

A SIMULATION OF RIVERBED FLOW WITH ENVIRONMENTAL RISK

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Abstract: In this paper we simulate a flood from Tarnava basin, as sub-basin of the Mures river, with the software MIKE 11. In the Tarnava river basin most of the floods are generated by rain. The annual runoff in the Tarnava river basin is influenced by the rainfall depth, evaporation, morphometrical characteristics of the flood channel, cutoffs coefficient and hydrogeological conditions of the drainage areas. When calculating the runoff we should include a series of parameters that will take into account the influence of accumulations and embankments built to prevent floods. Also, other parameters can be mentioned related to the cutoff coefficient, the morphometrical characteristics of the flood channel and the deposits.

Keywords: flood, flooding, cross section, causes, effects, river

1. Introduction

In this paper we choose a white space erodible river in Timis basin, for a flow simulation in Mike11 from DHI[1].

The Tarnava is a river in Romania. It is formed by the confluence of the Tarnava Mare and Tarnava Mică in the town of Blaj. The Tarnava flows into the Mureş after 28 km, near the town of Teiuş. Tributaries of the Tarnava, besides its two source rivers Tarnava Mare and Tarnava Mică, are the Tiur, Izvorul Iezerului and Secaş from the left and the Şoimuş from the right. Its drainage basin covers[2] an area of 6,253 km² (2,414 sq mi)(Figure 1) [7].

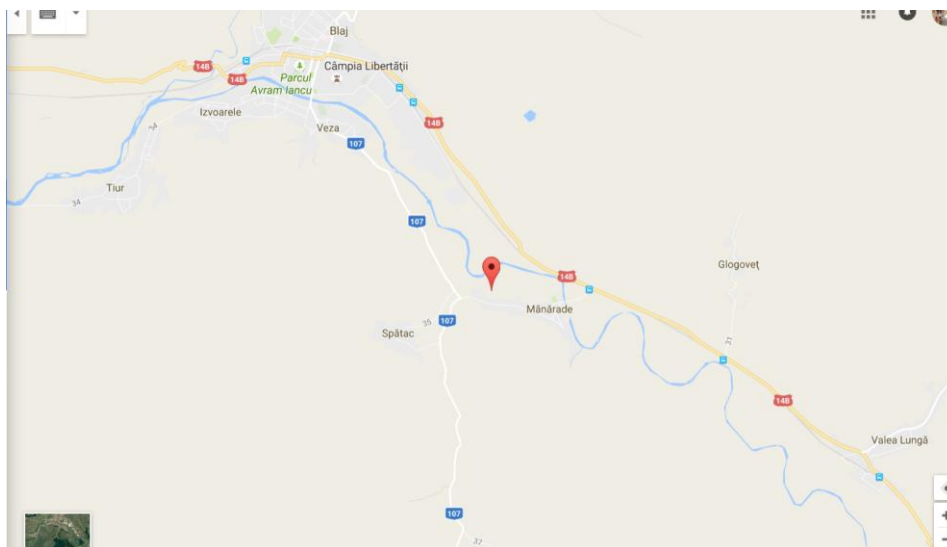


Fig. 1. Map of Tarnava River [6]

There is emphasis on the practical importance of maximum runoff observation on watercourse management works. The analysis of the maximum runoff genesis as well as the distribution of the values according to genesis was based on a comparative analysis of the climatic and hydrologic variations.

The most serious floods in Tarnava river basin, occurred in May 1970, July 1975, March 1981, December 1995-January 1996 and June 1998. The flood analyses from 1970-2004 periods at Sarateni hydrometric post illustrate a great number of important floods in May 1970, July 1975, May 1978 and May 1984, followed by a period of 10 years with modest floods until 1995. The last decade presents floods in April 1999 and 2000, May and August 2005. Floods vary according to seasons, the most numerous occurring in spring (30%-45%), less in autumn (6%-10%). The maximum frequency is in April and March, followed by June. [3]

The hydro-technical works in Târnava basin started as a result of important damages caused by the floods in 1970 and 1975. They implied the construction of some storage reservoirs, both permanent and non-permanent, to protect different objectives within the territory. By means of redistributing the flow during the year, they created a balance in the hydrologic system, compensating for minimum discharges and decreasing the maximum ones. [3]

