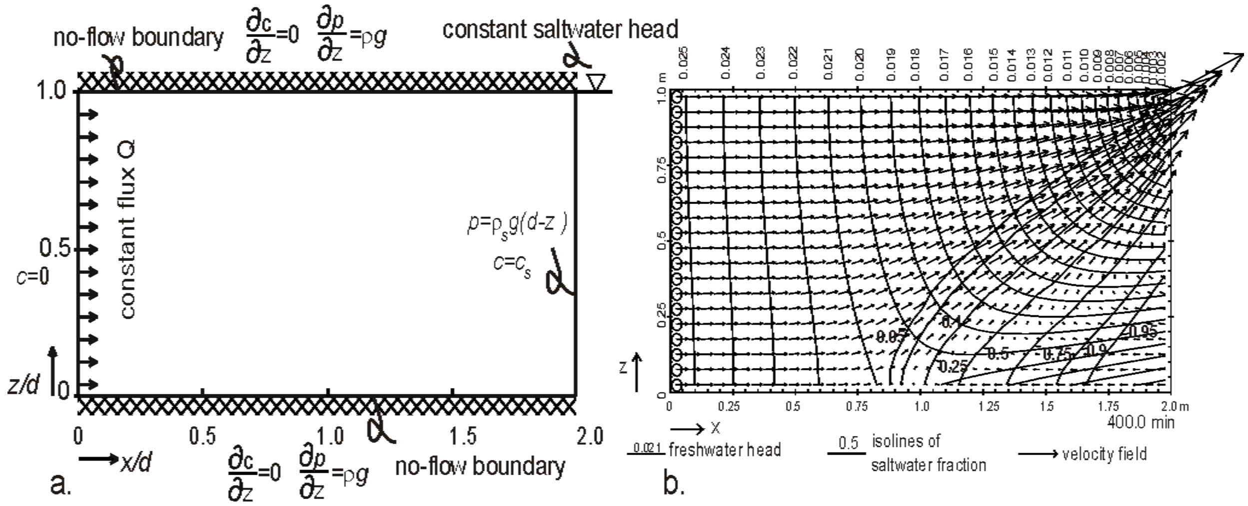
# Henry's case: Biscayne aquifer, Florida USA

Variable-density groundwater flow modelling with SEAWAT

Location model: https://publicwiki.deltares.nl/display/FRESHSALT/Download





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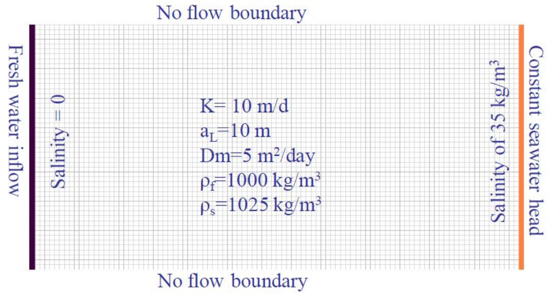
## Introduction

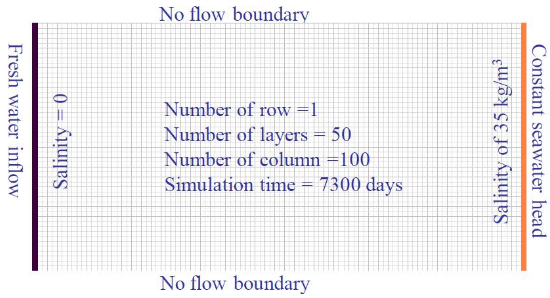
Henry's problem addresses the steady-state solution of a diffused saltwater wedge within a confined aquifer. Fresh water enters the confined aquifer at a constant rate from inland boundary and discharges into coastal boundary. Saltwater from the coastal boundary advances and mixes with the discharging fresh water.

