FLOODING OCCURRENCE WITHIN THE BUILT-UP AREAS OF BAIA MARE

S. ZAHARIA[1], *V. CHENDEŞ*[2], *B. DRIGA*[3]

ABSTRACT. – **Flooding occurrence within the built-up areas of Baia Mare.** Specific regulations regarding town planning, design and authorisation of works, and also of actions for the mitigation of destructive effects, impose the acknowledgement of local characteristics of flooding; based on field researches and the procession of existent geographic data bases, there have been established the main flood areas.

Key words: maximum flows, flooding, Baia Mare, mitigation

1. Introduction

Baia Mare Depression, where Baia Mare municipality is located, is included in the subunit of Silvano-Someşene Hills, actually an interim stage between Someş Plain and the Northern Group of Oriental Carpathians. Though, the administrative territory of Baia Mare municipality goes deep into the mountain area, from Săsar Valley (in the South), towards north, in the Gutâi Mountains. The Baia Mare territorial and administrative division (UAT) covers a surface of 23 347 hectares, from which 3762 hectares belong to the built-up area, powerfully fringed, especially in the northern part, with two prolate protuberances on Borcut and Firizei Valleys; the accelerated development of real-estate constructions from the last period rises more and more complex issues regarding the risk of flooding. The administrative territory develops on a high deviation of altitude, from 1307 m in Ignis Peak to 180 m (confluence of Săsar and Borcutului Valley) (figure 1). If we added the variety and the default dynamics of geomorphologic processes, against the lithological and geological diversity, within the conditions of obvious modifications of certain climatic elements, it results the special complexity in finding optimum solutions for a stable and sustainable development within the built-up areas.

[1] *Geoproject, Baia Mare, Romania, e-mail:geobaiamare@yahoo.com, sorinzaharia711@yahoo.com*
[2] *National Institute of Hydrology and Water Management, Bucharest,e-mail:chendesviorel@yahoo.com*
[3] *Institute of Geography, Romanian Academy, Bucharest, e-mail: driga_basarab@yahoo.com*

2. Regulations

Directive 2007/60/CE of the European Parliament regarding the evaluation and management of floods risk represents the most recent provision within this field. Nationally, Law 575/2001 regarding the approval of the National Spatial Plan – Section V Natural Risk Areas – refers to natural risk areas, including flooding. In accordance to these documents, the flood risk map, component part of the county and/or area spatial plan, shall be elaborated for the exceeding probabilities of maximum flows of 20%, 10%, 5% 2%, 1% or 0,1%, according to the importance of objectives from the risk area and the framing within classes and categories of importance appropriate to these. As a novelty, it may be ascertained the including of extreme events (0,1%), until the apparition of this Directive, the flood occurrence maps being realised for maximum 1%.

Figure 1. Baia Mare (Administrative area) – Hypsometric map.

3. Methodology

The data source for the descent variables, versants display and relief energy was the Land's Digital Model obtained based on the topographic information from 1:5.000 plans, the MDT pixel resolution being of 10 m.

The land's utilisation parameter was processed from the Corine Land Cover 2000 database (*Coordination of Information on the Environment*), at the level of the year 2000, with 44 classes of land's coverage grouped on 3 hierarchical levels. The lithology was obtained from geological maps realised by the Romanian Institute of Geology. The data layer regarding seismicity was derived from the Romanian Standard SR 11100/1-93 elaborated after the 1977 earthquake. The analysis of maximum rainfalls within 24 hours is based on record between 1872 and 2005, classified in four classes: <100 mm, 100–150 mm, 150–200 mm and >200 mm (Dragotă, 2006). For the determination of levels appropriate for maximum flows with 1% probability, there have been realised 15 transverse profiles on the surveyed and valued rivers within the town area, and also on small valleys situated north of the village village (horizontal and vertical scales in meters), as it follows: 3 transverse profiles on Borcut Valley, 4 transverse profiles on Craica, 1 transverse profile on Vicleanul Mare, 1 transverse profile on Sf. Ioan, 2 transverse profiles on Usturoiului Valley, 2 transverse profiles on Valea Roşie, 2 transverse profiles on Săsar (figure 2).

