

Solute pollutants transport modeling in the sewerage of the localities Boldur, Timiș County – Romania

Robert F. Beilicci¹

Erika B. M. Beilicci¹

Abstract – The Paper present unconfined groundwater flow and solute transport modeling sewerage of the localities Boldur area, using the PMWIN applications. Modeling purpose is to constitute extending pollution zone of aquifers in space and time generated of wastewater treatment plant. Knowledge of extending of pollution zone is necessary to settle technical measures to closing nonconformity landfill. The companion software Processing Modflow for Windows (PMWIN) offer a totally integrated simulation system for modeling groundwater flow and transport processes with MODFLOW-88, MODFLOW-96, PMPATH, MT3D, MT3DMS, MOC3D, PEST and UCODE.

Keywords: hydraulic modeling, pollutants transport

I. INTRODUCTION

Boldur village is located in south-eastern Romania, on the left bank of the river Timis county road DJ 592, Timis county belonging and being in the central-eastern thereof. Domestic wastewater sewerage networks are located along the streets of the village, in the green streets. (Figure 1).

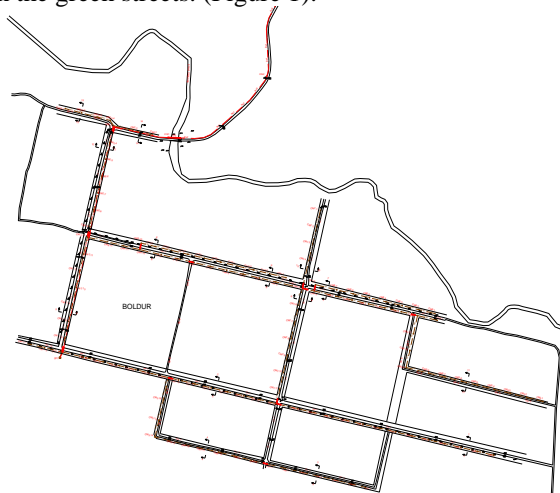


Figure 1. Boldur plan view

The total length of the sewer is 14106 m. Collectors have diameter Dn 250 mm and are made of PVC pipe SN4. (Figure 2).

Due to land configuration, technical solution to achieve the sewerage network provides realization of pumping station SP1. Water collected in the town Boldur, transported and discharged into the pumping station SP1. The pumping station SP1, the sewage is pumped through the discharge pipe in the first hostel in town Jabăr. The total length of the canaleizare is L

= 14.106ml, with a total of 205 pieces of domestic homes, 2 pcs. homes emptying and venting device. Connection to the pumping station is made of PVC pipe Dn 250 SN4.

The discharge pipe will have a length of 3.105 m and will be made of high density polyethylene pipe PE80 PN6 $\Phi 125 \times 7.1$ mm. On the pipeline route are provided two empty homes and one ventilation device placed under the plan situation.

The pumping station will be equipped with 1 + 1R submersible pumps. The pumps are installed in a home semi-buried precast concrete with a diameter of 2.0 m and 4.0 m depth.

Pump station is surrounded by a wire fence and has a gateway.

Homes drain, located in the discharge pipe are fitted with cast iron butterfly valves with flange PN10 / 16 DN100 diameter.

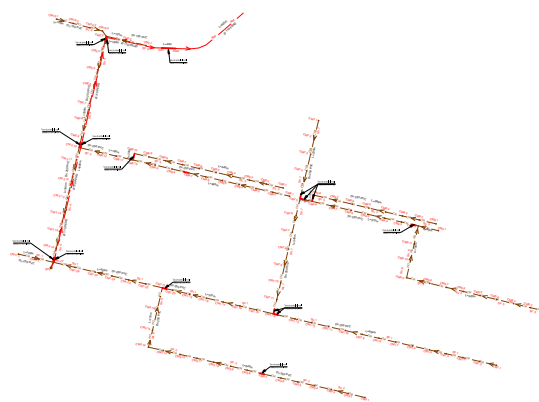


Figure 2. Flowsheet sewage Boldur

II. MATERIAL AND METHODS

The applications of MODFLOW, a modular three-dimensional finite-difference groundwater model of the U. S. Geological Survey, to the description and prediction of the behavior of groundwater systems have increased significantly over the last few years.

