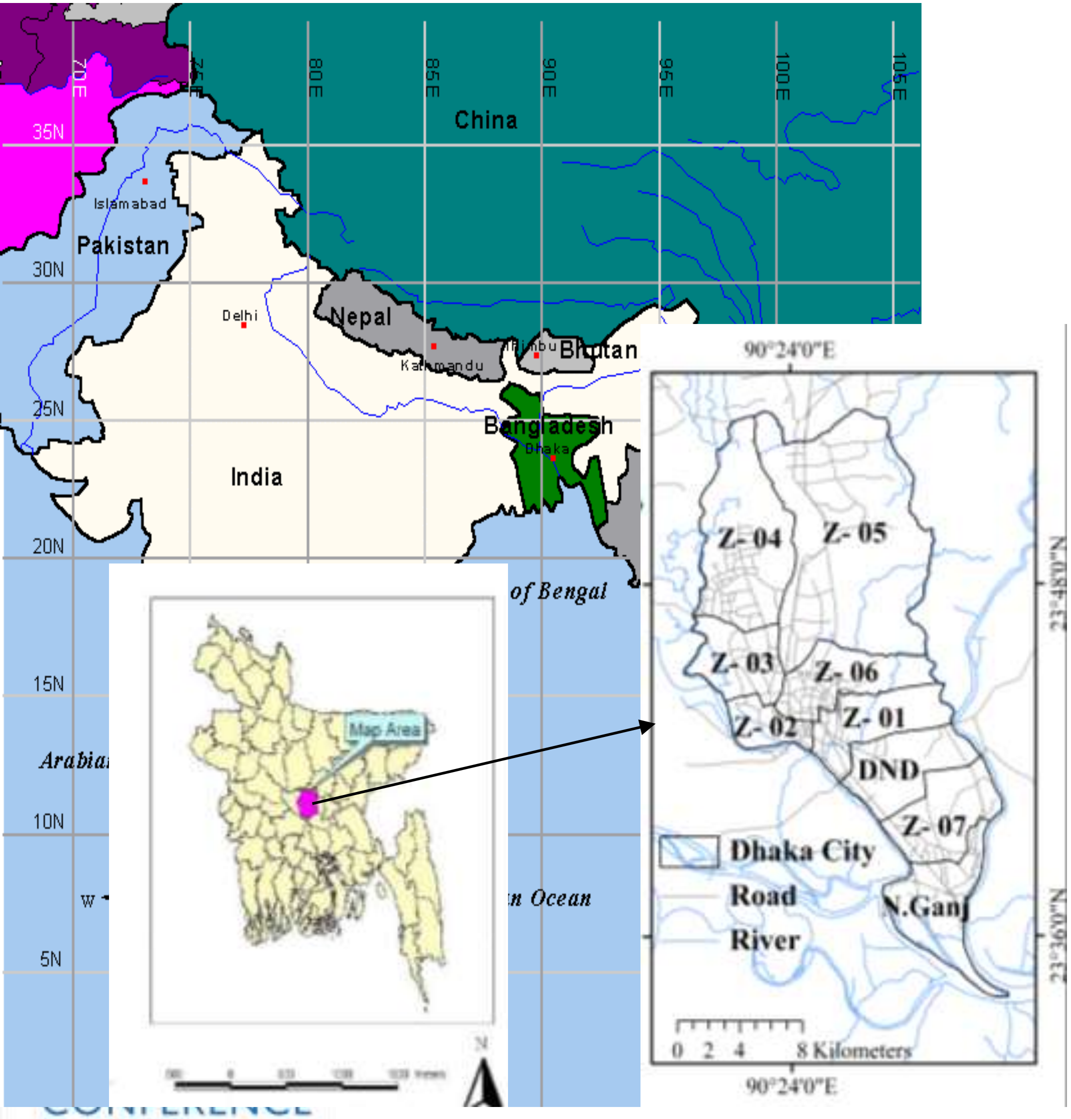
MAR - Objectives

MAR as a WR Management Tool

- Restoring groundwater levels
- Providing a barrier against seawater intrusion
- Usage of the aquifer as a reservoir facility for both seasonal and long term storage
- Usage of the aquifer as water transfer system

➔ The recharged water can be **clean water** (storm water, water surpluses, surface water, imported water, desalinated water etc.) or **treated effluent**