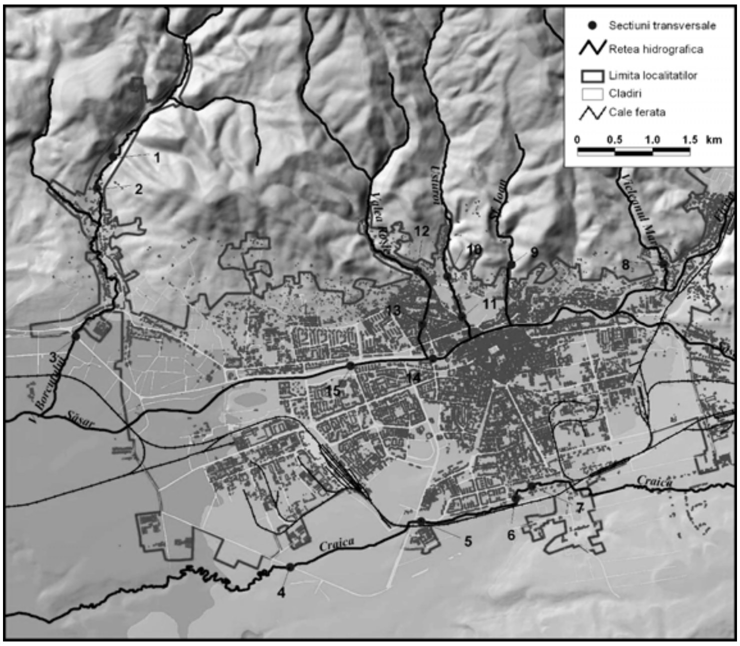

Figure 2. Transverse profiles performed for the flood occurrence evaluation.

4. Hydrographic network

The density of the hydrographic network was determined with the application ArcHydro and has a value of 1,06 km/km^2 for the surface of the drainage basins Săsar-Craica. The Săsar basin and the Firiza sub-basin have an almost average value (1,06 km/km^2 and 1,05 km/km^2, respectively), while the Craica basin, due to its oblong shape and the existence of a number of streams of water which in fact function as canals, has a slightly higher drainage density (1,17 km/km^2).

In the built-up area, although they are strongly modified, the natural watercourses are very important for territory planning. On the left side of the Săsar river, between Săsar and Craica, 4 streams can be identified: one of them is just downstream from the confluence with Firiza, the second one flows into Săsar opposite the confluence with Valea Roşie, the third one downstream from the confluence with Valea Roşie and the last one at the western boundary of the built-up area. On the right side, except for the main streams, a secondary one can be identified which connects the Sf. Ioan Valley with the Usturoi Valley, as well as a stream which flows westwards from the Valea Roşie basin, almost parallel to the Săsar river, crossing under the piedmont frame almost the entire Săsar neighborhood.

The Săsar river flows through the municipial territory for 9,4 km, from the sector located upstream from the confluence with Firiza, to the confluence with Valea Borcutului. The mountains situated northern from Baia Mare are drained by a series of short, quasi-parallel valleys, with an average altitude of 430-470 m, but with drainage basin slopes of more than 180: Sf. Ioan, Usturoi Valley, Valea Roşie and Borcutului Valley. The shorter the valleys, the steeper their slopes: 68.2 m/km for Sf. Ioan, 36.4 m/km for Borcutului Valley. The Săsar drainage basin corresponds to the *western carpathian type,* caracterised by spring high waters (March-April) and flashfloods during the other seasons. At the Baia Mare hydrological station the multiannual average flow is 6,04 m^3/s, while the drainage area in the station sector is 266 km^2 (1971-2000).

5. Maximum flows

Precipitation, through the maximum intensity, length and depth determine the size of maximum flow. The depth of precipitation, due to mountains, records high values, annually exceeding even 1100 mm. The highest values of maximum depths of precipitation fallen within 24 hours are produced during May-October, their monthly average reaching the highest value in August (60.2 mm). The absolute maximum depth registered 121.4 mm/13.05.1970.