Models or programs can be stand-alone codes or can be integrated with MODFLOW. A standalone model or program communicates with MODFLOW through data files. The advective transport model PMPATH (Chiang and Kinzelbach, 1994, 1998), the solute transport model MT3D (Zheng, 1990), MT3DMS (Zheng and Wang, 1998) and the parameter

¹ Politehnica University Timisoara, Faculty of Civil Engineering, Department of Hydrotecnics, Timisoara, Str. George Enescu, no. 1/A, Timisoara, Romania, www.ct.upt.ro

estimation programs PEST (Doherty et al., 1994) and UCODE (Poeter and Hill, 1998) use this approach.

The solute transport model MOC3D (Konikow et al., 1996) and the inverse model MODFLOWP (Hill, 1992) are integrated with MODFLOW. Both codes use MODFLOW as a function for calculating flow fields.

The companion software Processing Modflow for Windows (PMWIN) offer a totally integrated simulation system for modeling groundwater flow and transport processes with MODFLOW-88, MODFLOW-96, PMPATH, MT3D, MT3DMS, MOC3D, PEST and UCODE.

PMWIN comes with a professional graphical user-interface, the supported models and programs and several other useful modeling tools. The graphical user-interface allows you to create and simulate models with ease and fun. It can import DXF- and raster graphics and handle models with up to 1,000 stress periods, 80 layers and 250,000 cells in each model layer. The modeling tools include a Presentation tool, a Result Extractor, a Field Interpolator, a Field Generator, a Water Budget Calculator and a Graph Viewer. The Result Extractor allows the user to extract simulation results from any period to a spread sheet. You can then view the results or save them in ASCII or SURFER-compatible data files. Simulation results include hydraulic heads, draw downs, cell-by-cell flow terms, compaction, subsidence, Darcy velocities, concentrations and mass terms. The Field Interpolator takes measurement data and interpolates the data to each model cell. The model grid can be irregularly spaced. The Water Budget Calculator not only calculates the budget of user-specified zones but also the exchange of flows between such zones.

This facility is very useful in many practical cases. It allows the user to determine the flow through a particular boundary. The Field Generator generates fields with heterogeneously distributed transmissivity or hydraulic conductivity values. It allows the user to statistically simulate effects and influences of unknown small-scale heterogeneities.

The Field Generator is based on Mejía's (1974) algorithm.

The Graph Viewer displays temporal development curves of simulation results including hydraulic heads, draw downs, subsidence, compaction and concentrations.

Using the Presentation tool, you can create labeled contour maps of input data and simulation results. You can fill colors to model cells containing different values and report-quality graphics may be saved to a wide variety of file formats, including SURFER, DXF, HPGL and BMP (Windows Bitmap). The Presentation tool can even create and display two dimensional animation sequences using the simulation results (calculated heads, drawdowns or concentration).

At present, PMWIN supports seven additional packages, which are integrated with the "original" MODFLOW. They are Time-Variant Specified-Head

(CHD1), Direct Solution (DE45), Density (DEN1), Horizontal-Flow Barrier (HFB1), Interbed-Storage (IBS1), Reservoir (RES1) and Stream flow-Routing (STR1). The Time-Variant Specified-Head package (Leake et al., 1991) was developed to allow constant-head cells to take on different values for each time step. The Direct Solution package (Harbaugh, 1995) provides a direct solver using Gaussian elimination with an alternating diagonal equation numbering scheme. The Density package (Schaars and van Gerven, 1997) was designed to simulate the effect of density differences on the groundwater flow system. The Horizontal-Flow Barrier package (Hsieh and Freckleton, 1992) simulates thin, vertical low-permeability geologic features (such as cut-off walls) that impede the horizontal flow of ground water.

The Interbed-Storage package (Leake and Prudic, 1991) simulates storage changes from both elastic and inelastic compaction in compressible fine-grained beds due to removal of groundwater. The Reservoir package (Fenske et al., 1996) simulates leakage between a reservoir and an underlying ground-water system as the reservoir area expands and contracts in response to changes in reservoir stage. The Stream flow-Routing package (Prudic, 1988) was designed to account for the amount of flow in streams and to simulate the interaction between surface streams and groundwater.

In the block-centered finite difference method, an aquifer system is replaced by a discretized domain consisting of an array of nodes and associated finite difference blocks (cells). The nodal grid forms the framework of the numerical model.