The profile (cross-section) of Henry's case contains an aquifer with thickness=500m and length=1000m. In the table below, you see the parameters.

| Parameters | | | |
|---|---|---|---|
| Layers | 50 | $K_{hor}$ | 10 m/d |
| Rows | 1 | Anisotropy $K_{hor}/K_{ver}$ | 1 |
| Columns | 100 | Eff. porosity $n_e$ | 0.35 |
| Δx | 10 m | αL | 10.0 m |
| Δy | 1 m | αT | 1.0 m |
| Δz | 10 m | Moleculair diffusion | 5 m2/d |
| Stress period | 1 | Specific storage | 0.0001 |
| Length of time | 7300 days | Salinity seawater | 35 kg/m$^3$ |
| | | Buoyancy | 0.025 |

## Overview boundary conditions of the model






**Step 1 Numerical model grid**

(1) Mesh size:
- a. Number of layers=50; Model thickness=500m; Model top elevation=500m
- b. Number of rows=1; Model extent=1m
- c. Number of columns=100; model extent=1000m
- d. Vertical exaggeration=1

(2) Layer property
- a. All layers=confined

(3) Boundary (IBOUND-MODFLOW)
- a. Cell values = 1 (active) for columns 1 to 99
- b. Cell values =-1 (constant head) for column=100

(4) Boundary (ICBUND-Transport models)
- a. All cell values=1 (active)

(5) Top elevation
- a. Layer 1=500m; …., layer 50=10m

(6) Bottom elevation
- a. Layer 1=490m; ...; layer 50=0m

**Step 2 Parameters**

(1) Time:
- a. Time unit=days
- b. Simulation=transient
- c. Stress period=1
- d. Period length=7300 days
- e. Transport Stepsize=10
- f. Number of time steps=730

(2) Initial hydraulic heads
- a. All cells=1m

(3) Horizontal hydraulic conductivity
- a. All cells=10m/d

(4) Vertical hydraulic conductivity
- a. All cells=10m/d

(5) Specific storage
- a. All cells=0.0001m

(6) Effective porosity
- a. All cells=0.35

**Step 3 MODFLOW packages**

(1) Well
- a. Injection rate at all cells in the first column = 1 $m^3$/d to simulate inflow from east boundary

(2) Solver package
    a. PCG2

**Step 4 MT3DMS/SEAWAT packages**

(1) Simulation settings
    a. Variable Density Flow and Transport with SEAWAT
    b. Species: Salt TDS $kg/m^3$
    c. Density ON
    d. DRHODC=0.7143

(2) Initial concentration
    a. All cells 1-99 =0 $k/m^3$
    b. Cells in the last column 100=35$kg/m^3$ for seawater

(3) Advection
    a. Use 3rd-order TVD Scheme (ULTIMATE)

(4) Hydrodynamic dispersion
    a. $\alpha_T/\alpha_L$=0.1
    b. DMCOEFF: $D_m$=5$m^2$/d for all cells
    c. $\alpha_L$=10m for all cells

(5) Sink/Source concentration
    a. Constant head cells: Salt=35 $kg/m^3$; (other cells: Salt=0)
    b. Well: Salt=0 35 $kg/m^3$

(6) Concentration observations
    a. OBS1: x=795m, y=1m, layer=35
    b. OBS2: x=845m, y=1m, layer=40
    c. OBS3: x=995m, y=1m, layer=44

(7) Output control
    a. Output times: Output frequency=20, minimum=365; maximum=7300, interval=365

**Step 5 Run the model**

(1) Run SEAWAT

**Step 6 Presentation of model results**

(1) Contour map of salt concentrations
(2) Break-through curves
(3) Animate evolution of mixing

**Step 7 Implement a shallow groundwater extraction well in the coastal zone, 250m from the sea.**

Copy the old model to a new one in another subdir (!) and rename this model
What are the effects?

**Step 8 Insert a measure to reduce salt water intrusion**

Copy the old model to a new one in another subdir (!) and rename this model
What could be measures, what do you expect and are the effects?

**Step 9 Due to climate change it is getting drier. The freshwater inflow flux is 30% less**

Copy the old model to a new one in another subdir (!) and rename this model
Reduce in Models, Flow Packages, Wells the rate of all wells with 30%. What are the effects?