Study Area – Dhaka City, Bangladesh



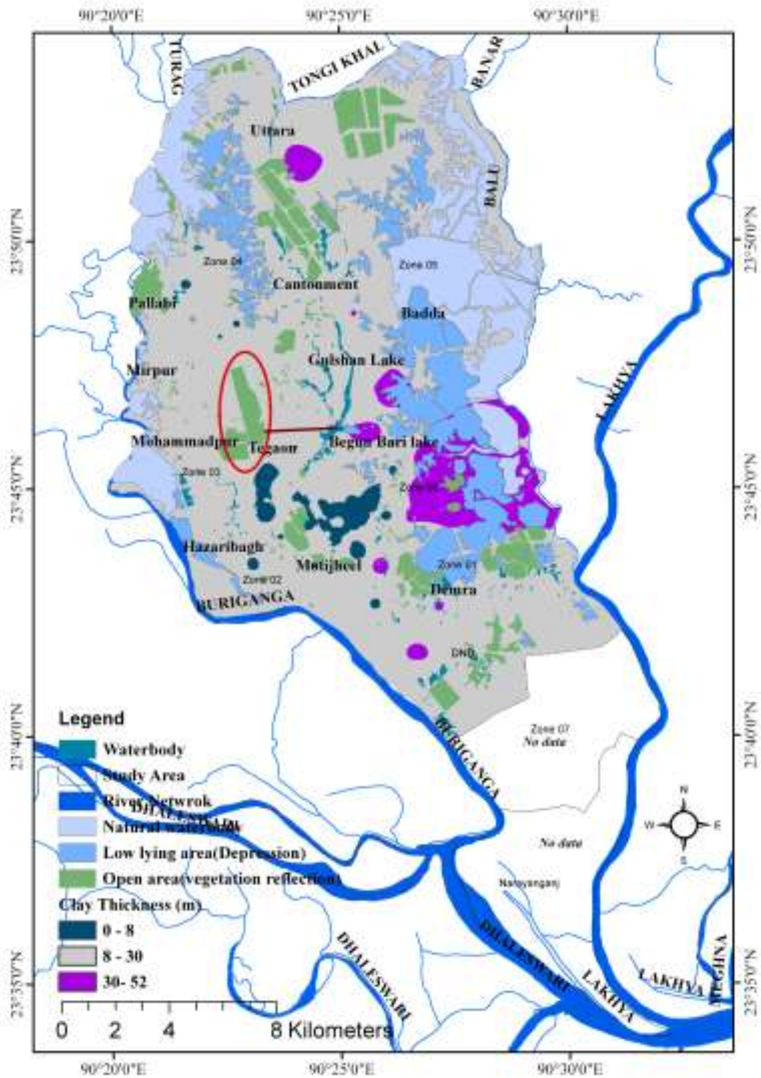
WR problems at the city

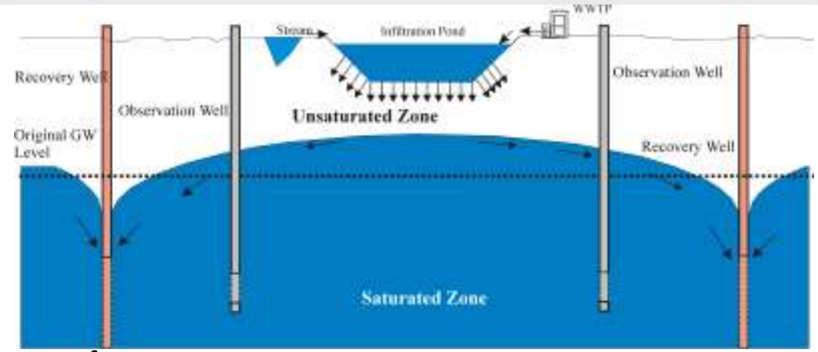
- Upper aquifer is almost exploited
  - ➔ less water supply
- Surface water bodies are already polluted
  - ➔ reducing trend in water quantity
- Declining groundwater level (2-3m/yr)
  - ➔ de-function of wells

- Water company of Dhaka (DWASA) is planning for MAR implementation, recently.

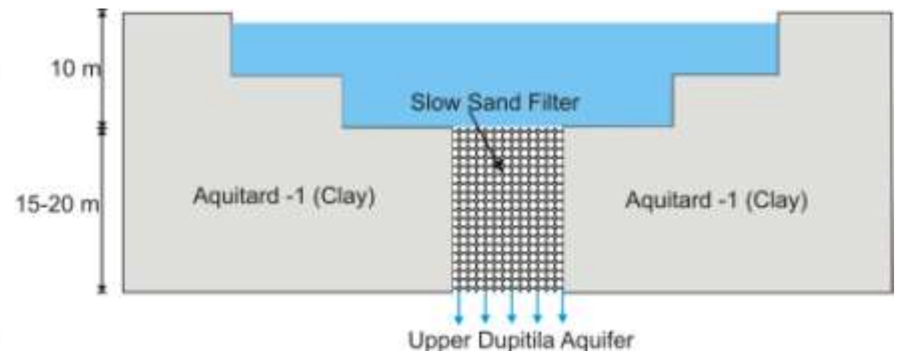
- Intensive **hydrological**, **hydrogeological** and **geochemical** investigations were performed based on ***secondary data***.

