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Solute pollutants transport modelling in Amarastii de Sus village, Dolj County – Romania

Beilicci Robert[1] Beilicci Erika[1]

Abstract: The Paper present unconfined groundwater flow and solute transport modelling Amarastii de Sus village, using the PMWIN applications. Modelling 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 modelling groundwater flow and transport processes with MODFLOW-88, MODFLOW-96, PMPATH, MT3D, MT3DMS, MOC3D, PEST and UCODE.

Keywords: Hydraulic modelling, pollutants transport

1. INTRODUCTION

Amarastii de Sus village is located in the south east of Dolj County, in an area of lowland agricultural purposes, the county road DJ 604 at about 60 km from the city of Craiova (Figure 1).

Pipeline routes are located partly on area roadways, partly in the green area in front of the houses.

The location of the proposed pipeline route will be the same as far as possible, with all streets.

The pipes will be laid in the ground at an average depth of 1.20 m below freezing. To ensure water consumers in the city, take into account a degree of assurance of water use by cs = 0.95 and a maximum allowable pressure in the network of 60 m H2O.

Homes valves to be performed (35 pcs.) Will be concrete inner diameter of 1250 mm (29 pieces) respectively the inner diameter of 1500 mm (6 pieces).

According hydrogeological study prepared by C.N. Romanian waters for water supply source is indicated shallow aquifer complex, stationed in the range 25-50 m. The aquifer can provide a flow rate of 5 l / s through execution and completion of drilling correct.

By study recommends two wells with depth of 50 m, completed with a single column De.250x11.9 mm, confined aquifer layers that will capture the 25-50 m range, about 3-4 layers. Surface active filters will be over 8%.

Exploration drilling operation will team with one submersible pump the following characteristics Q = 5 cm / h, H = 45 mWS, P = 2.2 kW.

Over drilling runs homes for protection of concrete, housing helmet shaft drilled and hydraulic installations necessary to ensure the flow and pressure regime.

In the basement room of valves: pumping station will be made of three pumps 2 + 1 R Q = 18 m³ / h, H = 57 m, P = 5.5 kW and a fire pump Q = 24 m³ / h, H m = 57, P = 7.5 kW and hydraulic installations required (4 valves separation - rubber butterfly valve, non-return valves 4, 4 valves pump selection - rubber butterfly valve, all DN 50, PN25). The plant is fully automated switchboard by AER variable speed pumps operated via frequency inverter controlled flow out of Plant and read the pressure in the distribution system of meter reading in the home.

2. 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 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

[1] Politehnica University Timisoara, Faculty of Civil Engineering, Department of Hydrotecnnics, Timisoara, Str. George Enescu, no. 1/A, Timisoara, Romania, www.ct.upt.ro, robert.beilicci@upt.ro

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.

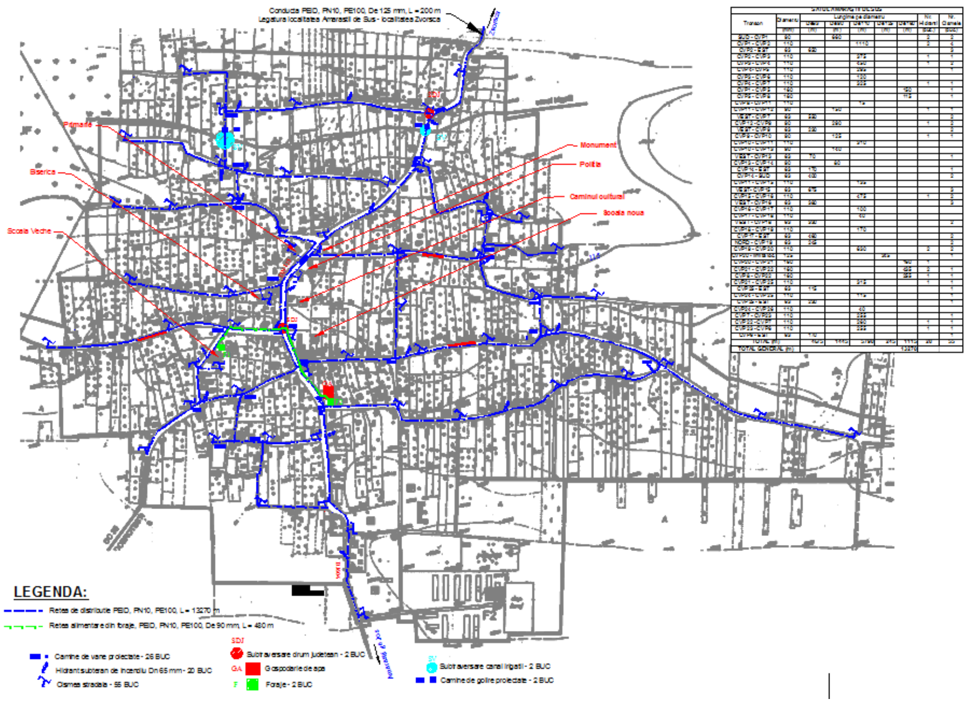

Figure 1. Plan view Amarastii de Sus

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).

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 (2,1 x 1,6 km), situated in space of irrigation chanel in vest and east. In map presented in Figure 2 is marked model limits.

The top and bottom elevations of the aquifer are variabily 120 m and 117 m, respectively.

The average horizontal hydraulic conductivity is 0.0001 m/s; the effective porosity is 0.25.

The water stage in the irrigation chanel is 118 m to 116 m above the bottom elevation, which is the reference level for the simulation.