For this model of the river bed we need the following elements need to be studied:

- a. Data location and description of the catchment area, applicable to Tarnava ;
- b. Data on power sources aquifer basin, applicable to Tarnava;
- c. Balance river flows in the Tarnava;
- d. Reporting to the climatological normal space Tarnava basin.
- e. Hydrometeorological regime for Tarnava catchment area. [2]

2. Tarnava flow simulation in the riverbed by MIKE 11 Program

a. Mike 11 Software

MIKE 11 is synonymous with top quality river modelling covering more application areas than any other river modelling package available. Mike 11 is useful for project deals with flooding, navigation, water quality, forecasting, sediment transport, a combination of these or other aspects of river engineering.

The software has a lot of benefits:

- MIKE 11 can get one of the world's most well proven and widely applied 1D river modelling packages
- MIKE 11 is the preferred choice for professional river engineers when reliability, versatility, productivity and quality are keywords
- It is a powerful river modelling toolbox with more features than any other river modelling package
- MIKE 11 is the software product, which made the MIKE brand name synonymous with top quality modelling software from DHI and it remains one of the most widely used MIKE by DHI products.[8]

On the *Input/edit side* MIKE 11 features:

- graphical data input/editing
- simultaneously input/editing of various data types
- copy & paste facility for direct import (export) from e.g. spreadsheet programs fully integrated tabular and graphical windows
- importing of river network and topography data from ASCII text files
- user defined layout of all graphical views (colours, font settings, lines, marker types etc.)

On the *Output side*, advanced presentation facilities are available, including:

- coloured horizontal plan graphics for the system data and results
- animated presentation of results in horizontal, longitudinal and time series plot
- synchronized animation of results
- presentation of external time series

- copy & paste facility for exporting result tables or the presentation graphics into other applications (spreadsheet, word processing or others)

a. Modeling equations

The equations for the flow cross-section are the Saint-Venant equations (eq.1, 1', 1'') and for along the riverbed flow, the turbulent flow equations, i.e. equation for turbulent kinetic energy (eq. 2), dissipation equation ε (eq. 3)[2]:

$$\rho \cdot Q \cdot dt - \rho \cdot (Q + \frac{\partial Q}{\partial x} dx) dt = \rho \cdot dA \cdot dx = \rho \cdot \frac{\partial A}{\partial t} dx \cdot dt ; \quad (1)$$

$$\frac{\partial Q}{\partial x} = \frac{\partial A}{\partial t} ; \quad (1')$$

$$\frac{\partial Q}{\partial x} - B \cdot \frac{\partial h}{\partial t} = 0 ; \quad (1'')$$

$$\frac{\partial}{\partial t} (\rho_m k) + \nabla \cdot (\rho_m \bar{v}_m k) = \nabla \cdot \left(\frac{\mu_{t,m}}{\sigma_k} \nabla k \right) + G_{k,m} - \rho_m \varepsilon ; \quad (2)$$

$$\frac{\partial}{\partial t} (\rho_m \varepsilon) + \nabla \cdot (\rho_m \bar{v}_m \varepsilon) = \nabla \cdot \left(\frac{\mu_{t,m}}{\sigma_\varepsilon} \nabla \varepsilon \right) + \frac{\varepsilon}{k} (C_{1\varepsilon} G_{k,m} - C_{2\varepsilon} \rho \varepsilon) ; \quad (3)$$

where

ρ_m is the mixture density (eq. 4) consists of several phases ($\alpha_1 \dots \dots \alpha_N$) with density ρ_i ; \bar{v}_m is vector speed (eq. 5), $C_{1\varepsilon}$ is concentration of component z, k is tensor of permeability, $\mu_{t,m}$ is mixture turbulent kinematic viscosity (eq. 6), ε is volume fraction of the α phase:

$$\rho_m = \sum_{i=1}^N \alpha_i \rho_i ; \quad (4)$$

$$\bar{v}_m = \frac{\sum_{i=1}^N \alpha_i \rho_i \bar{v}_i}{\sum_{i=1}^N \alpha_i \rho_i} ; \quad (5)$$

$$\mu_{t,m} = \rho_m C_\mu \frac{k^2}{\varepsilon} , \quad (6)$$

with C_μ a constant.

b. Boundary conditions of the flow:

Boundary Conditions of the flow are:

- discharge flow upstream of the control section, downstream;
- tributaries flow;
- condition for convergence solution-end flow, $Q = 0$;
- water depth, h (1 ÷ 2.0) m;
- weather-wind, currents;
- conditions for Q / h downstream flow (never upstream).

c. Modelling flood

We are modelling a flood of Tarnava river from 2015.