MAR site and technology



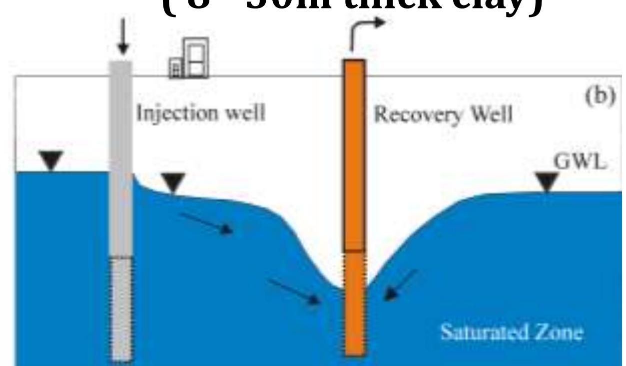


Înfiltration Method- **(0- 8m thick clay)**



Recharge trench with sand filter

(8- 30m thick clay)



Aquifer storage, transfer and recovery

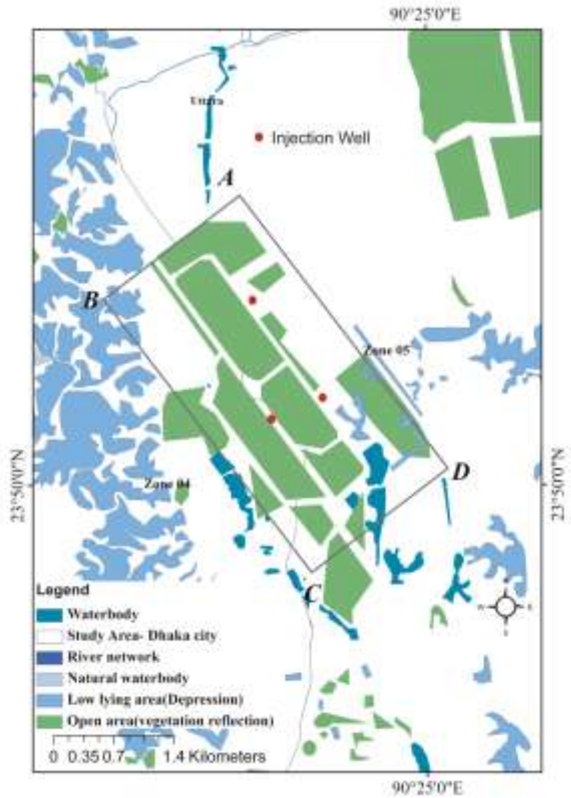
(30-52 m thick clay)

Objective

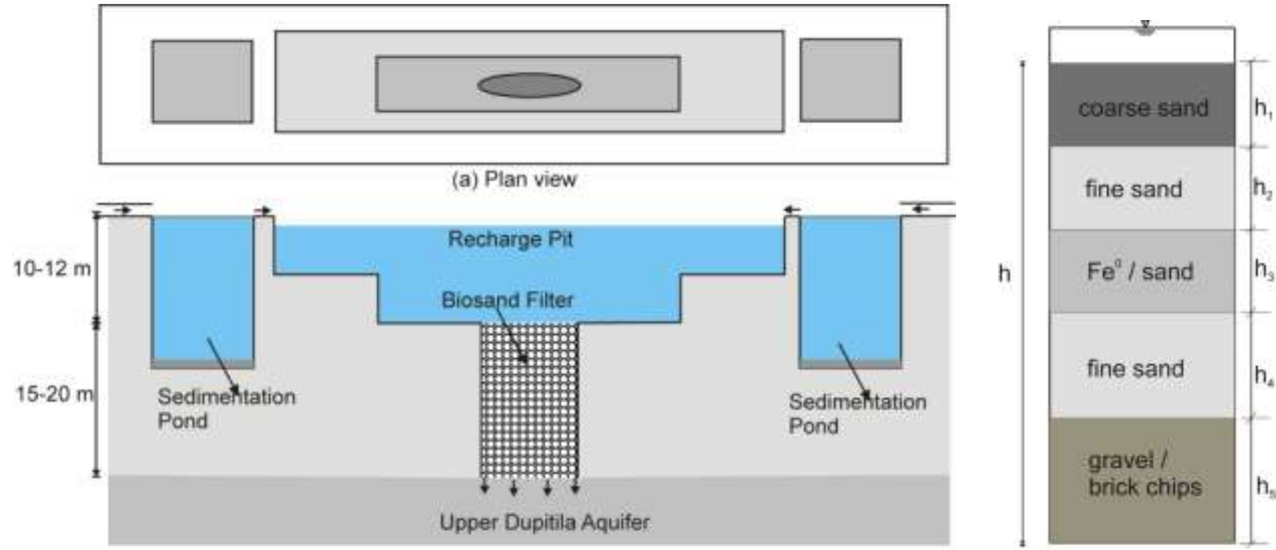
- Assessment of groundwater flow condition under different MAR scenarios
- Design of monitoring networks and recovery wells position
- Optomization of the layers of biosand filter for water quality improvement
- Assessment of water quality changes under MAR condition