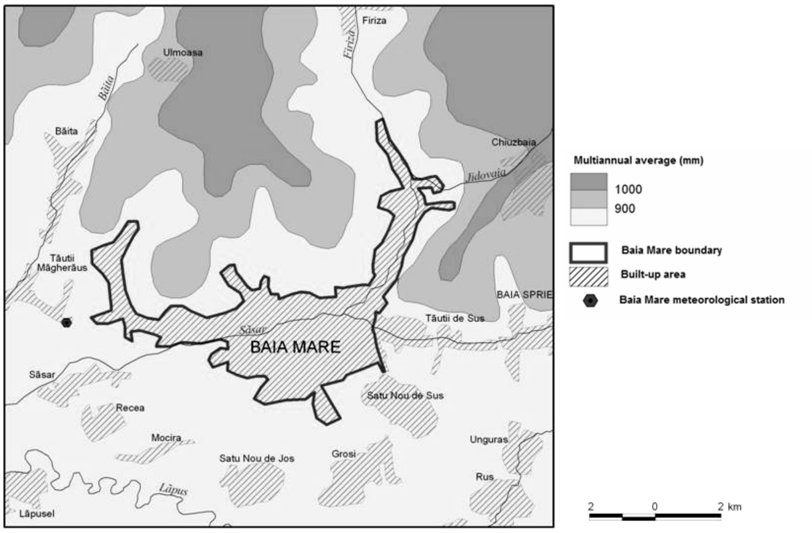

Figure 3. Multiannual precipitation average (mm).

One can notice the progressive, continuous growth of the decadal precipitation average, from 835 mm (1971-1980), to 925 mm (1991-2000) and 975 mm (2001-2007).

In addition to this, of great importance is the maximum capacity of water retention in the basin, estimated between 55.7 mm (Firiza, upstream of Vicleanul Mare) and 42.3 mm (Valea Roşie).

Maximum flows also depend on the length of the main bed and of the basin's slope, these two parameters being used for the calculation of concentration time T_C (defined as the largest time in which a drop of water falling into the basin reaches the exit or the time passing between the end of the rain and the production of the inflection point on the descendent curve of the hydrograph) and of delaying time T_{LAG} (time that passes between the rain and the moment in which the peak of high flood is produced).

$$T_{LAG} = (3{,}28084 * L)^{0{,}8} * \frac{(S+1)^{0{,}7}}{1900\sqrt{I_B}}$$

$$T_C = 1{,}6667 * T_{LAG}$$

Where:

T_C – concentration time in hours; T_{LAG} – delaying time in hours;

L – length of main bed in m;

I_B – average slope of the basin in %;

$S = \frac{1000}{CN} - 10$ and represents the maximum retention into the basin.

The maximum flows were estimated at 1% probability using the morphometrical parameters, precipitation, soil and vegetation characteristics. Flows are not calculated in an arranged regime, due to the lack of precision necessary to bridges' design, etc. For the Săsar river, upstream from the confluence with Firiza, the estimated flow is 165.3 m^3/s, while after the confluence with Firiza this rises up to 314.1 m^3/s. At the town limit, upstream of Borcut Valley, the 1% flow value reaches 339.4 m^3/s. Small valleys, affluent from the north, record estimated flows between 25-80 m^3/s, nevertheless, being small torrential basins, they are characterised by specific discharges that may exceed 10 000 $l/s/km^2$ (10 326 $l/s/km^2$ for Sf. Ioan).