First of all, we need a cross section of the river. The cross sections are integrated in the MIKE11 simulation as a function. For example, the function Width (Level). As a result, forelands with a dike between river and foreland have to be simulated separately: otherwise the foreland will already contain water before the water level reaches the top of the dike. Processed data look like follow (Figure 2):

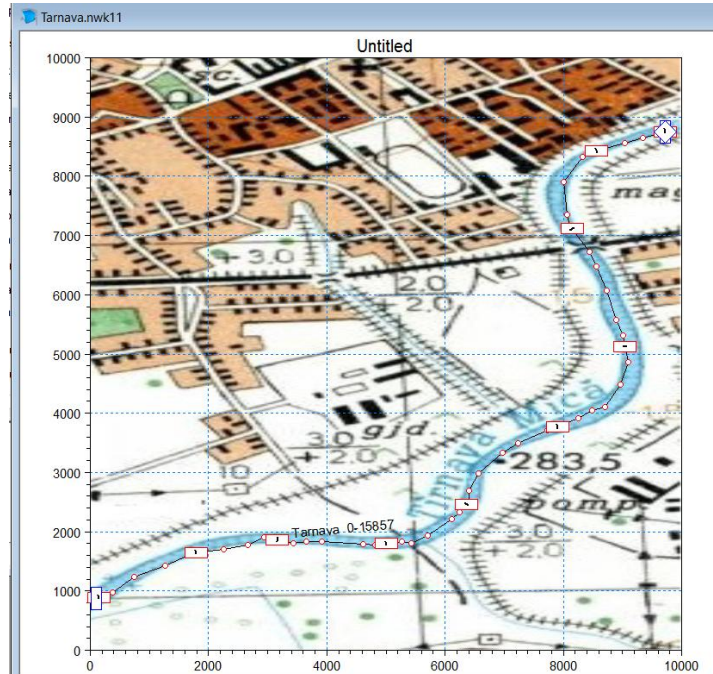


Fig. 2. Cross section in Mike 11[6]

Here we make a subdivision below the branch name in 'TOPO-IDs'. This can be used for calculating alternative cross sections for one branch[4]. The TOPO-ID being used in the simulation has to be defined for that branch in the network file (tabular view). The last point being mentioned in this chapter is related to the markers of a cross section. For the coupling especially the marker No 2 is obligatory (Bottom of profile). Using the option "Cross Sections/Apply to all sections" the markers 1, 2 and 3 can be updated for all cross sections at once. By using "Settings/Cross-Section/Update Markers" one can select which of the markers have to be updated. Processed data look like follow (Figure 3):