COMSOL Multiphysics and Visual MODFLOW → comparison of results

Recharge pit/Trench- Design

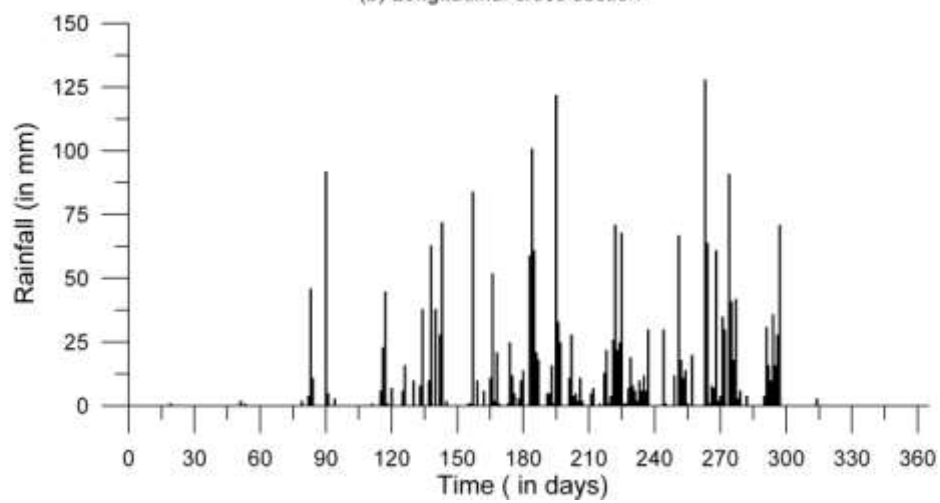


Test Site



(a) Plan view

(b) Longitudinal cross section



Examplary rainfall distribution, year 2005

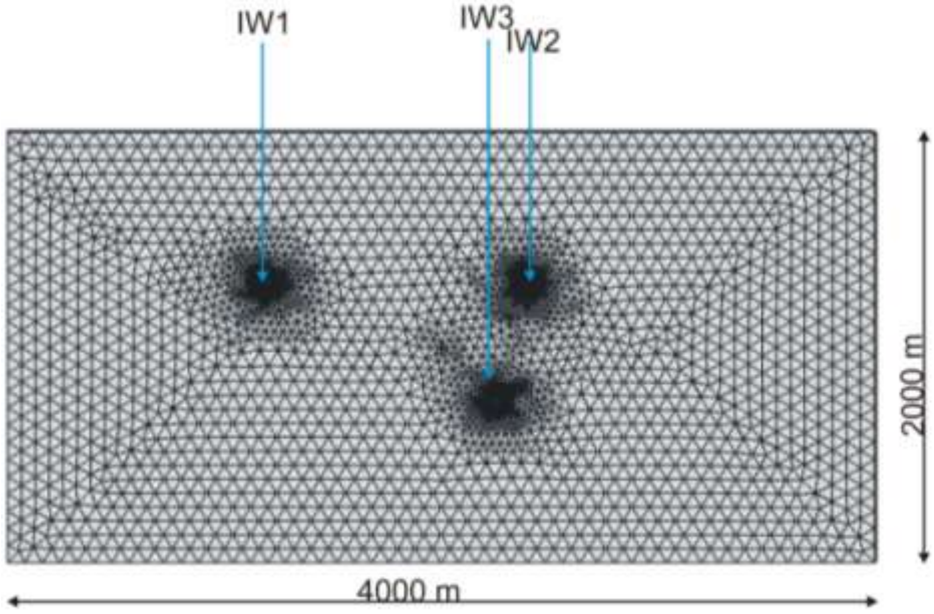
Model set up – COMSOL Multiphysics (v 4.3)

Darcy‘s law with continuity equation

$$\frac{\partial}{\partial t}(\rho\varepsilon)+\nabla.(\rho.u)=Qm$$

$$u=-\frac{\kappa}{\mu}\nabla p$$

u = the Darcy velocity or specific discharge vector (SI unit: m/s);
κ = the permeability of the porous medium (SI unit: m2);
μ = is the fluid’s dynamic viscosity (SI unit: Pa·s);
p = the fluid’s pressure (SI unit: Pa)
ρ = its density (SI unit: kg/m^3);
ε = the porosity,
*Q*m = a mass source term ($kg/(m^3 \cdot s)$).



