Bulletin of the *Transilvania* University of Braşov
Series II: Forestry • Wood Industry • Agricultural Food Engineering • Vol. 6 (55) No.2 - 2013

USING *GIS* FOR THE DETERMINATION OF PEAK DISCHARGE IN A SMALL FORESTED WATERSHED

Cornel Cristian TEREŞNEU[1]

Abstract: *This paper aims to analyze the facilities of GIS for the application of TR-55 model in a small forested watershed and to do a comparison between the peak discharge estimated for this model and by the rational model, the latter being commonly used in the project activity from our country. The two methods were applied in a small watershed (65 ha) from a mountainous area of Romania. It has been shown that the application of TR-55 model is not only easy to apply but also very useful, since the results obtained by applying this model are very similar to the results obtained with the rational model.*

Key words: *GIS, TR-55 Model, AutoCAD, watershed.*

1. Introduction

For the torrential watersheds of Romania, the forecast of the peak discharge is performed by means of indirect methods, which take into account the depth of the rainfall which generates the flood and the watershed characteristics which influence flood generation and propagation [1].

Determination of flow with some of these methods (including rational method, which is required to apply in project documentations), implies elaborate computation efforts and an extended processing time.

This is why, in the last two decades, in Romanian literature there have been described new hydrological methods, which, when applied using geographic information systems, provides the automation of the process (partial or even complete) to determine the maximum flood flow [4].

Among these new models there are also included the TR-55 (Technical Release 55) model, which was developed by the Natural resources Conservation Service NRCS – USA [9] and enables the working out of the unit hydrograph both in tabular and graphical formats.

Because possibilities provided by this model were investigated in previous work, we intend to deepen the knowledge of the advantages of this model by considering the hydrological order items with which they operate and the results offered [6].

Specifically, there are two objectives that are followed in this paper:

- on the one hand, highlighting the features that GIS tools provide in the automatic application of the model;
- on the other hand, tracking and knowing how estimated peak discharge

[1] Dept. of Forest Engineering, Forest Management Planning and Terrestrial Measurements, *Transilvania* University of Brasov.

by a primarily recommended model for on the one hand, highlighting the features that GIS tools provide in the automatic application of the model;

- on the other hand, tracking and knowing how estimated peak discharge by a primarily recommended model for urban or urbanized basins (as it is the TR-55 model), approaches or moves away from the estimated peak discharge by the rational model, the latter being a model commonly used in the project activities from Romania, in order to determine the maximum flow generated by rainfall in the small watersheds, mainly covered by forests and meadows.

2. Materials and methods

The application was done on the occasion of the previous research [6] into a small watershed of 65 ha, located in the middle third of the Valea Porții brook, Braşov county. Its boundaries are the Bucegi Mountains to the east and the Piatra Craiului Mountains to the west. The coordinates of the research area are 45^{o}47′98′′ east longitude and 25^{o}38′66′′ north latitude (Figure 1).

The TR-55 model requires the specification of the following values: rainfall distribution model, drainage area, runoff curve number, runoff coefficient, concentration time, time of runoff travel, area of pond sand swamps, and of flooded zones, rainfall frequency and intensity for each sub-basin [9].

Using an AutoCAD program there have been determined all these elements, taking into account the characteristics of the studied area [6], [7]. It specified that, for determination of the runoff coefficient concentration time, as well as to calculate other hydrological indicators, the Hydrology module extension of AutoCAD program is required.