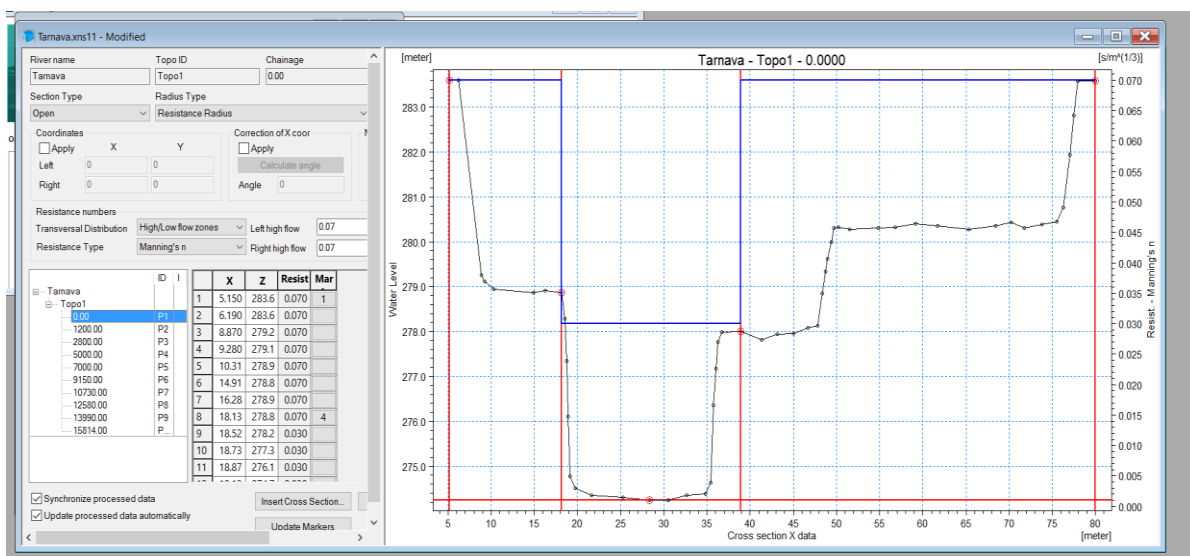


Fig. 3. Branch name TOPO1

Based on topographic data, initial hydraulic data and data obtained by graphic-analytical and also the limnometric key of Tarnava riverbed using MIKE 11 software was simulated a flow specific to a situation of flood in 2005 (Figure 4).

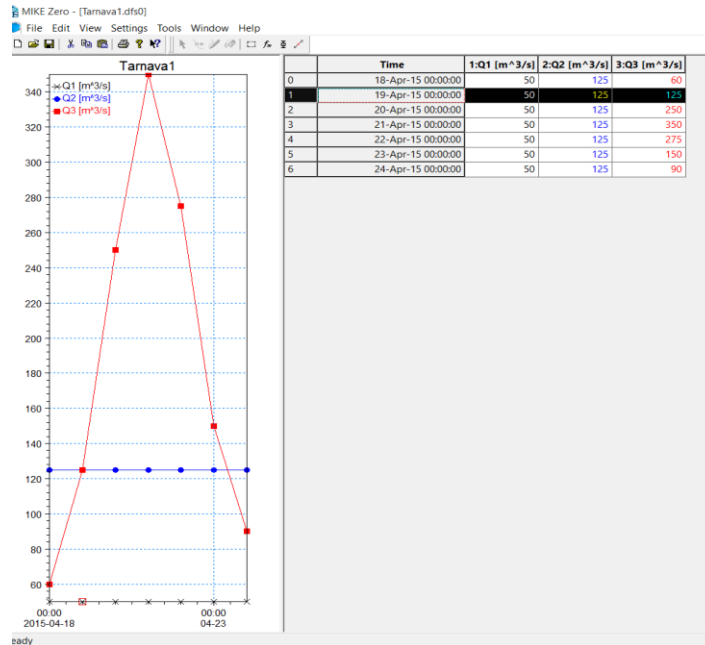


Fig. 4. Flow simulation for three flow discharge in 2015.

The result of the MIKE 11 simulation program consists of a contemporary representation while during flood flow path on the Tarnava course, viewing velocity vector (green, Figure 5) for the entire length of the river.