Physics:

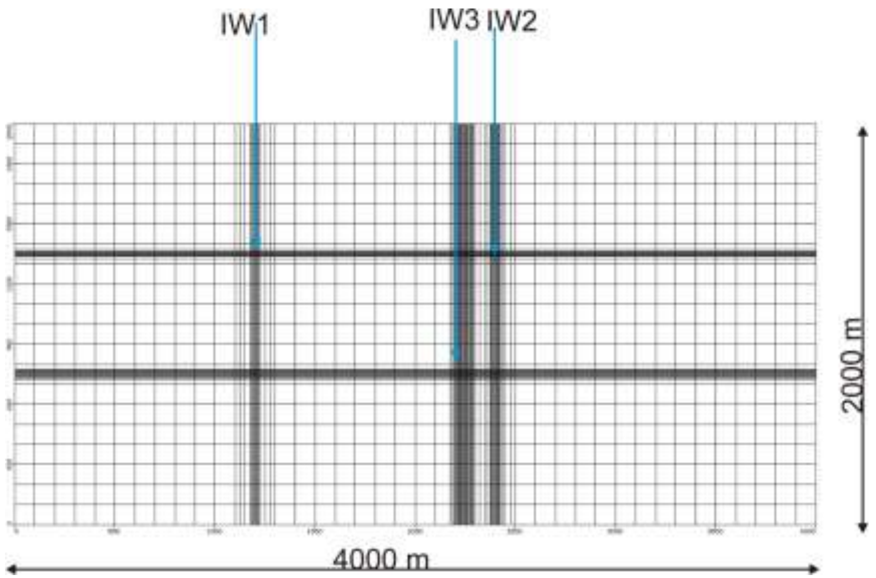
- Fluid Flow
  - Porous media and subsurface flow
  - Particle tracing for fluid flow

Model set up- Visual Modflow

Visual Modflow is a complete and easy-to-use modeling environment for practical applications in three-dimensional groundwater flow and contaminant transport simulations.

$$\frac{\partial}{\partial x}\left(K_{XX}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{YY}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{ZZ}\frac{\partial h}{\partial z}\right)+W=S_s\frac{\partial h}{\partial t}$$

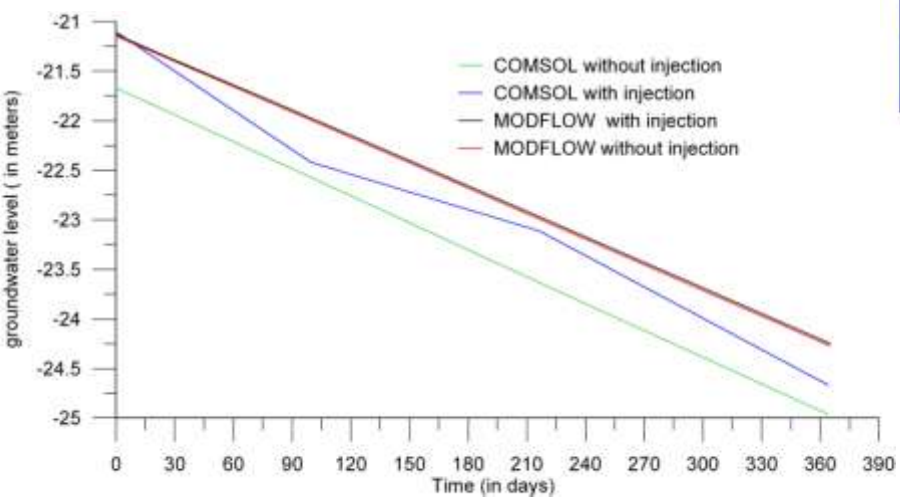
K_{xx}, K_{yy}, and K_{zz} = Values of hydraulic conductivity along the x, y, and z coordinate axes (L/T);
h = Potentiometric head (L);
W=Volumetric flux per unit volume representing sources and/or sinks of water, with W<0.0 for flow out of the ground-water system, and W>0.0 for flow in (T^{-1});
S_S = Specific storage of the porous material (L^{-1});