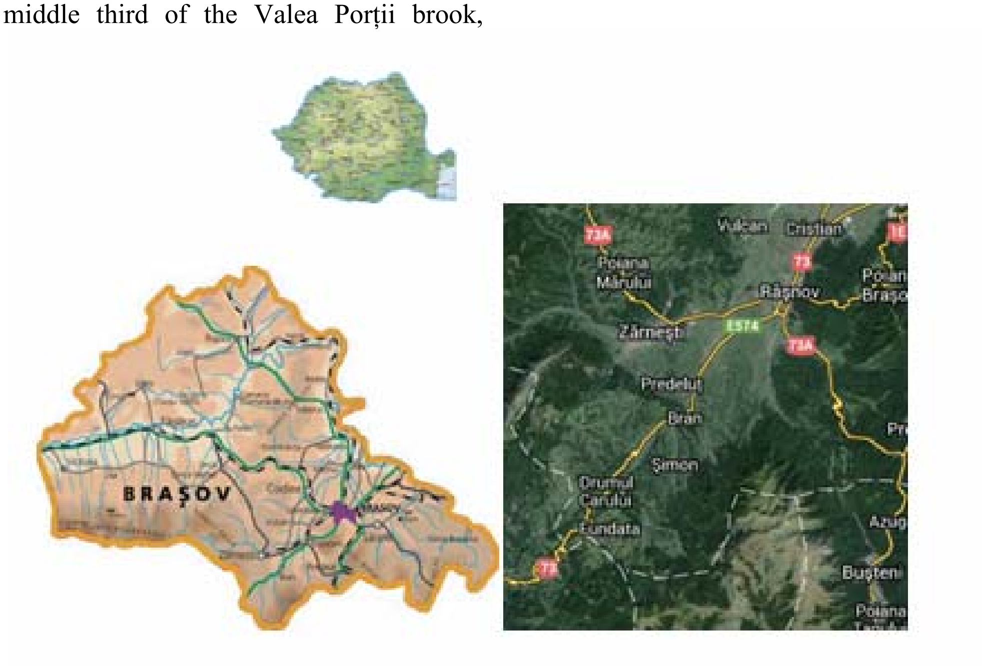

Fig. 1. *Research location*

3. Results and Discussions

As the watershed under consideration is covered by stands aged 60 to 100 years, with stand densities in the range of 0.6 (sometimes even 0.4) and 0.9, the soil being a typical brown soil, the 76 runoff curve has been adopted.

Using digital terrain model created for this basin (Figure 2) and specialized integrated software within the model there were established the following hydrological interest elements [5], [6]:

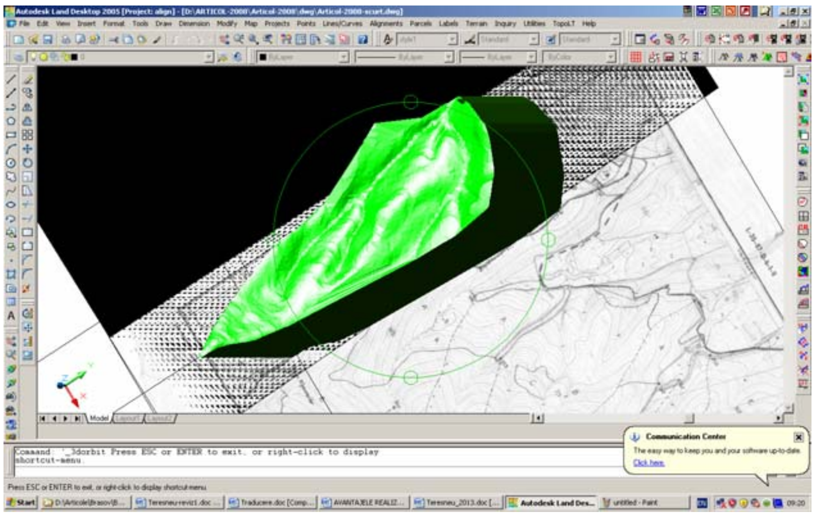

Fig. 2. *The digital terrain model*

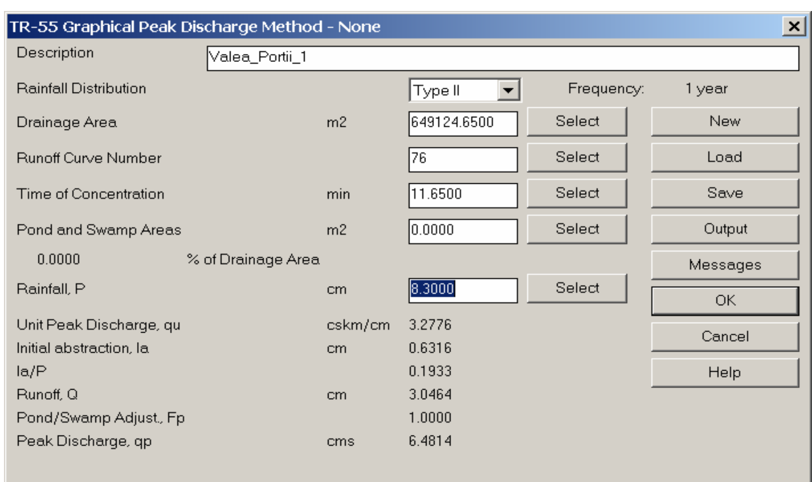

Fig. 3. *Input data for the graphical format of the hydrograph by means of the TR-55 model*

- average inclination of the basin equal with 46.6% (using AutoCAD Land software);
- runoff coefficient concentration time, equal with 11,65min (using Hydrology module extension of AutoCAD program);
- runoff, equal with 3,05cm (using Hydrology module extension);
- peak discharge, equal with 6,48mc/s (using Hydrology module extension) (Figure 3).

