Flood Risk Management in River Basins Argeş, Romania

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Abstract

While experiencing a growing social responsibility, the floods that have occurred in many countries in recent years and the consequences that followed have led to a new approach - the flood risk management, where the human community awareness and commitment are essential to avoiding loss of lives and reducing damage.

Flood risk management consists of applying policies, procedures and practices with the goal of risk identification, analysis and evaluation, treatment, monitoring and reassessment of the risks in order to reduce them so that the human communities and all the citizens can live, work and satisfy their needs and aspirations in a durable physical and social environment.

The Arges basin is one of the major river basins in Romania because of the hydropower potential, of the existing water resources used in industry, irrigation and public water supply, including the capital city, Bucharest.

The surface of the Arges hydrographic basin is of 12,550 km^2 which includes the mountain, sub-Carpathian and plain areas and is controlled by numerous reservoirs (27 reservoirs, 8 of which have a water volume of over 50 million cubic meters), derivative and intra-basin pools, adjustments, dams, water intakes and more.

In this context, the efforts of the authorities involved in water management activities in our country are to be highlighted, by analyzing the measures implemented in the Arges hydrographic basin.

Keywords: Arges hydrographic basin, floods, risk, management

Introduction

Floods are phenomena that are naturally found in the hydrological regime of any river. They have deeply marked and still mark the development of human society, both negatively and positively.

The risk is the likelihood of a human community of being affected by a hazard. It consists of the expected loss level in case the expected event occurs (IDNDR, 1992). The risk is closely related to human presence in the territory capable of acknowledging the causes and consequences of the phenomenon. Without the human community there wouldn't be any risk, only hazard, regardless of the magnitude and consequences of the extreme phenomenon which occurs in the natural space.

While experiencing a growing social responsibility, the floods that have occurred lately and the consequences that have followed have led to a new approach of the issue - flood risk management. This new approach is based on human community awareness and involvement, with the purpose of avoiding loss of life and reducing natural damage.

Flood risk management consists of implementing policies, procedures and practices with the objective of identifying the risks in order to reduce them so that human communities and all the citizens can live and satisfy their needs and aspirations in a durable physical and social environment.

The actions and measures undertaken in order to reduce losses of lives and material goods caused by floods have been used in Romania for more than 200 years. Nowadays, there are many operational population and property protection systems, mainly dams (about 9920 km long), adjustments of river beds (6300 km), non-permanent reservoirs (217 lakes that have volumes of flood mitigation of 893 million cubic meters) and permanent reservoirs (1232 lakes totaling 2017 million cubic meters of water, flood mitigation volumes).

Description of the Arges hydrographic basin

The Arges hydrographic basin is one of the best equipped river basins in the country, with a large number of complex reservoirs with multiple purposes (for electricity generation, flood control and water supply), diversion works (galleries, channels and pipes) for basin and inter-basin water transfer, flood control works and waterbeds adjustment works, outlets, bridges and more. The main water source of the Arges river basin is surface water (rivers and canals, reservoir lakes and natural lakes) and underground water (groundwater and deep water).

