Modelling of Storm-water Drainage Systems in Residential Areas

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Abstract. All the processes that take place in an urban water system are parts of the hydrological cycle of water. Any urban development will have a negative impact on the environment, but through an optimal approach and management of rainwater, storm water drainage and pollution leakage, we prevent the degradation of these natural resources. This paper presents aspects regarding the management of the storm-water on the surfaces related to the developed residential areas within the localities, which do not have a centralized system of meteoric sewage. In most of the localities, the storm water is not collected centrally. It is being evacuated through the slopes of the lands to the gutter, where it exists and to the areas with the lowest levels of the localities. In recent years, the climate change and poor management of the storm-water in these localities led to a major risk of flooding. The paper analyses the potential flood risks of the drainage system designed for the residential area in the analysed river basin.

1. Introduction
In recent years, due to climate change, storm-water management is paramount to prevent erosion of agricultural land, as well as flooding urban areas, but especially new residential areas. All these effects have environmental consequences and can cause severe damage.

Storm-water management is the science of limiting these negative impacts on the environment and enhancing the positive impacts, while minimising the associated negative environmental impacts [1].

Waterproof surfaces in urban areas or new residential areas lead to flooding that occurs very often, and the leakage from these surfaces has a high speed, which is added to storm-water drainage systems. Urban leaks have an increased load of pollution, which leads to water pollution [2].

When rain falls on the ground, it either seeps into the ground or flows above the ground and becomes drain. Trees and vegetation also capture the nutrients that water brings, but nevertheless, when the water has no way to enter the ground, such as when it falls on a waterproof area – the streets of new residential areas, will continue to flow.

In order to mitigate the effects of floods in new residential areas, the use of tanks is used, a way of collecting rain, which with the help of these tanks temporarily stores meteoric water and then slowly releases, so as not to aggravate floods in the residential area, but also in areas located downstream.
2. Database and methodology
The study area is in Ghiroda, a village in Timiş County, which is part of the Banat river space, Romania. Ghiroda is in the centre of Timiş County, a short distance northeast of the municipality of Timişoara, with which it borders [3] (Figure 1).

The relief is low plain and is part of the Timis plain, characterized by wide waves being covered with a loess bedspread. This low-plain feature is attributed to it due to the fact that being an extension of the Tisei Plain, in the western Piedmonts area, it consists of alluvial formations with smaller bumps caused by the presence of crops and has altitudes ranging from 80 to 100 m.

The extraction of drainage networks from digital elevation data is important for quantitative studies in geomorphology and hydrology [4].

From a geological point of view, the area belongs to the Panonic Basin, the lithological column of this area comprising a tectonically affected lower floor and a post-tectonic bedspread (table 1).
Average annual rainfall is 600-700 mm, and heavy rainfall occurs mainly in the spring season.

From a geomorphological point of view, the site under investigation is found in a low-level area of recent subsidence aluvial subsidence, formed during the quaternary period from river-lake deposits (clays, sands, gravels), having a relatively flat surface, with altitudes between 89,00 m ... 91.00 m (Figure 2, 3).

### Table 1. Intercepted stratification in a residential area

| No. Crt. | Boring | Road structure | The nature of foundation soil |
|----------|--------|----------------|-------------------------------|
|          |        |                | Ic/Id Gravel Sand Dust Clay Soil type Ep |
| 1 2 3    |        |                | [-]  [%]  [%]  [%]  [%]  type  [MPa] |
| 1. Bore F1 | 10 cm - large mountain stone with dirt | 10 cm - hard blackish clay 120 cm - hard brown clay down - hard blackish gray clay | 1.05 | 13 | 50 | 37 | P5 | 70 |
| 2. Bore F2 | 15 cm - crushed stone 70 cm - hard brown clay 130 cm - hard brown blackish clay down - hard brown dusty clay | 1.26 | 15 | 47 | 38 | P5 | 70 |
| 3. Bore F3 | 15 cm - crushed stone 105 cm - hard blackish dusty clay 100 cm - hard brown dusty clay down - hard blackish gray clay | 1.20 | 15 | 54 | 31 | P5 | 70 |

Figure 2. Soil map for the area study

Figure 3. DEM map for the area study

The study area is not affected by physic-mechanical phenomena, which endanger its stability through sliding phenomena.

### 3. Result and discussion

The storm sewerage of the studied objective will be carried out through a sewerage network equipped with drains on the related streets, a hydrocarbon separator decanter, a retention basin, discharge pipe and a mouth in the canal (Figure 4).

The storm-water sewer age network of the objective is made up of several sections, located in the axis of the street, and the storm drain is gravitational.
Figure 4. Representation of the section network

Conventionally clean waters will be discharged into the drainage channel in the area via a discharge pipe and a spillway.

These drainage systems are needed in developed urban areas, such as these new residential areas, because of the interaction between human activity and the natural water cycle. If rainwater falling on these surfaces were not properly drained, it would cause flooding and risk.

The pipeline network to establish a network chart is processed in the Storm Water Management Model (SWMM 5.1) program, where the drainage system nodes and links could be digitized as shown in figure 5 [5, 6].

Figure 5. Urban drainage network and sub-watershed
SWMM, Epa meteoric water management model is a dynamic simulation of precipitation model used for a single of the new residential area, the entire study area being divided into subcategories.

Nodes (junctions) were introduced if a rapid change in the pipes was detected (depth, width, slope, roughness coefficient) or when the tributary channels are connected to the main network (Figure 6).

SWMM was first developed in 1971 and went through several major upgrades. The precipitation leakage algorithm used by the SWMM program is called nonlinear tank routing, and the calculated hydrograph form depends on several parameters, such as the representative slope of secondary capture, the Manning n of the surface (areas), etc.

Figure 6. The water elevation in the nodes

Rainfall, land cover, the drainage system, the soil and hydraulic conditions in developed areas provide a useful model for evaluating the sub-catchments runoff (Figure 7).

Figure 7. The extreme rainfall in 24 hours and cumulated rainfall

For each sub-catchment was determinate the areas, the slopes, the width, percentage of pervious area, percentage of total impervious area (Figure 7, 8).
4. Conclusions
Urbanization is occurring globally and increasing at an extremely rapid rate in most developing countries, particularly in Romania.

In this work, based on the characteristics of the processes of precipitation leakage and surface flow in the residential region, roads and pipes are considered as the main way of water flow. Due to the changes in land use in the residential area, arising from urbanization, natural leaks have been converted into artificial drainage.

The case study carried out in this paper demonstrated that the SWMM software is suitable for urban modelling and management in flood conditions. Among the most important parameters in determining flow in the channel are the dimensions of the pipe, slope, roughness.

Urban development’s indicate that floods have increased in intensity and frequency, and various structural or non-structural measures are needed for the management and control of floods in these developing areas.

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