Hydro stratigraphic units can be represented by one or more model layers. The thicknesses of each model cell and the width of each column and row can be specified. The locations of cells are described in terms of columns, rows, and layers.

MODFLOW requires initial hydraulic heads at the beginning of a flow simulation. Initial hydraulic heads at fixed-head cells will be kept constant during the flow simulation. An IBOUND array is required by the flow model MODFLOW. The IBOUND array contains a code for each model cell. A positive value in the IBOUND array defines an active cell (the hydraulic head is computed), a negative value defines a fixed-head cell (the hydraulic head is kept fixed at a given value) and the value 0 defines an inactive cell (no flow takes place within the cell).

III. RESULTS AND DISCUSSIONS

The tasks are:

- to calculate and show head contours,
- model calibration,
- to calculate and show time variant concentration of solute pollutants transport

The aquifer extends several square kilometers (830 x 685 m), situated in space Boldur vilage. In map presented in Figure 3 is marked model limits.

The top and bottom elevations of the aquifer are variably 92-90 m and 60 m, respectively. The average horizontal hydraulic conductivity is 0.0001 m/s; the effective porosity is 0.25. The water stage in the river is 89,5 m to 88,5 m above the bottom elevation, which is the reference level for the simulation.

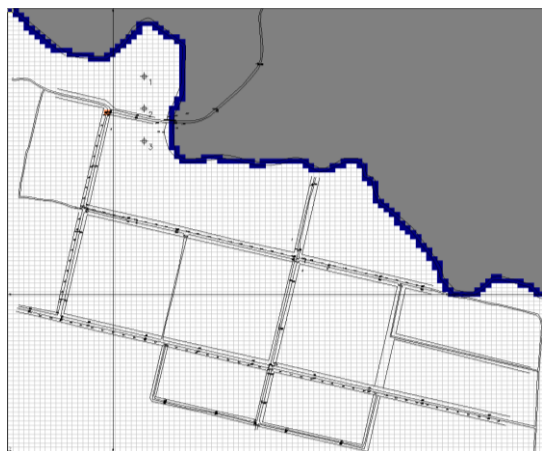


Figure 3. Model and Discretization

The aquifer is simulated using a grid of one layer, 100 columns and 100 rows. A grid spacing is regular (8,274 m is used for column and 6,8528 m is used for row) (Figure 3). The layer type is unconfined. The river are modeled as fixed head in the channel. One boundary is fixed hydraulic head boundaries. Figure 4 shows the head contours.

To modeling polluted transport the pollution source is the pumping station considered as a permanent pollution.

As boundary conditions there are accepted:

- concentration $C=100\%$ on the pumping station as a permanent pollution source
- concentration $C=0$ in the field outside of vilage.

The dispersivity has the following characteristics: $\alpha L=50$; $\alpha T/\alpha L=0.1$.

Permanent source assumption is based to fact treatment plant is in function of more decades and determinant pollution infiltration process in conjugate precipitation effects persist in many years.