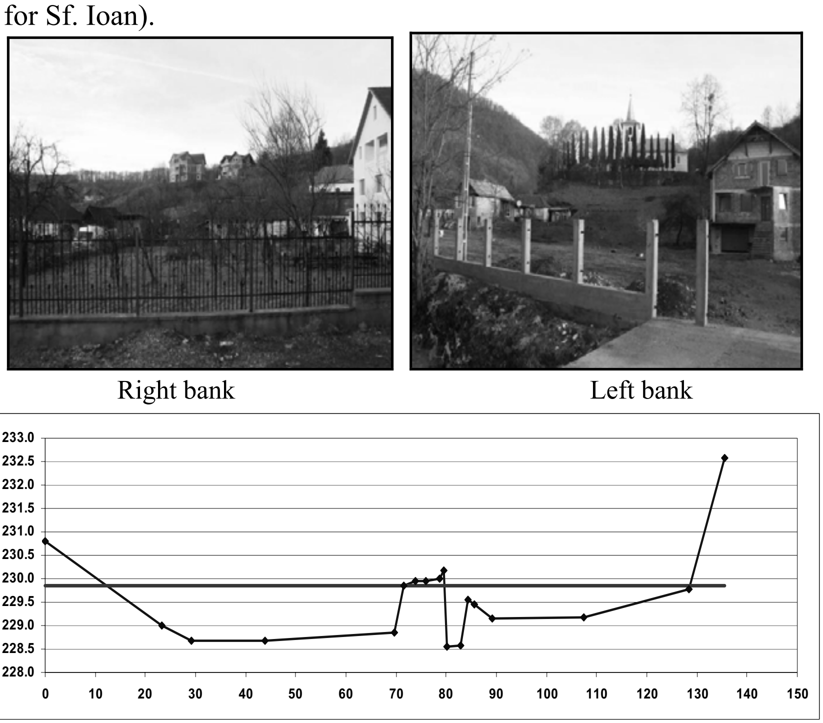

Figure 4. Section 2 on Borcutului Valley.

The watershed line between Craica and Săsar, as the 5-10 m terrace of Săsar, are characterised by extremely low slopes and level differences. This area is „compartmentalized" by the higher lines represented by earth banks of certain roads. The lower areas and microdepression areas from this sector of Craica stream are floodable areas. To extreme rains, these phenomena are amplified both by the small section of the bridge passing under the industrial road, and also by the refuse blockages (figure 5). We think that this bridge may be transited only by approx. ca ¼ from the maximum flow with 1% probability.

Total view Bridge section

Bridge section blockage

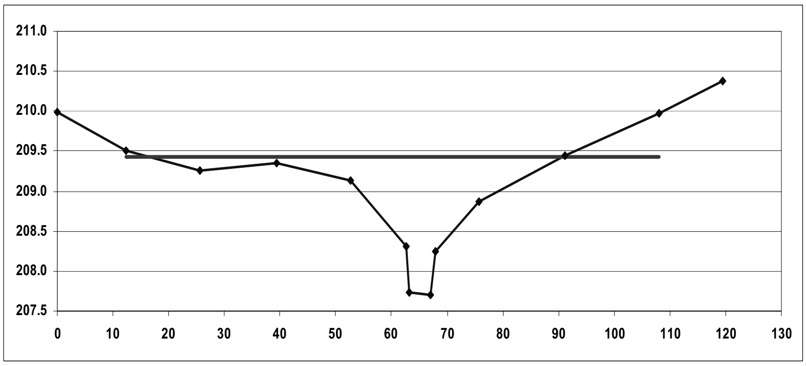

Figure 5. Craica Valley – section 4.

In December 2009, Grăniceri district was flooded by the waters of Craica stream. The right bank was further consolidated and set up, but only in the block of flats' area. This set up area (figure 6), contributes to the transit of a much bigger flow. Based on performed calculations, the transit of 1% flow is at limit, but the blockages that may occur into the bed right downstream this section may lead to the bottom land flooding.

Flood of December 2009 within the profile 5 section

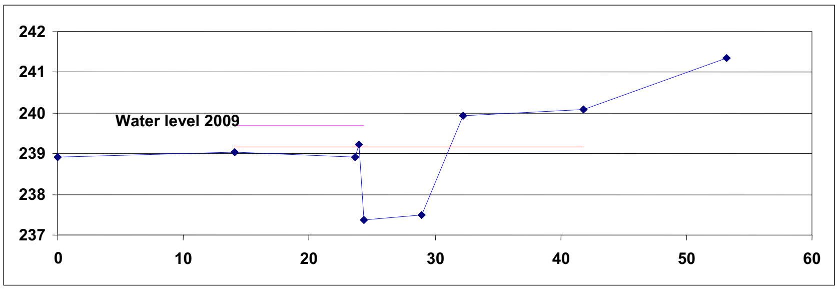

Figure 6. Craica Valley – section 5.

Conclusions

For Baia Mare city, from the point of view of flooding occurrence, the biggest issues are the bed of Craica River during its entire watercourse and the Usturoi Valley in the lower sector.

