ROMANIAN REVIEW OF REGIONAL STUDIES, Volume VI, Number 2, 2010

THE ROLE OF HYDROTECHNICAL FACILITIES IN FLOOD PROTECTION – CASE STUDY: THE UPPER BASIN AND THE CORRIDOR OF THE SOMEŞUL MIC RIVER

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ABSTRACT – The complex management of the catchment area proved to be the only effective way to cope with the extreme hydrologic phenomena and their effects. The watercourses controlled by artificial lakes have a quasi-total protection, water-flooding volumes being often fully retained in the man-made water accumulations. Therefore, both the Someşul Cald Valley and the Someşul Mic stream sector, downstream of Gilău have been protected from flooding, except for several outbursts of side tributaries of the Someşul Mic, with low socio-economic losses. In addition, the watercourses controlled by small dams with water adduction pipes have a minimal effect on maximum flow and especially during flooding periods. In the past, violent effects on the Someşul Rece catchment area were recorded in its meadow sector and in the locality bearing the same name, expressed by the destruction of several civilian targets and of the road that accompanies the river.

Keywords: hydrotechnical facilities, artificial lake, water intake, water adduction pipe, flood

INTRODUCTION

Favorable natural conditions in the upper basin of the Someşul Mic allowed a great hydro-technical development, which harness the natural potential that occurs in the area (Figure 1). The 860 km^2 controlled in the section of the Gilău dam were subject to planning since the late '60s, when four large reservoirs have been achieved in the valley of the Someşul Cald (Fântânele, Tarniţa, Someşul Cald and Gilău), as well as two water intake dams, with related pipes on the Someşul Rece, designed to supplement the discharge flow in the mentioned four lakes.

The hydro technical development has been extended beyond the watershed border, separating the Someşul Mic River and the Arieş River, through the creation of several dams and connection pipes, in the upper basin of the Iara River, whose water was driven towards the artificial lakes of the Someşul Cald, after the junction with adduction pipes from the Someşul Rece Basin (Figure 1).

In *the first phase* (1968-1980), the largest reservoirs were completed, two of them on the Someşul Cald River and one on the Someşul Mic. The first accumulation put into use was Gilău Plant, in 1972, followed by Tarniţa, in 1973, and Fântânele, in 1976. Also, in the first stage, the work on the dams and connection pipes from the Someşul Rece and the Iara basins began, one of these being ready to use (Someşul Rece II).

In *the second phase* (1980-1990), other adduction pipes and derivation connections were put into use, as well as the last of the four accumulation lakes located on the Someşul Cald River: the one bearing the same name being finalized in 1983.

The main axis, Iara-Fântânele, the major connection pipe of this dam system has a total length of 21 km, of which 4.7 km between Iara and Şoimul intake points, 4.9 km between Şoimul and Negruţa, 4 km between Negruţa and Someşul Rece-I, 3.7 km between Someşul Rece-I and Răcătău and also between Răcătău and Fântânele Lake (Pop, 1996). Of the eight existing water intake points on the axis, one has a reservoir (Someşul Rece I). The others are smaller and are equipped with a water

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intake outlet of Tyrolean type. Iara-Fântânele connection pipe that is headed for Fântânele Lake is sized to provide a water volume of 5.87 m^3/s for an average yearly flow. This amount comes from the Iara upper basin (1.78 m^3/s) and from the upper basin of the Someşul Rece River (4.09 m^3/s).

The second component of water caption and underground feed pipe of Someşul Rece II (Tarniţa Channel - Figure 2). This component aims to increase the water flow in Tarniţa Lake and also downstream of this point, after collecting the water which drains the areas of interbasinal space of the Someşul Rece, situated downstream of the above mentioned dams.