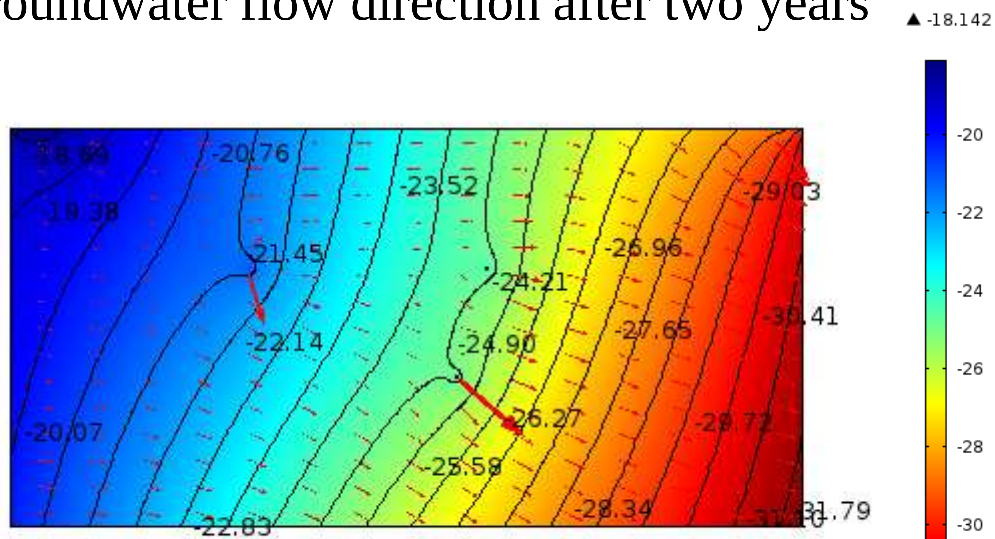
- ***Groundwater flow 2000***
- ***MODPATH***

Results – Comparison : COMSOL and Visual MODFLOW

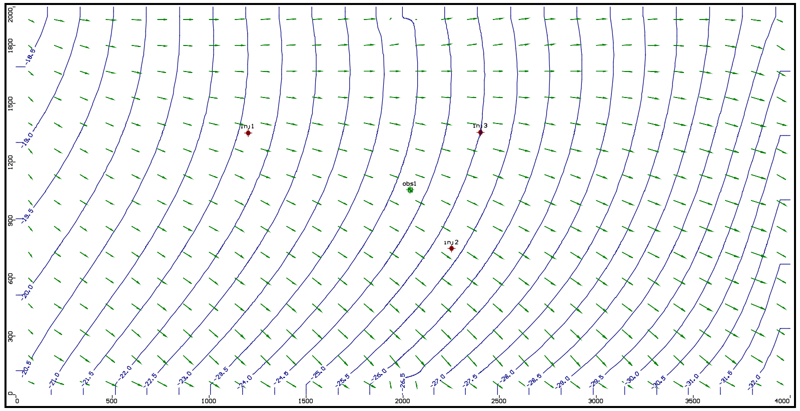
- Three recharge wells
- Capacity 50 m^3/day per well



Groundwater flow direction after two years



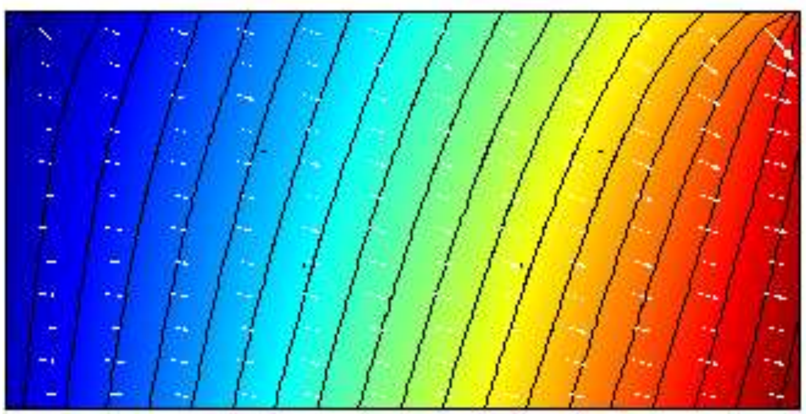
COMSOL



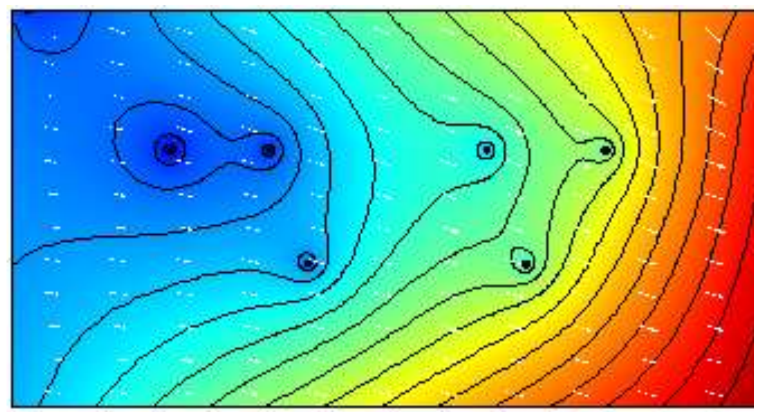
Visual MODFLOW

Results- Second scenario

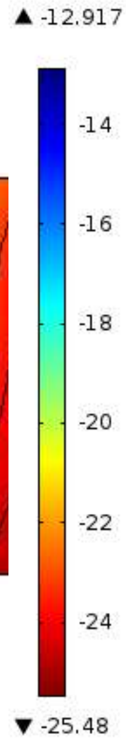
- Six recharge wells
- Capacity 155 m^3/day per well