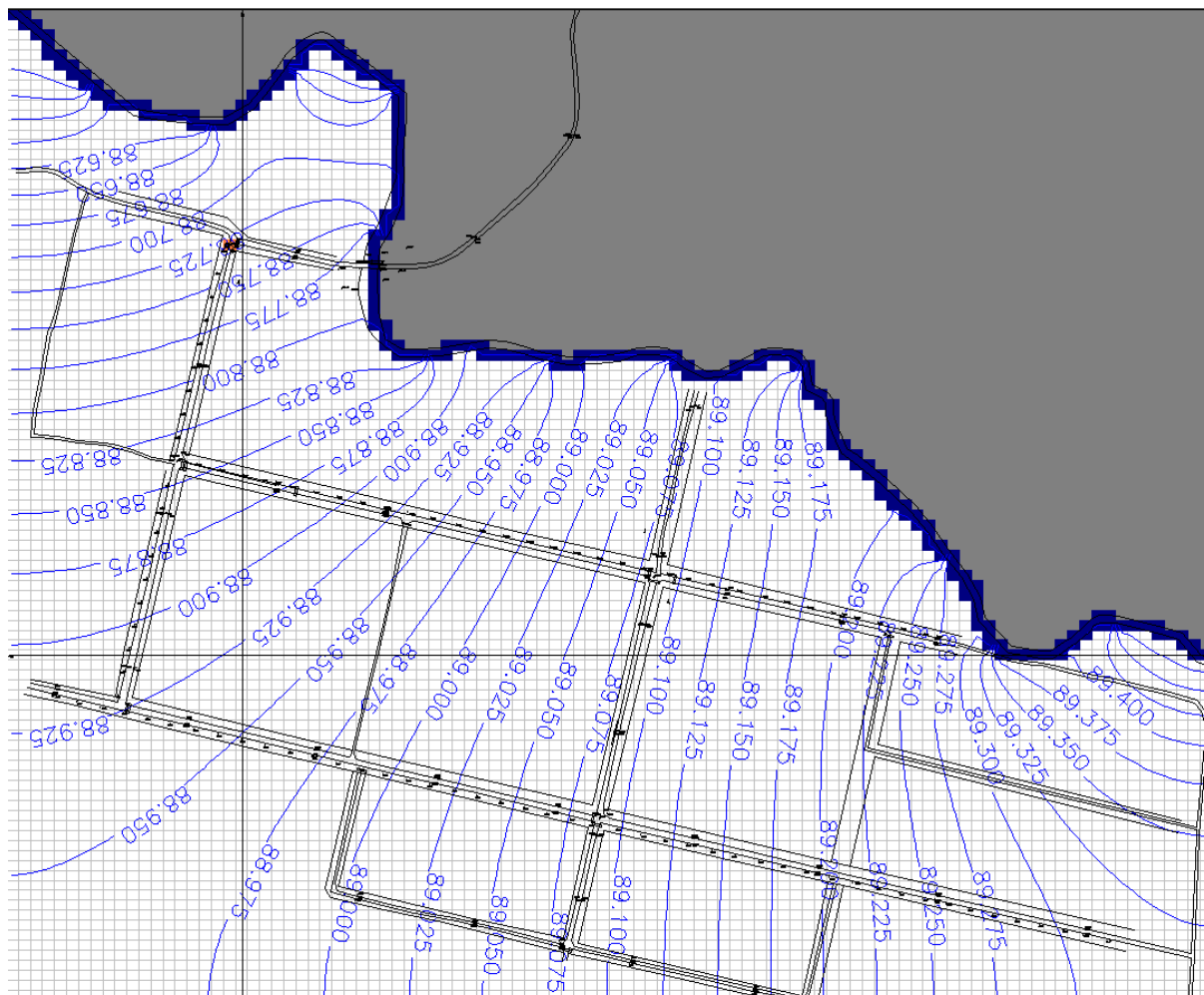


Figure 4. Head contours

Results are presented in figures under polluted extending areas with different concentrations (isoconcentrations) for 10 years (Figure 5).

The results of simulation permit exactly quantify evolution of concentrations in time, for all points of polluted zones. This think is important to find a

technical method for limitation, reduce or eliminate in time pollution.

A special remark that is not necessary to specify pollutant nature, because the modeling was making in general for all kind of pollutants. The concentration values are expressed in percentage from the total quantity of pollutant. Concentration is a general parameter and maybe serve base for calculation an absolute concentration (for example mg/l) for all dissolved pollutants in water.

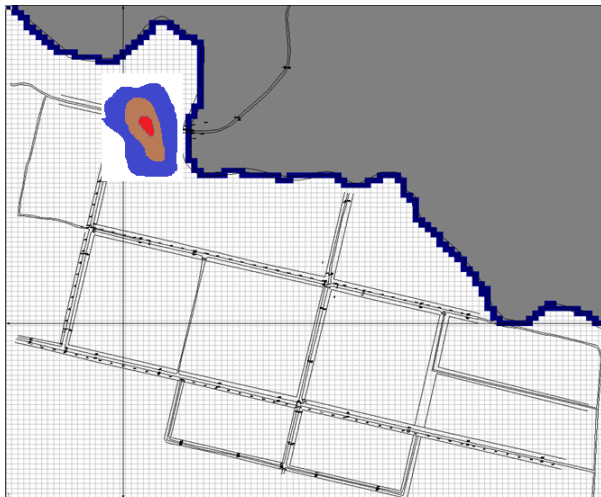


Figure 5. Distribution of the pollutant

From the concentrations diagrams the Local Authorities has possibility to know the directions and evolution in time of the pollution from treatment plant.

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