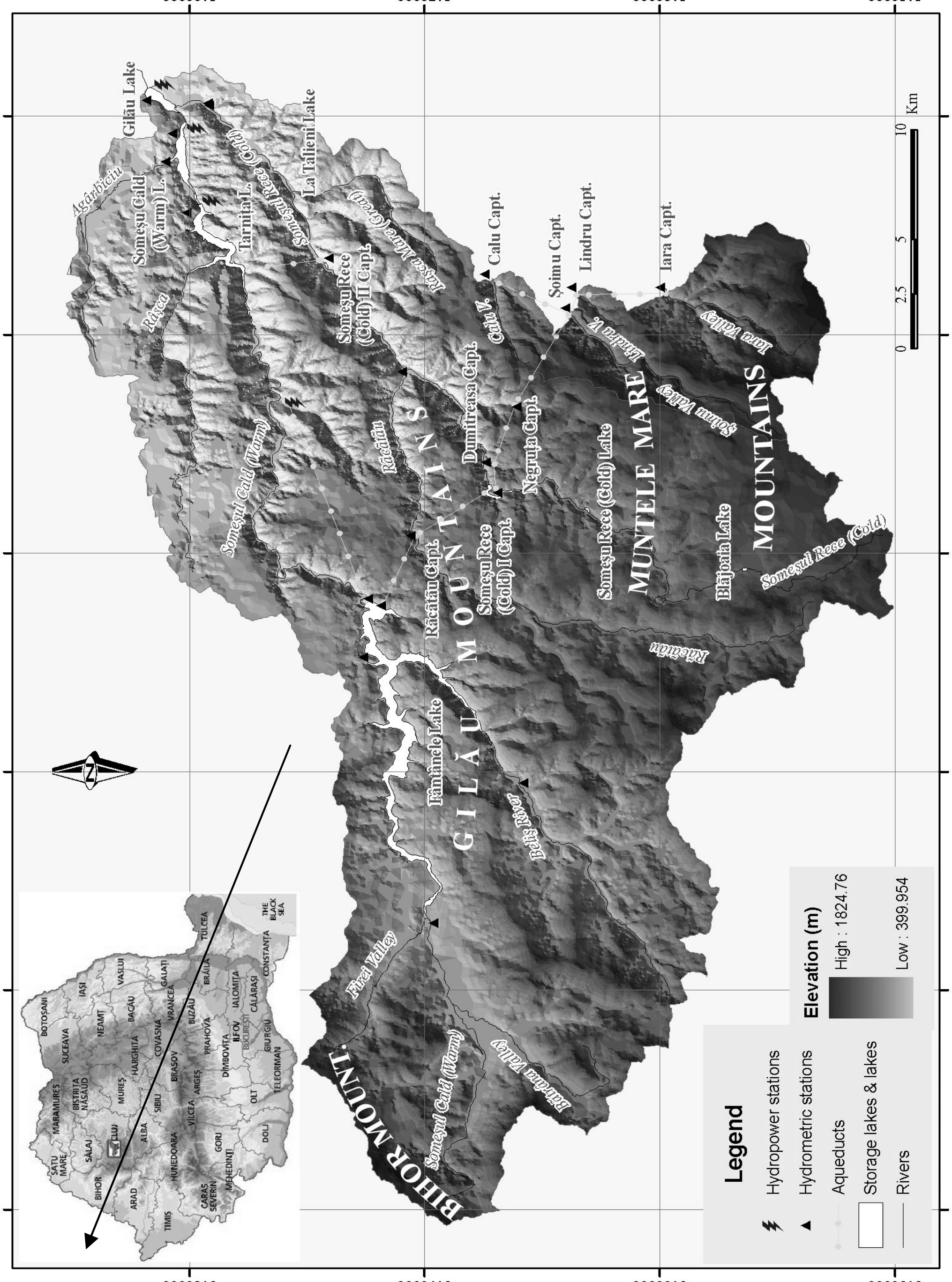

Figure 1. *The position of hydrotechnic system from the upper basin of the Someşul Mic in relation with major morphographic units*

The multi-yearly average flow transported by the water pipe adduction (3 km long) is about 0.800 m^3/s. Adding the multiannual average flow of the Iara-Fântânele underground feed pipe with the one of the Someşul Cald at Fântânele Dam section (6.81 m^3/s), a tributary flow in the lake system of 12.68 m^3/s can be obtained.