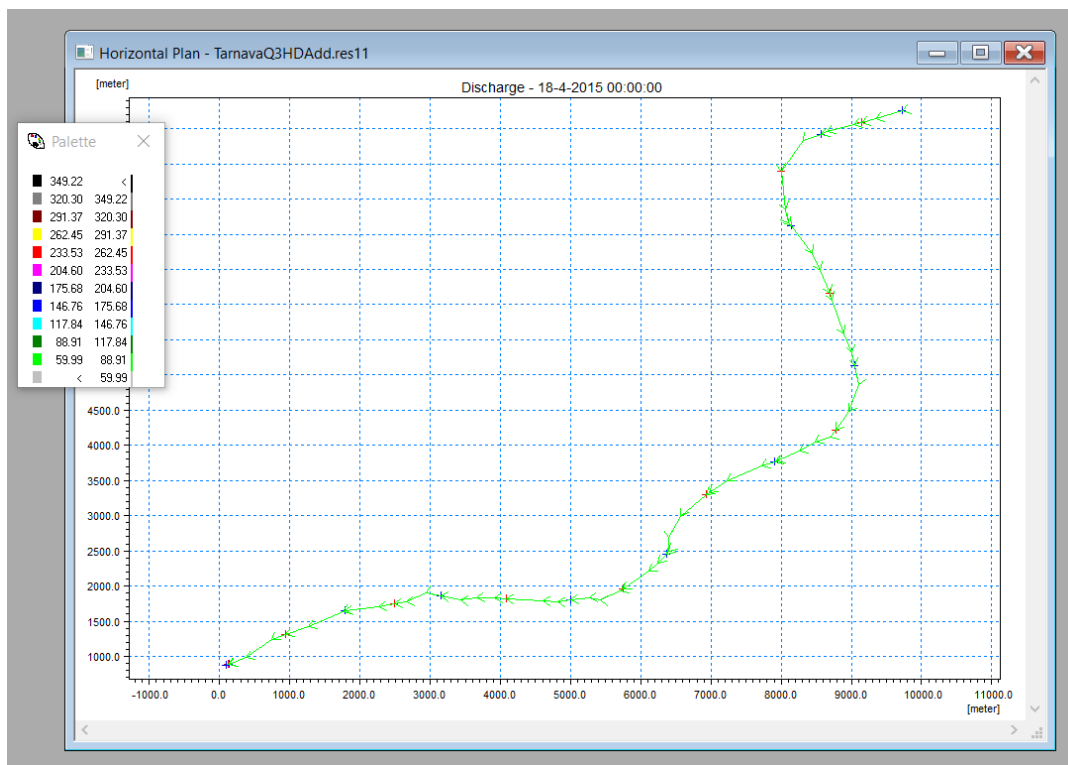


Fig. 5. Flow visualization and velocity vector along the riverbed Tarnava.

The final results of modeling with MIKE 11 program are plotting and maximum rates for the flood of 2007 (Figure 6) and flow profile along the riverbed Tarnava (Figure 7) .