at 0 day

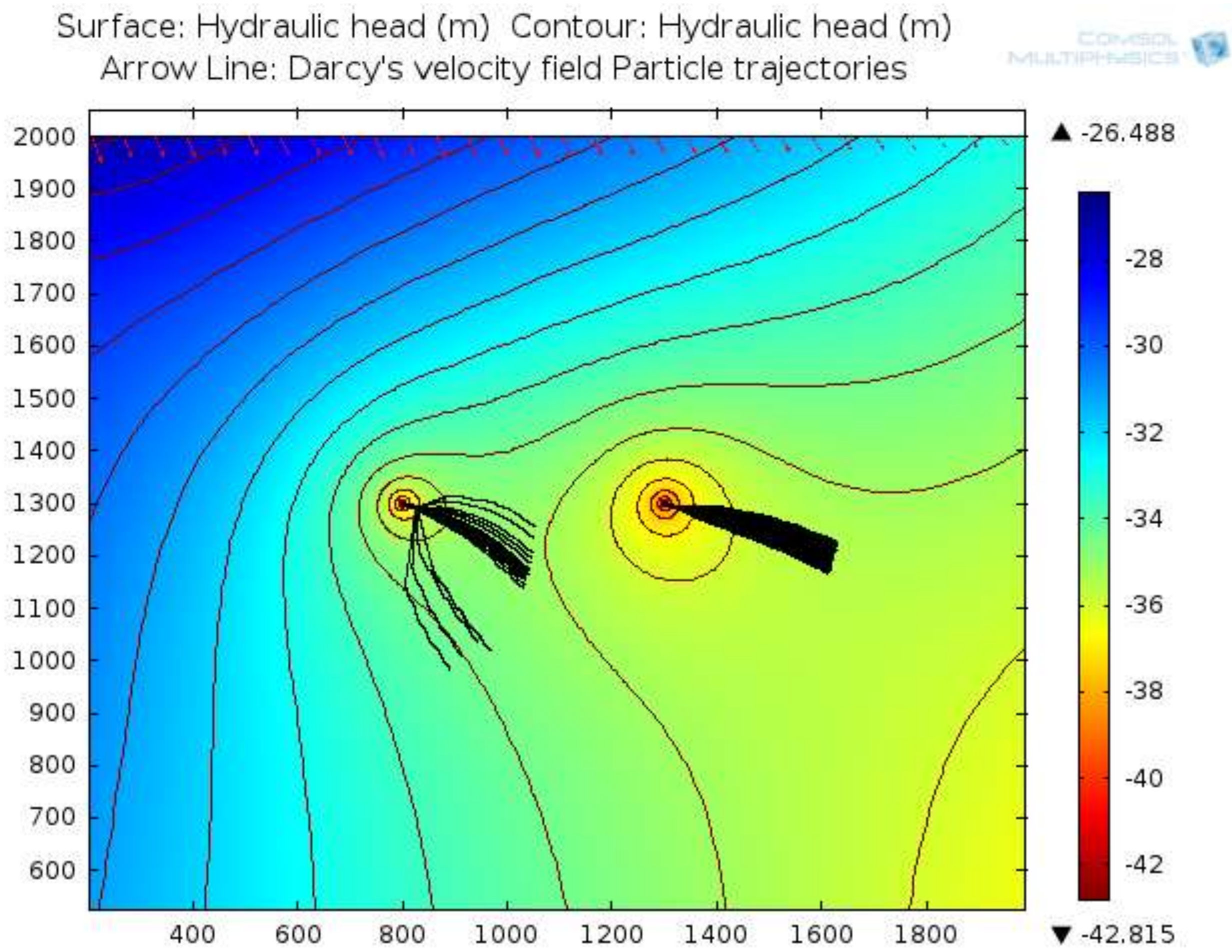


at 730 day

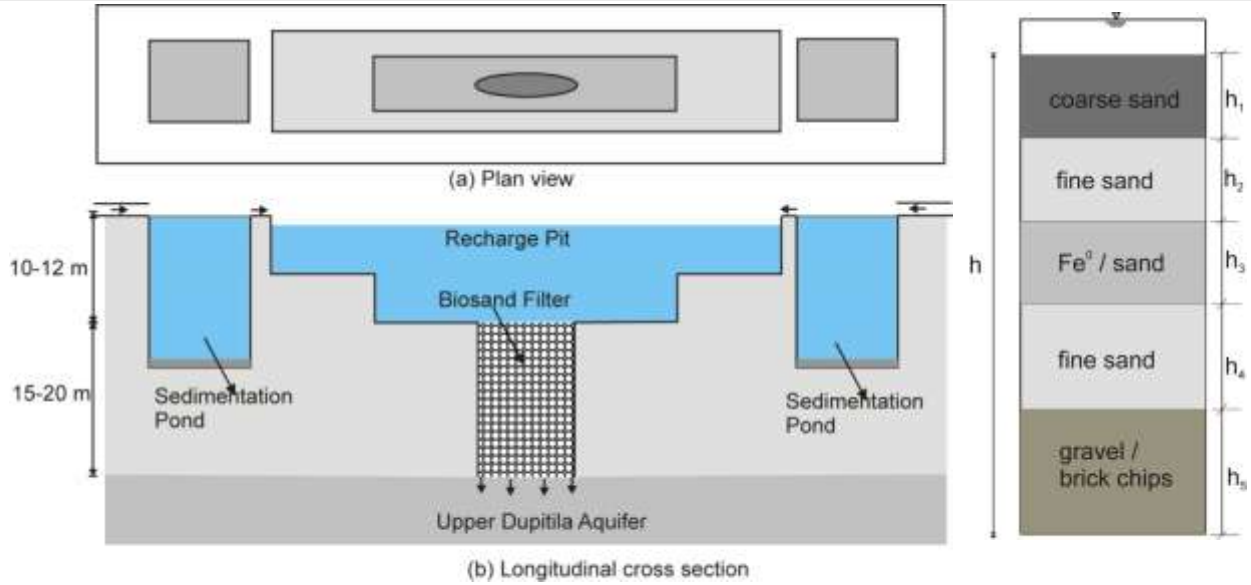


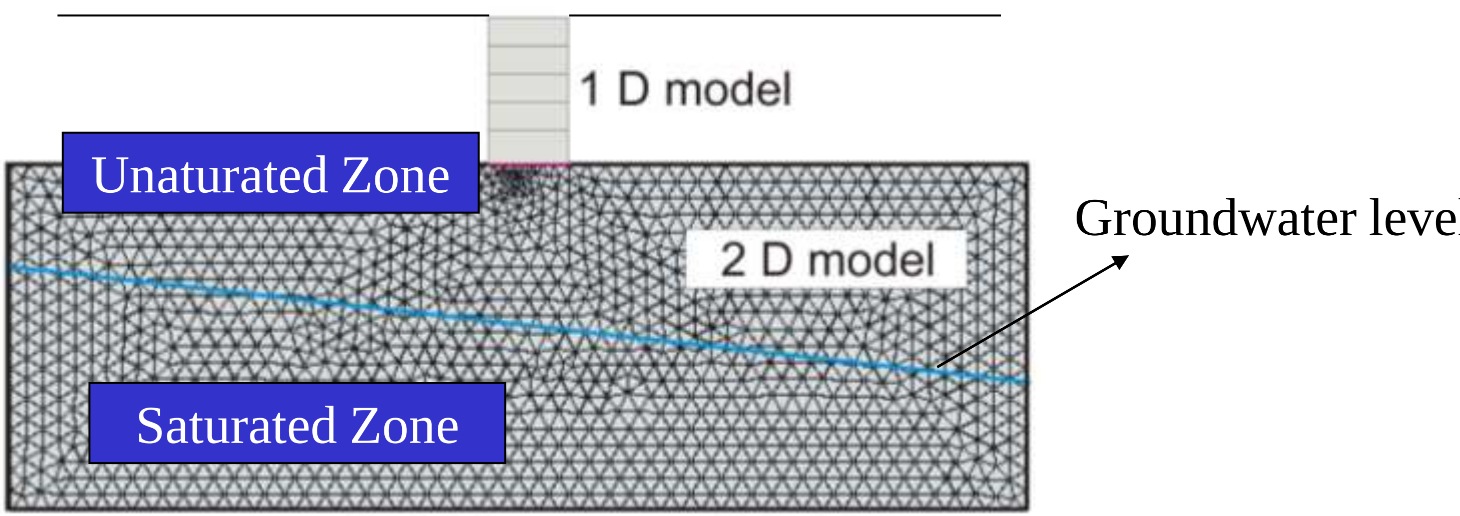
➔ Groundwater flow direction is important to design monitoring/ recovery wells

Results – Particle tracing



Prospectives





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THANKS FOR YOUR ATTENTION