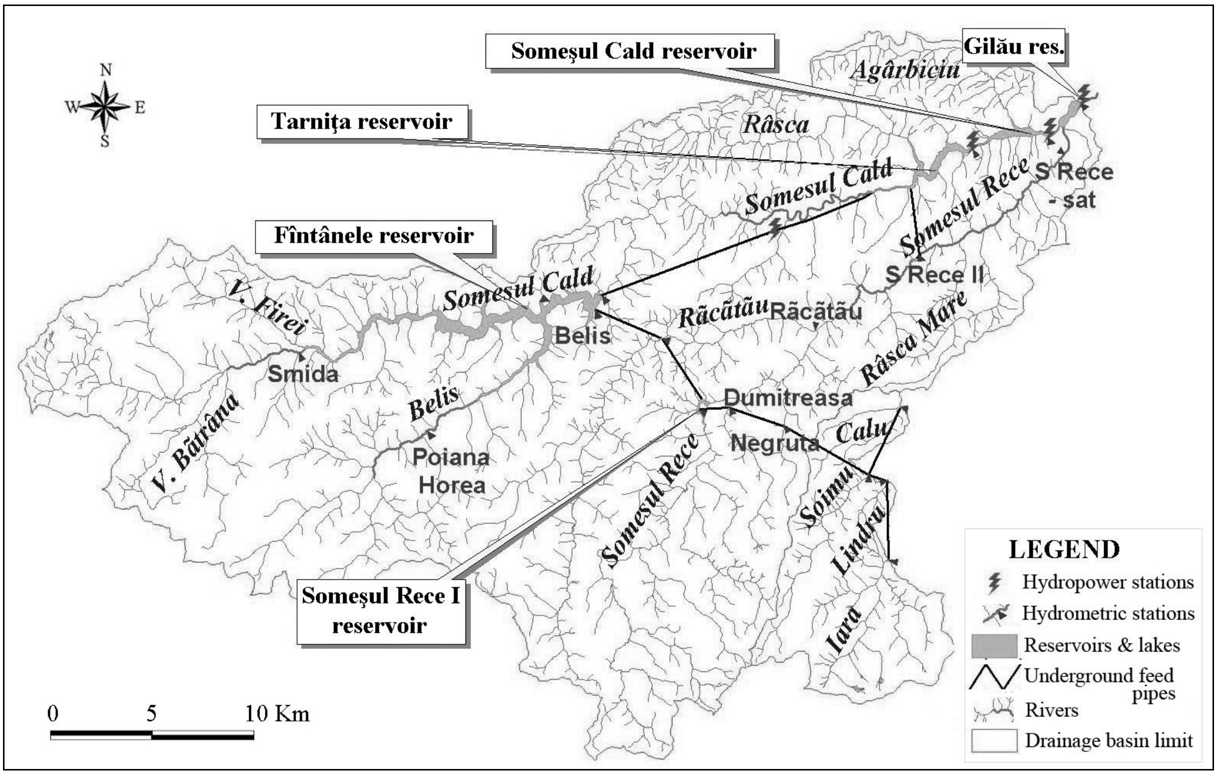

Figure 2. *The hydrotechnic system and the hydrometric network from the upper basin of the Someşul Mic.*

In the Tarniţa accumulation lake, the multiannual average flow value is of 14.99 m^3/s, with one part from the multiannual average flow of the Someşul Cald River in the section of Tarniţa Dam (8.32 m^3/s). The second is due to the average flow of the Someşul Rece, in the water caption section of Someşul Rece II – 4.89 m^3/s (4.09 m^3/s from the basin drained towards Someşul Rece I Lake and 0.800 m^3/s from the inter-basin area associated with the Someşul Rece II caption), and also the multiannual average flow from the upper basin of the Iara catchment (1.78 m^3/s).