The aquifer is simulated using a grid of one layer, 100 columns and 100 rows. A grid spacing is iregular (21 m is used for column and 15,6 m is used for row) (Figure 2). The layer type is unconfined. The irrigation chanel are modeled as fixed head in the chanel. One boundary is fixed hydraulic head boundaries.

Figure 3 shows the head contours.

To modeling polluted transport the pollution source is the wastewater treatment plant considered as a permanent pollution.

3. RESULTS AND DISCUSSIONS

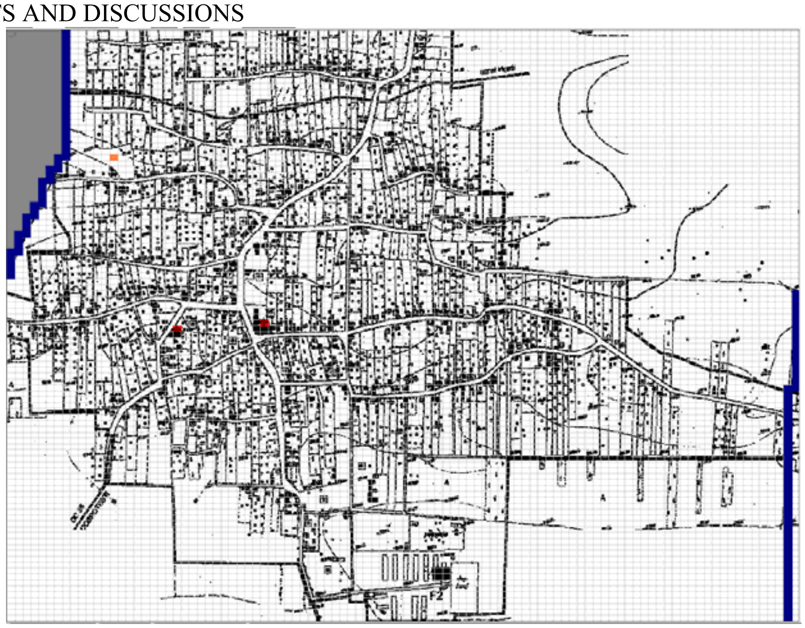

Figure 2. Model and Discretization

As boundary conditions there are accepted:

- concentration C=100% on the treatment plant as a permanent pollution source

- concentration C=0 in the field outside of landfill area.

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.

Results are presented in figures under polluted extending areas with different concentrations (isoconcentrations) for 10 years (Figure 4).

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

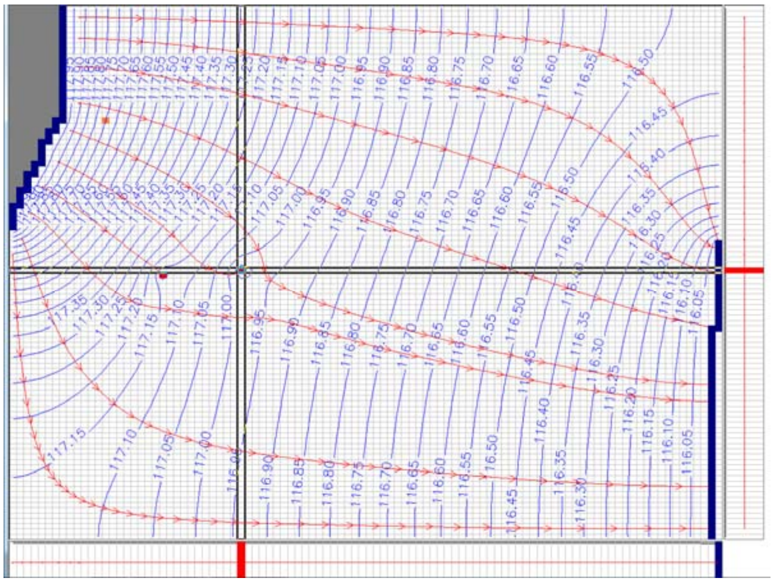

Figure 3. Head contours

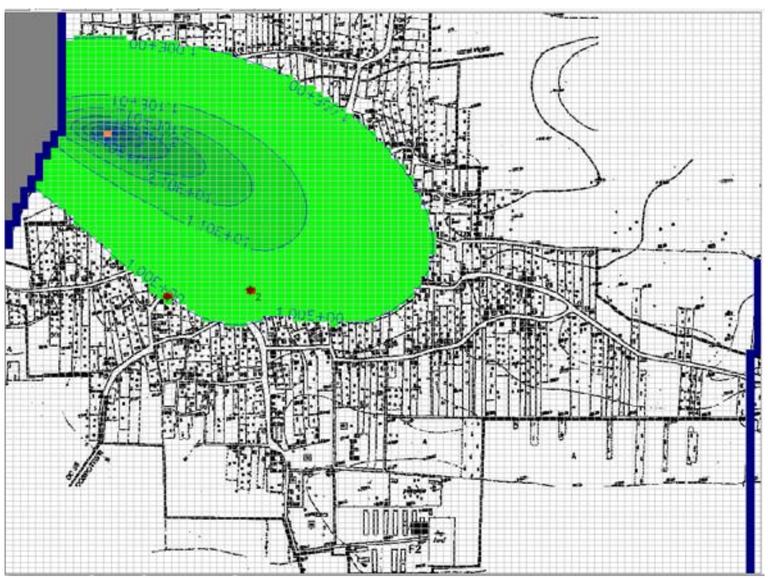

Figure 4. Distribution of the pollutant

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