The total theoretical water resources of the basin are estimated at approx. 2656 million cubic meters (1960 million cubic meters of which are surface water and 696 million cubic meters are groundwater). Approximately 85.5 percent of these theoretical resources are technically usable (2271 million cubic meters, 1671 million cubic meters of which from surface sources and 600 million cubic meters from underground sources).
The current usage level of water resources from the basin is high, representing 600 cubic meters/year per capita, exclusively from surface sources.
The Arges river is 340 km long and its catchment hydrographic basin measures 12,550 square km. Vâlsan river, Doamnei river, Târgului river and Dâmboviţa river are the main left influents of the Arges river and Neajlov river is the main right influent.
Dambovita river crosses the country's capital city Bucharest, flowing through a concrete canal built in the 1987-1989 period (open for clean water and encased for wastewater).
The hydrographic network of the Arges river includes a large number of water courses with a total length of 4579 kilometers, which represents approx. 5.8 percent of the length of all the inland rivers of the country.
The average density of hydrographic network is of 0.36 km/square km and a maximum of up to 1.40 km/square km, ranging from 0.67 km/square km in the upper sector, to 0.51 in the middle sector and up to 0.30 at the lower sector of the catchment basin.
The longitudinal slopes of the beds of these water courses are of 10 percent in the case of the mountain rivers, 1-0,4 percent for rivers in the hill areas, and less than 0.1 percent for rivers in the plain areas.
In the Arges hydrographic basin there is an important and functional network for basin water transfer. The network includes a total of 31 works of derivation, 13 of which are underground (tunnels and galleries with a total length of 67 km) and 18 are above ground (open channels with a total length of 127 km).
In the Arges hydrographic basin, a total of 38 reservoirs were built and are now operational, which constitute defense against floods, generate electricity, water supply and agricultural irrigation, with a total capacity of approx. 1135 million cubic meters of water (Table 1).

Table 1 Main reservoirs - Arges river basin

Nr. crt.	***Reservoirs dam***	River	Accumulation			Year
			Volum (mil. m^3)	Area (ha)	Purpose	
1	Vidraru	Argeş	465	1000	PG	1965
2	Oieşti	Argeş	1,80	42	PG	1967
3	Cerbureni	Argeş	1,65	35	PG	1968
4	Curtea de Argeş	Argeş	1,10	26	PG	1970
5	Zigoneni	Argeş	13,3	165	WS,PG	1973
6	Vâlcele	Argeş	54,8	640	WS, PG, FC, I	1975
7	Budeasa	Argeş	54,9	643	WS, PG, FC, I	1978
8	Bascov	Argeş	5,10	140	WS, PG, I	1970
9	Prundu-Piteşti	Argeş	4,50	141	WS, PG, FC, I	1971
10	Goleşti	Argeş	78,5	680	WS, PG, FC, I	1983
11	Zâvoiu-Orbului	Argeş	16,1	280	FC, I	1988
12	Ogrezeni	Argeş	7,60	241	WS, FC, I	1997
13	Mărăcineni	Doamnei	38,5	380	PG, FC	1982
14	Baciu	Doamnei	0,68	5,80	PG	1966
15	Vâlsan	Vâlsan	0,18	1,50	PG	1966
16	Pecineagu	Dâmboviţa	69,0	180	WS, PG, I	1984
17	Lacul Morii	Dâmboviţa	19,41	246	FC, I, R	1987
18	Văcăreşti	Dâmboviţa	54,10	730	WS, PG, FC, I	1989
19	Satic Speriata	Dâmboviţa	0,10	18	PG	2006
20	Râuşor	Târgului	60,0	190	WS, PG, I	1987

Purpose of the Reservoir: FC - Flood, PG – power generating, WS – water supply, I. irrigation,
R - recreation.

After the flash floods recorded in the 1970 and 1979, the largest flash floods that have ever occurred on the Arges river, a series of derivatives, hydro-technical junctions and water catchment outlets were built in order to defend the major towns in the basin against floods and to supplement flows during

droughts in certain deficient sub-basins. More polders for controlled flooding were built in order to alleviate the maximum flows of the floods. Also, areas of the river were embanked in order to protect settlements and derivatives were used both for defense as well as for water supply during draughts.
Nowadays, the Arges river basin represents a complex development scheme with the help of which the water potential of the basin is used and which also helps avoid losses caused by flooding (Fig. 1).