RESERVOIRS IN THE SYSTEM – MAIN COMPONENTS IN FLOOD CONTROL

The upper basin of the Someşul Mic includes five accumulation lakes (Fântânele, Tarniţa, Someşul Cald, Gilău, Someşul Rece I - Figure 1) with a combined volume of 333.62 mil.m^3, which represents 72.0% of the total volume of accumulations in the Someş river basin (462.32 mil.m^3). Their computed water surface is about of 1200 ha, which represents approximately 1% of the total surface of the hydroenergetic accumulations in Romania (Şerban, 2007).

The specific volumes give an insight over the capacity of the accumulations and the functions they carry out (Table 1).

Through the attenuate volume of over 47 million m^3, the retentions in the Someşul Cald Valley can accumulate the freshets caused by heavy rains, annihilating the risks of flooding the populated sites located downstream, in the upper riverbed of the Someşul Mic River. The influence in the flow regime is increasing directly proportional to the increase in the attenuate volume affiliated to every flooding wave.

Therefore, only the Fântanele retention lake can hold a substantial amount of water (37 million m^3), equivalent to the volume of a flood with a 5% probability formed on its two tributaries, the Someşul Cald and the Beliş, with the addition of the limited flow of the underground connection pipe Iara-Fântânele and the water drainage from the basin's slopes. We have to mention also, that this retention lake is rarely maintained at its highest level, equal with the one associated with the overflow weir, allowing an increase up to three times of the available slice attenuate volume (Şerban, 2007).

Table 1. *Characteristic volumes of the retention lakes in the upper basin of the Someşul Mic, after the latest bathymetric works*

No.	Lake / Year of bathymetric works	Characteristic volumes (mil. m^3)					
		Total	Gross	Attenuate	Useful	Reserve	Dead
1	Fântânele / 2000	244.69	207.59	37	186.93	10.17	10.5
2	Tarniţa / 2001	75.25	68.08	6.9	13.79	39.08	5.62
3	Someşul Cald / 1993	8.45	6.45	1.99	0.86	3.41	2.18
4	Gilău / 2005	3.56	2.45	1.12	0.61	1.4	0.44
5	Someşul Rece I / project	1.67	1.34	0.33	0.98	-	-

The other water accumulations on the Someşul Cald River have a lesser influence on the flood waves volume and Someşul Rece I underground-intake connection pipe cannot handle the total amount of water collected by the first waterway of connection pipes (an exception is the Răcătau river intake).

MANAGED FLOODS AND THE EFFECT OF HYDRO-TEHNICAL SYSTEM IN THE AREA

In the last decades, marked by a hydrometrical activity in the area, several such events took place, out of which, the ones occurred in 1970, 1975, 1981, 1991, 1995, 1997, and 1998 had a special amplitude. Some of the most important were the events that occurred at the end of spring (month of May), beginning of the summer season (June) and also those that took place in the beginning of the winter season, which had devastating local effects (December). Before the accumulations were brought into use, floods had the same configuration even after they left the mountain area, sometimes facilitating the formation of secondary pulses caused by the contribution of the downstream tributaries. The values of the water flow recorded at the hydrometric station in Cluj-Napoca were almost double compared with those recorded at the stations in the mountain area (the Someşul Cald river at the former station, Beliş), therefore increasing the duration of flood (Figure 3).