On Craica river the water levels are influenced also by the natural factor, respectively the clay layer present almost on the entire basin, which contributes to a high coefficient of discharge (reduced infiltration), but also by anthropical factors related to refuse blockages. Usturoi Valley, unlike Craica, crosses an intense anthropised area, with many houses. The disadvantaging factors are related to the small surface of the bed (under 3 m^2), to bridges and culverts with very small free sections.

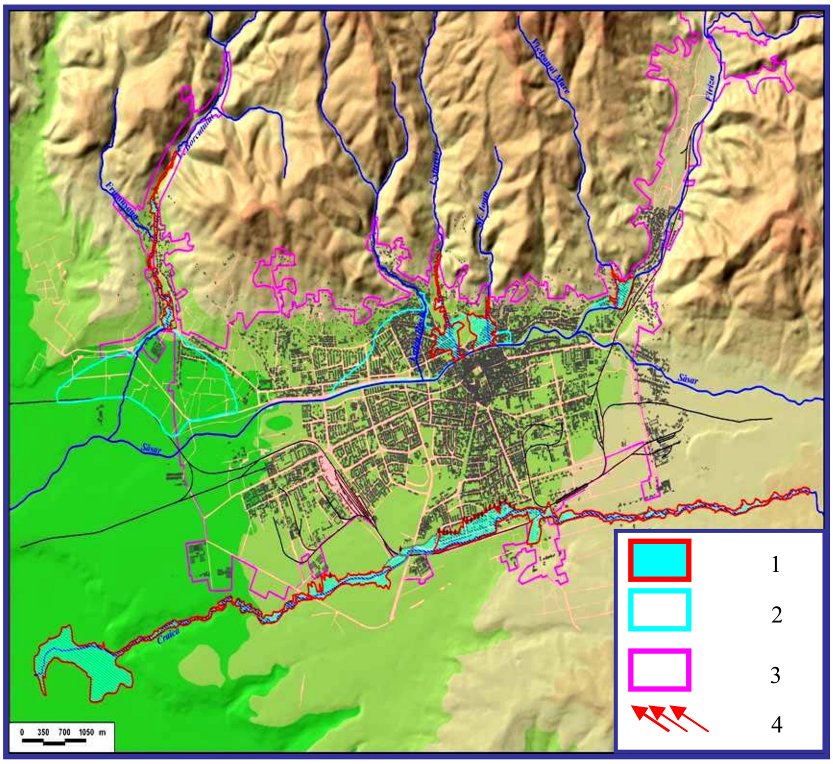

Figure 7. Potentially floodable surfaces in the Baia Mare built-up area
1. Potentially floodable surfaces at flows with 1% probability; 2.Potentially floodable surfaces at flows with < 1 % probability or at slope discharges; 3. Boundary of buil-up area; 4. Water flow directions from Craica into the city.

Similarly complex problems can be identified on the other valleys from the built-up area, right-side affluents of the Săsar river. The large extention of homes and their infrastructure, in the context of an accidented terrain, amplify the posibility of landslide triggering or reactivation, as well as of local floods (especially due to slope drainage) and groundwater discharge. In this situation, correlating the urban development with the natural potential and its dinamics is an absolute necessity.

REFERENCES

1. Dragotă Carmen - Sofia, (2006), *Precipitațiile excedentare din România*, (Excedentary precipitation from Romania), Romanian Academy's Publishing, Bucharest.
2. Drobot, R., Chendes, V. (2008), *Metodologie simplificată pentru identificarea bazinelor generatoare de viituri rapide. (Simplified Methodology for the Identification of Basing Generators of Fast Floods).* Conference: Set up of torrential hydrographical basins. Sylvology vol. VI. p. 265-284. Romanian Academy's Publishing, 2008. ISBN 973-27-0570-1
3. *** (2004), *Emergency Ordinance regarding the National System of Emergency Situations' Management*, O.U. no. 21/2004 from 15/04/2004, Official Journal, Part I no. 361 from 26th of April 2004.
4. *** (2006), *Encoding Procedure of weather notices and warning and hydrological warnings and alerts,* Order 823/2006 of the Minister of Environment and Water Management, respectively 1427/2006 of the Minister of Administration and Internal Affairs, Official Journal no. 795 from 21st of September 2006.