GROUNDWATER MANAGEMENT INSTITUTE

ict4water.eu

Boundary conditions used in Tutorial 2

FREEWAT

Free and Open Source Software Tools for Water Resource Management

EU HORIZON 2020 Project

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

MODFLOW GHB Package/1

MODFLOW GHB Package allows to simulate flow into or out of a grid cell from any external source (e.g., a superficial water body), depending on the head gradient between the source itself and the groundwater system.

The flow between the external source and the aquifer in cell *n* is given by:

$$QB_n=CB_n(HB_n-h_n),$$

where:

CB_n is the hydraulic conductance between the external source and the grid cell (user-defined);

HB_n is the head assigned to the external source (user-defined);

h_n is the head at the node of the cell.

MODFLOW GHB Package/2

The hydraulic conductance between the external source and the grid cell can be expressed as:

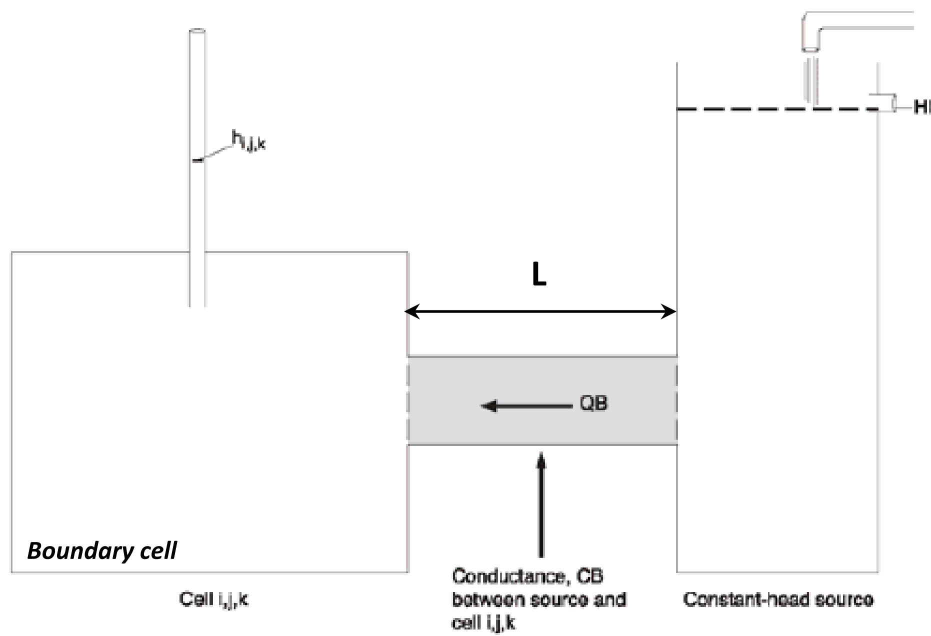
$$CB=KB*A/L,$$

where:

KB is the hydraulic conductivity between the external source and the grid cell (user-defined);

A is the area of the boundary cell perpendicular to the flow;

L is the distance between the external source and the boundary cell (user-defined).



MODFLOW RIV Package/1

MODFLOW River (RIV) Package allows to simulate river/aquifer seepage, depending on the head gradient between the river and the groundwater system.

The riverbed is made of low permeability material and the water level in the model cell stays above its bottom.

The flow between the river and the aquifer in reach *n* is given by:

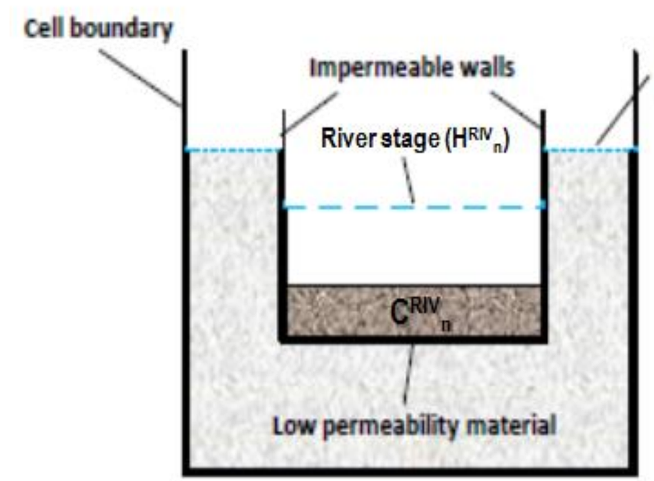
$$Q_n = C^{RIV}_n (H^{RIV}_n - h_n),$$

where:

C^{RIV}_n is the conductance of the riverbed material (user-defined);

H^{RIV}_n is the river stage (user-defined);

h_n is the head at the node of the cell.



MODFLOW RIV Package/2

C^{RIV}_n is grid size dependent, but can be approximated by the hydraulic conductivity of the riverbed and its geometry, according to the following equation:

$$C^{RIV}_n = K_n L_n W_n / M_n \qquad (1)$$

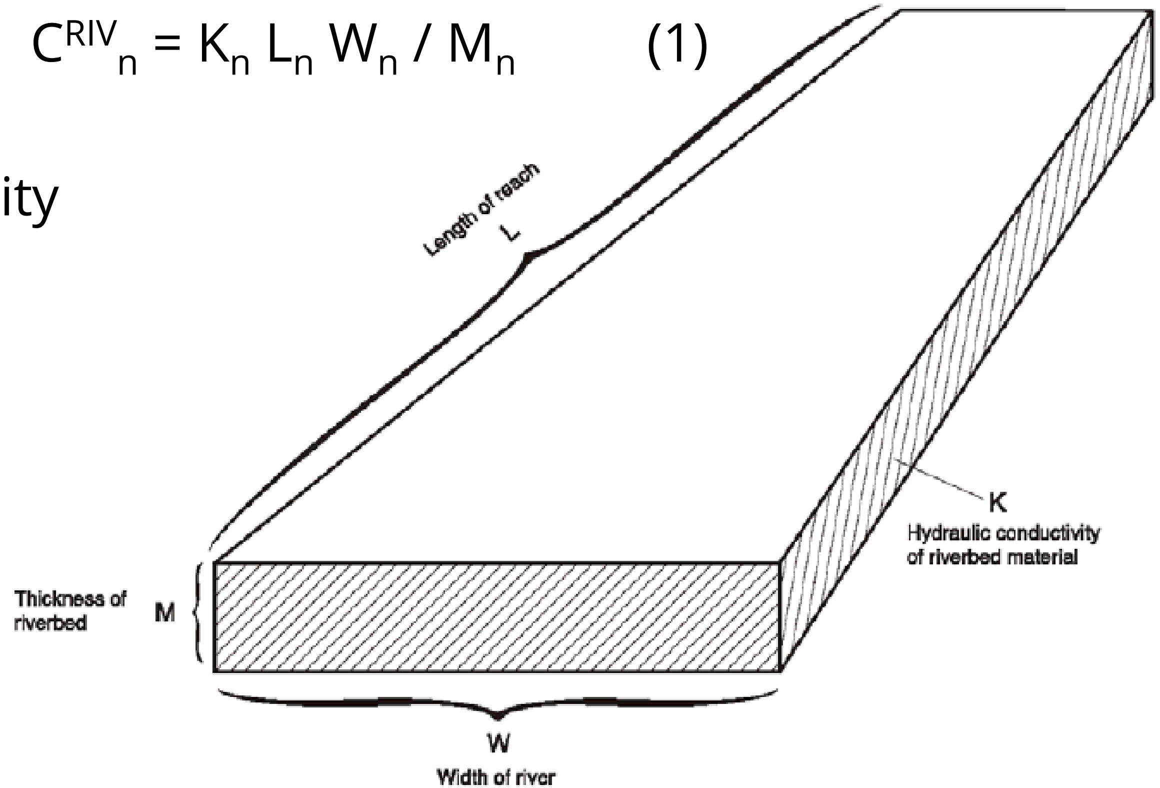
where:

K_n is the hydraulic conductivity of the riverbed material;

L_n is the length of reach;

W_n is the width of the river;

M_n is the thickness of the riverbed.



Figures from Harbaugh AW (2005) *MODFLOW-2005, the U.S. Geological Survey modular ground-water model – the Ground-Water Flow Process*. U.S. Geological Survey Techniques and Methods, 6-A16.

MODFLOW DRN Package

MODFLOW DRN Package allows to simulate the effects of features (such as agricultural drains), which remove water from the aquifer if the head in the aquifer is above a certain fixed elevation, called the drain elevation.

The outflow from the aquifer in cell n is given by:

$$Q^{DRN}_n = C^{DRN}_n (h_n - H^{DRN}_n) \quad \text{if } h_n > H^{DRN}_n ,$$

$$Q^{DRN}_n = 0 \quad \text{if } h_n \leq H^{DRN}_n ,$$

where:

C^{DRN}_n is the drain conductance (user-defined);

H^{DRN}_n is the drain elevation (user-defined);

h_n is the head at the node of the cell.

C^{DRN}_n is calculated depending on the drain bed geometry and its hydraulic conductivity (these parameters are user-defined), as for the river conductance (C^{RIV}_n).

MODFLOW RCH Package

MODFLOW Recharge (RCH) Package allows to simulate areally distributed, direct recharge to groundwater, usually used to represent rainfall recharge.

The user must define, for each SP, the recharge flux to be applied to the map area, in units of length per time [L/T]. This recharge flux is then internally multiplied by the area of each cell, to get the recharge flow rate at each cell, then expressed as a fluid volume per unit time [L^3/T].

The user must also specify if the areal recharge has to be applied:

(1) to the upper model layer,

(2) to the uppermost variable-head cell in each vertical column, or

(3) to any cell in each vertical column belonging to the user-defined model layer.

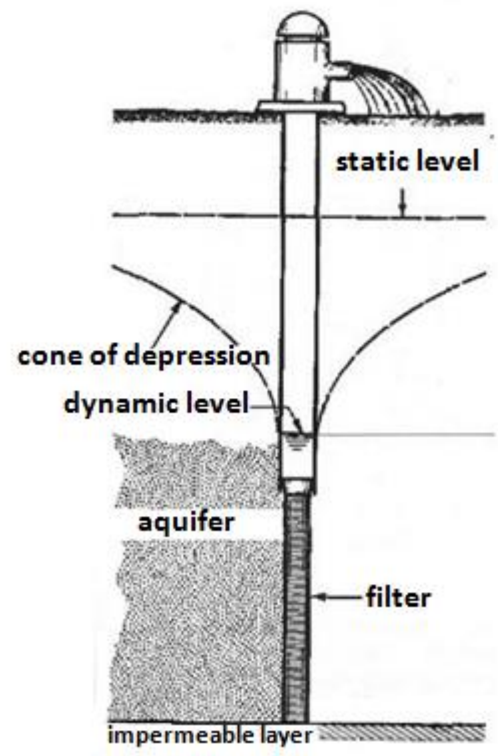
MODFLOW WEL Package

MODFLOW Well (WEL) Package allows to simulate wells that withdraw water from or add water to the aquifer at a constant rate during a SP.

The user must define, for each SP, row, column and layer number of the cell in which the well is located and its extracted/recharge flow rate (Q).

Q is expressed as a fluid volume per unit time [L^3/T].

Negative values for Q are used to indicate a pumping well, whereas positive values for Q indicate a recharge well.



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