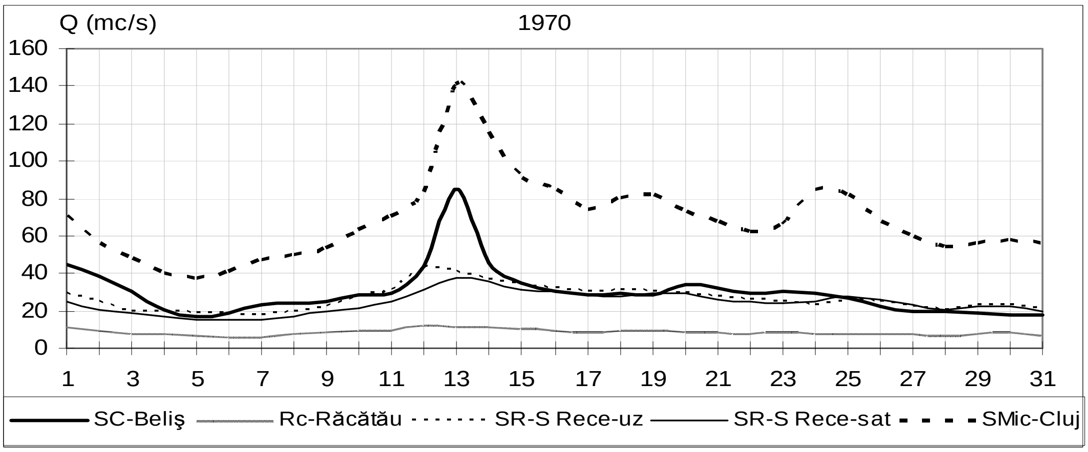

Figure 3. *The oscillation of mean daily flow in the upper basin of the Someşul Mic during the flood of March 1970.*

Consequently, after the finalization of the hydro-technical system, the flood propagation along the Someşul Rece and the Someşul Cald Rivers took a different turn. The moment when the flood reached the maximum value was delayed a few days between the closing station located on the Someşul Mic (Cluj-Napoca) and Smida station located on the Someşul Cald. The quantities of water discharged from reservoirs underwent significant changes and abided a different regime compared with the natural evolution of the flood. During the flood of December 1995, the diffluent discharge from the Fântânele accumulation was null during the manifestation period; the volume of the flood was entirely captured in the lake because its volume was close to the minimum operational level. The increase of the water volume in the lake was spectacular, from 15 to 90 million m^3 (Figure 4a).

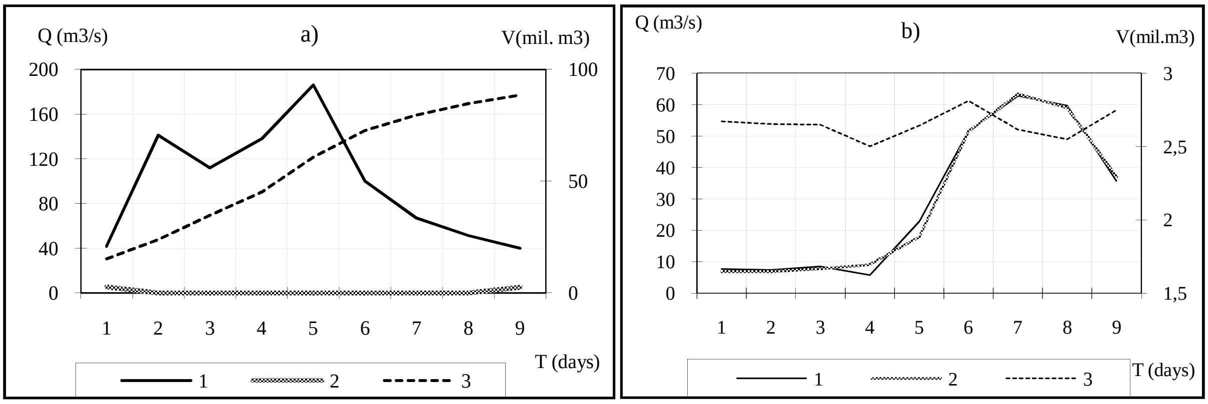

Figure 4. *The influence of Fântânele and Gilău reservoirs over the flood of 23.12.1995-02.01.1996. 1. Affluent discharge; 2. Diffluent discharge; 3. Volume oscillation in lakes.*

The elapsed time in the post-development period proved that the adduction pipes and the water intakes do not represent a good protection against floods for the populated sites located downstream. Neither the 5 m^3/s captured in the Someşul Rece basin, nor the maximum of 20 m^3/s cannot significantly reduce the flood hazard in the event of the formation of flash floods whose exceedance probability is below 10%.