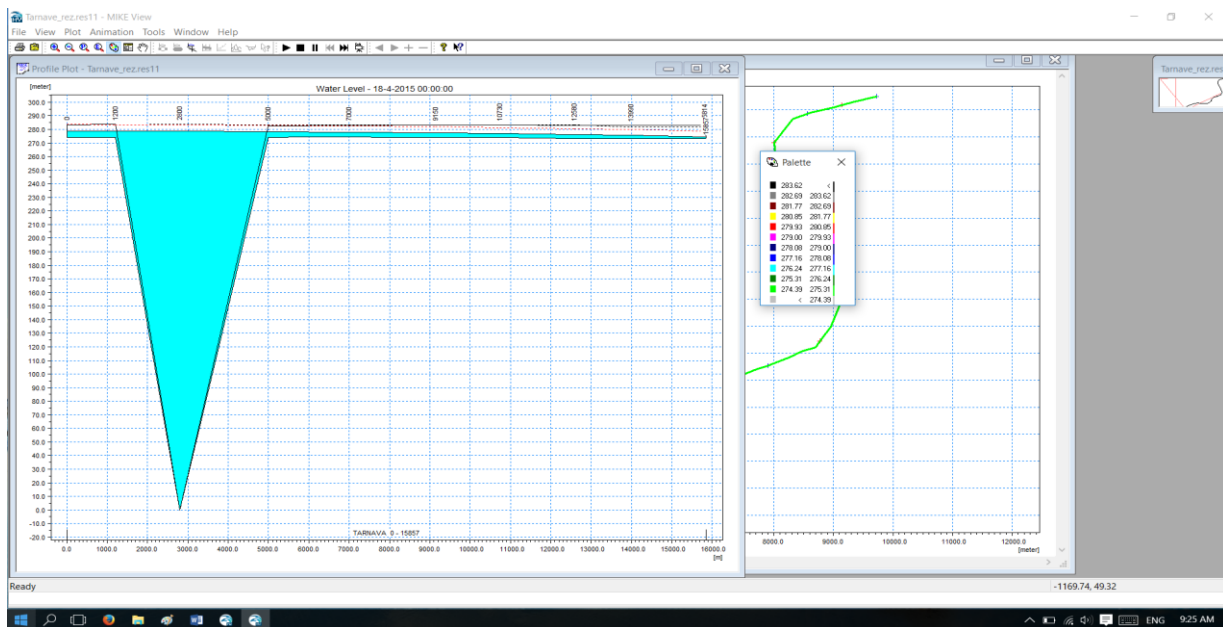


Fig. 6. Shares riverbed for flood in 2015

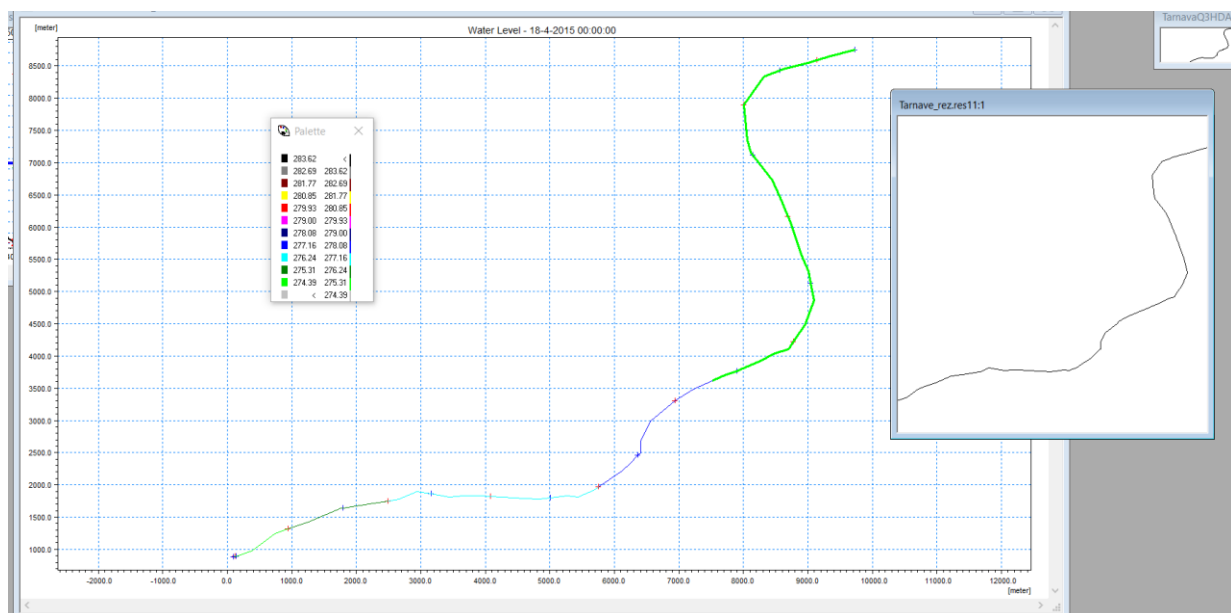


Fig. 7. The final flow profile along the riverbed Tarnava and water level

On the length of Tarnava river was represented the allowance variation of the riverbed, the distribution of the velocity vector for related shares initially introduced in the program.

Conclusions

For studying the flow in the Tarnava riverbed[5] eroded with environmental risk were analyzed elements: location and description of the hydrographic area, data sources feeding the aquifer basin data sources feeding the aquifer basin balance flows to the hydrographic area Tarnava for 2015, reporting to the climatological normal catchment area Tarnava; morphological and morphometric

elements of the bed of the guests; Tarnava riverbed proper flow modeling; risk analysis in the event of floods.

Building the model accordingly to Tarnava basin riverbed assumed the existence of a stage modeling that was done with the program MIKE 11 situation of 2005, the hydrograph basin Tarnava, based hyetogramm rainfall; then simulated the flow along the river, indicating the distribution of speeds of flood related natural hydrograph.

Environmental risk analysis appropriate basin bed Tarnava imposed through some stages of analytical calculation and construction of flood wave hydrograph and its separation into its basic components, and use the same program to raise MIKE 11 hydrographer.

Following theoretical and experimental findings about river conditions change in response to the liquid phase flows and sediments are:

Current depth is directly proportional to fluid flow and inversely proportional to the flow of solid material dragged;

- limits the embankments of river bed varies in direct proportion to the flow of liquid and solid material;
- varying flow is directly proportional to the variation solid ratio width / depth;
- slope of the river bed varies in direct proportion to solid and grain alluvial flow and inversely proportional to fluid flow;
- river meanders rate is directly proportional to the variation in relief and inversely proportional to the solid flow.

References

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