To formulate an initial response to the second objective, there has been

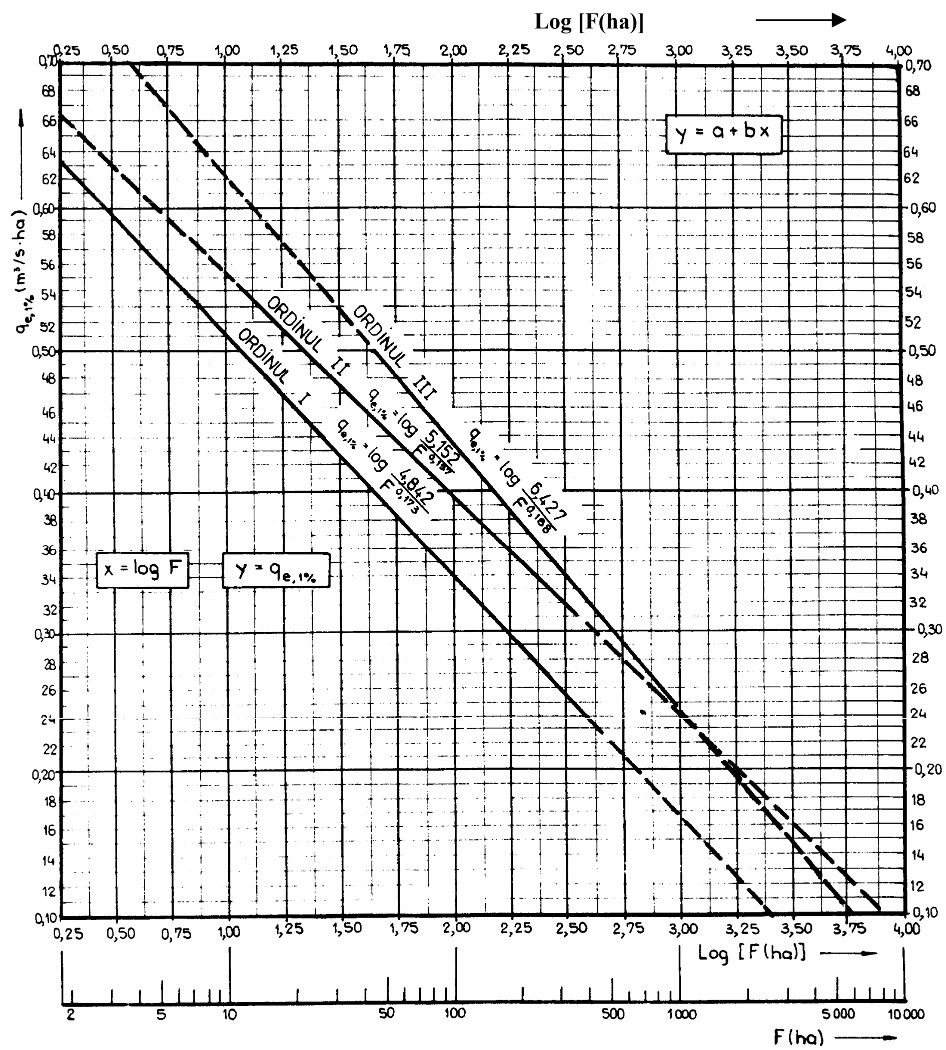

Fig.4. *Correlation between maximum specific standard morphological chart ($q_{e,1\%}$) and surface of the basins (F), in torrential watersheds from Romania mountains (area of crystalline shale) (by Clinciu, 1985).*

applied the classical path of the rational model (but with GIS support) [1],[2],[8]. According to this model, maximum flood flow is generated by duration of the rain which is equal to concentration time of runoff in the watershed.

Using for determination the graphical alternative application of the model, the so-called "standard morphological chart" (Figure 4), was obtained for the given area of 65ha and hydrographic order I, a value of 0,37mc/s/ha which is the maximum "standard morphological chart". After multiplying this value with the basin area and with the average basin runoff coefficient, based on the adopted Frevert system [3], it has been found the size of the peak discharge: 7,70mc/s.

Subtracting the difference between the result of the above and the one obtained by application of the TR-55 model and expressing this difference as a percentage, it results:

$$\frac{|Q_{TR-55} - Q_{MR}|}{|Q_{MR}|} \cdot 100 = 15{,}84\% , \qquad (1)$$

which shows a very good approach between peak discharges estimated by the two models. It is obvious that this result encourages us, but, at the same time, forces us to extend the TR-55 model applications within small watersheds of the forest area of Romania, located in different physico-geographical conditions comparative with the characteristic for the watershed taken for study, especially since automated alternative for determination of the peak flow is a feasible one and TR-55 model is friendly to apply, its successful implementation being straightforward and strongly influenced by the operating abilities of the user.

References

1. Clinciu I., 1985. Rational equation and concept of morphometrical standard watershed – premises to establish diagrams for maximum flow capacity. In: Revista Pădurilor no. 1, p. 4-6.
2. Clinciu I., Lazăr N. 1999. The bases of controlling torrents. Publishing House LuxLibris, Braşov.
3. Niță M.D., Clinciu I., 2010. Hydrological Mapping of the vegetation using Remote Sensing products. In: Bulletin of the Transilvania University of Braşov, Series II, vol.3 (52): 73-78.
4. Păcurar V.D., 2008. Modelling and Simulation of Hydrological and Erosion Processes in Forest Watersheds at the Beginning of XXI Century. In: Silvologie VI, Romanian Academy Publishing, Bucuresti, p. 215-239
5. Tereşneu C.C., Brad M.L., 2006. The execution of the digital model of the field using AutoCAd software in order to explore the torrential river basins. In: Studia Universitatis "Vasile Goldiş" Arad, Academic Publishing House "Vasile Goldiş" Arad, p. 77-86.
6. Tereşneu C.C., Tamaş Şt., Clinciu I., Vasilescu M.M., 2008. Possibilities of estimating discharge in small watersheds by means of TR-55 model. In: Sustainable forestry in a changing environment. Editura Silvică, Bucureşti, p.189-195.
7. Tereşneu C.C., Vasilescu M.M., 2009. GIS possibilities and topographical measurements on torrential hydrographyc network used to elaborate risk maps of flooding. In: RevCAD, Journal of Geodesy and Cadastre. Alba Iulia. Aeternitas Publishing House, p. 343-352.

8. ***, 1978: Methodology for computing maximum flow capacity in the small hydrographic basin rains for studies and projects of torrential watershead planning. M.E.F.M.C., Forestry Department, Bucureşti.

9. ***, 1986. TR-55: Urban hydrology for Small Watersheds. In HydroCAD Manual (http://www.hydrocad.net/hcmanual.htm