The discharge value of the flash flood generated in this area in December 1995 managed to pass through the accumulation Gilău unmodified because of the limited capacity of the intakes to take over the discharge and of the accumulation's insignificant attenuation volume (Figure 4b). Even worse, the water level of the Someşul Rece overflowed by 70 cm beyond the canopy of the dam at the accumulation-intake Someşul Rece I, and the spreading of the afferent discharge downstream towards the villages of Măguri-Răcătău and Someşul Rece produced hazards and damages almost unique in the local history (Figure 5).

Figure 5. *Problems created by the flood of December 1995, in the meadow of the Someşul Rece. 1. Damaged road near Măguri-Răcătău; 2. Clogged intake of Someşul Rece II; 3. House carried by flood.*

The flood that took place in December 1995 was an experience hard to forget for the residents of Măguri-Răcătău, for those from the Someşul Rece floodplain, downstream of the intakes, as well as for those in Someşul Rece village. Several tens of minutes after the water spilled over the canopy of the Someşul Rece dam reached 70 cm, several buildings in Măguri-Răcătău were destroyed (including the school), the road was dislocated from the underlying structures, and the annexes of the flooded cabins in the river floodplain were mobilized downstream by the whirling waters. By the village of Someşul Rece-sat, the flood was alleviated in the riverbed up to 20%, but still created several damages.

The floods of 1997 and 1998 had a lesser impact on the basin due to the optimal management of the reservoirs, which led to the mitigation of both floods.

To supplement the information previously presented, the maximum flow data, production date, security, and drainage coefficients produced by floods in the upper basin of the Someşul Mic are included in table 2.

Table 2. *Maximum flow, exceedence probabilities and drainage coefficients of several floods in the upper basin of the Someşul Mic (according to "Administraţia Bazinală de Apă Someş-Tisa", Cluj)*

No.	Hydrometric station	1970			1995				1997				1998			
		Q max	Data	P (%)	Q max	Data	P (%)	η	Q max	Data	P (%)	η	Q max	Data	P (%)	η
1	Smida	-	-	-	108	24 Dec	4	1.29*	49.1	9 May	44	0.95	36.9	19 Jun	52	0.59
2	Poiana Horea	-	-	-	36.1	27 Dec	42	0.79	19.2	9 May	72	0.84	11	19 Jun	89	0.60
3	Răcătău	16.4	8 Aug	82	56.5	27 Dec	24		21.6	9 May	70	0.93	18.5	19 Jun	78	0.47
4	Someşul Rece-sat	-	-	-	98	27 Dec	20	0.22	32	9 May	62	0.30	57	19 Jun	46	0.25
5	Cluj-Napoca	191	11 Jun	14	170	27 Dec	21	0.08	79.5	9 May	91	0.26	169	19 Jun	21	0.02

* the over unit value of the leakage coefficient is due to the pre-existence of a consistent snow cover

If on both rivers, the Someşul Cald and the Someşul Rece, equipped with reservoirs and intakes with underground adduction pipes, the effects of floods were different, after the completion of the hydro-technical system in the Someşul Mic Corridor, a considerable improvement of the socio-economic impacts of floods and a reduction of the areas affected by significant flooding and damage problems can be noticed (Figure 6).

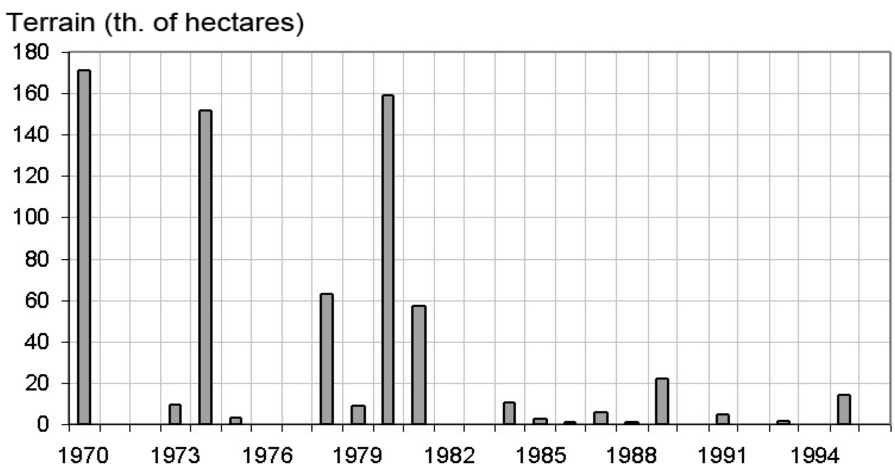

Figure 6. *The land areas in the Someşul Mic Corridor affected by the floods produced in the homonymous hydrographic basin (1970-1996).*

The largest land areas were affected between 1970 and 1981 (more than three quarters of the total events). With the come into use of the latest dam (the accumulation of the Someşul Cald - 1983), a decrease in the frequency of flooding some lands was recorded, based both on the absence of major floods and, especially, on their mitigation into accumulations.

From a technical viewpoint, the maximum tributary flows into lakes of Tarniţa and Fântânele decrease after mitigation to 211-217 m^3/s for the insurance value of 1%, to 495-511 m^3/s for the insurance value of 0.1% and to 827-862 m^3/s for the insurance value of 0.01% ± 0.20 (according to the National Administration "Romanian Waters" - Administration Someş-Tisa Water Basin and S.C. Hidroelectrica S.A. - Cluj Branch).

In the case of the Fântânele reservoir, the flood volumes (mil. m^3), with different insurance for the total time of 100 hours and the increasing time of 24 hours, have the following values: 16.3 for the 10% insurance value, 20.9 – 5%, 24.5 – 3%, 31.5% - 1%, 70.8 – 0.1% and 108.7 – 0.01%.

Through the mitigation capacities of the reservoirs, the maximum tributary discharges can be reduced up to 55% for the 1% insurance value and up to 64% for the 0.01% insurance value in the case of Fântânele reservoir, while, in the case of Tarniţa, the reduction of maximum discharges is achieved up to 80% for the 1% insurance value and up to 91% for the 0.01% insurance value. The other reservoirs (Someşul Cald, Gilău and Someşul Rece I) cannot mitigate the flood discharge values due to their low capacities.

CONCLUSIONS

From those presented above and from the gained experience in applied hydrology, we can say that reservoirs are the only sustainable management solution, oriented towards natural and socio-economic environmental protection against floods and their hazards and effects. Every work intervention over watercourses and over associated catchment areas proved to be less efficient if they are not complemented by a hydro-technical facility, including reservoirs with flood control capacities. The difference in the development of events in the equipped basins and those inadequately equipped is more than obvious. The Someşul Mic catchment area is not an exception. A quasi-total control on the Someşul Cald axis can be noticed, where people have already forgotten what flood effects mean, and a limited control on the other axis, of the Someşul Rece, where the limited capacities of reservoirs can create damages to habitats and socio-economic facilities, especially during the floods with exceedence probabilities below 10%.

ACKNOWLEDGMENTS

We wish to thank the Water Department "Someş-Tisa" and the Hydrological Station Cluj, the Hydrological Service, the Department of Defence Against Flooding, then to S.C. Hidroelectrica S.A. – Cluj Branches and all employees who contributed to making this work. We also thank Babeş-Bolyai University, Faculty of Geography, for the technical and logistic support provided during office works.

REFERENCES

BRAVARD, J.P. (2000), *Les régions françaises face aux extrêmes hydrologiques* [French Regions face of Hydrological Extremes], Gestion des excès et de la pénurie, SEDES, Paris.

FăRCAŞ R., FETEA P., CRISTUREANU T., NISTOR CĂLINA, ŞERBAN GH. (1996), *Consideraţii privind viitura din perioada 23.12.1995 - 01.01.1996 din bazinele hidrografice Tisa şi Someş-Crasna* [Considerations regarding the Flood of 23.12.1995 - 01.01.1996 in the Hydrographic Basins of Tisa and Someş-Crasna], Studii şi Cercetări de Hidrologie, Institutul Naţional de Meteorologie şi Hidrologie, Bucureşti.

PANDI, G. (1988), *Amenajarea hidrotehnică a bazinului Crasna şi efectele ei asupra activității hidrologice* [The Hydrotehnical System of Crasna Basin and its Effects upon the Hydrological Activity], Hidrotehnica, 33, 8, Bucureşti.
PANDI, G. (2002), *Riscul în activitatea de apărare împotriva inundațiilor* [The Risk involved in Flood Protection Activity], Vol. "Riscuri şi catastrofe", Editor Sorocovschi, V., Edit. Casa Cărții de Ştiință, Cluj-Napoca.
POP P. GR. (1996), *România - Geografie hidroenergetică* [Romania – Geography of Hydropower], Editura Presa Universitară Clujeană, Cluj-Napoca, 237 p.
ŞERBAN, GH. (2004) *Influența amenajării hidrotehnice din bazinul superior al Someşului Mic asupra scurgerii lichide medii şi maxime în bieful aval* [The Influence of Hydrotehnical Facilities in the Upper Basin of the Someşul Mic upon the Mean and Maximum Flow Runoff in the Downstream Sector], Analele Universității din Oradea – seria Geografie, pp. 211-226.
ŞERBAN, GH. (2007), *Lacurile de acumulare din bazinul superior al Someşului Mic. Studiu hidrogeografic*, [The Reservoirs in the Upper Basin of the Someşul Mic. Hydro-geographic Study], Edit. Presa Universitară Clujeană, Cluj-Napoca, 236 pg.
ŞERBAN, GH., PANDI, G., HATTEMER, C., VINET, F. (2009), *Benzile de inundabilitate 5% şi 1% în perimetrul localității Someşul Rece-sat aval de captările din bazinul Someşului Rece - Munții Apuseni)* [The Flooding Strips of 5% and 1% in the area of Someşul Rece-sat Village, Downstream of the Intakes in the Someşul Rece Basin – the Apuseni Mountains], Conferința Ştiințifică Anuală a INHGA „Estimarea şi Predicția Fenomenelor Hidrologice Extreme", 21-22 octombrie, Bucureşti, România, selected to be published in Hidrotehnica, 2010.
ŞERBAN, GH., SELAGEA, H., MÁTHÉ EMOKE, HOGNOGI, GH. (2010), *Efecte produse de viitura din 20.06.2006 în bazinul râului Ilişua (bazinul Someşul Mare)* [Effects Caused by the Flood of 20.06.2006 in the Ilişua Catchment Area – the Someşul Mare Basin], in the volume of the Conference „Aerul şi Apa – componente ale Mediului", Editori Pandi, G., Moldovan, F., 19-20 Martie, Universitatea Babeş-Bolyai, Facultatea de Geografie, Cluj-Napoca, pp. 156 – 166.
VINET F. (2007), *Approches nationales de la prévention des risques et besoins locaux : le cas de la prévision et de l'alerte aux crues dans le Midi méditerranéen*, Géocarrefour, vol. 82, 1-2/2007, pp. 35-42.
* * * (2007), *Amenajarea teritoriilor periurbane. Studiu de caz: Zona periurbană Bistrița*, [Peri-urban Spatial Planning. Case Study: the Peri-urban Area of Bistrița], Coordinator: Prof. dr. Pompei Cocean, Editura Presa Universitară Clujeană, Cluj-Napoca, 272 p.