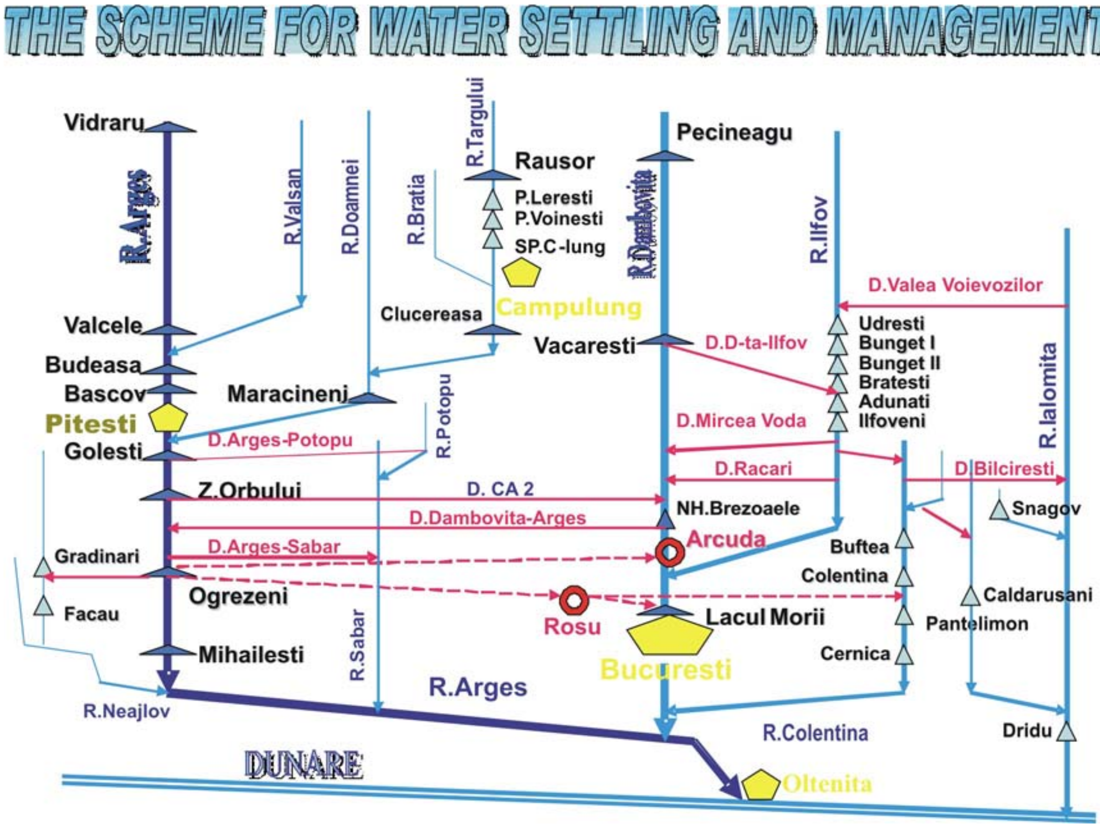

Figura 1 The scheme for water settling and management of river Argeş

From February to August 2005, in the Arges basin, several dangerous hydro-meteorological phenomena have been registered, during which the maximum capacity of the reservoirs was exceeded.
Due to the fact that the normal retention levels were exceeded in the Vidraru reservoir (8th highest in Europe and 20th in the world, which has a volume of 465 million cubic meters) there was an uncontrolled discharge over the dam crown on high water dischargers located at 160 m from the thalweg bench mark.
The high intake flow in conjunction with the high level of the Vidraru reservoir led to the closure of all the inlets which transferred the flows from other hydrographic basins (Doamnei, Vâlsan, Topolog) to the Vidraru reservoir and to the ceasing of operations at the hydropower plant so that the large reservoir operated freely, spilling the entire influent flow on the surface dischargers located at the 830 mdMN bench mark.
The maximum flow of water spilled on the high water dischargers from the Vidraru reservoir amounted to 24.0 cubic meters/s on 12.07.2005, a water flow registered at the Căpăţâneni hydrometric station located 2 kilometers downstream from the reservoir.
Following the rainfalls in the hydrographic basin of Arges river, which totaled 85 l/sqm at the Căpăţâneni hydrometric station, upstream of the confluence with the Valsan in the Vâlcele reservoir there was recorded a influent water flow of 165 cubic meters/s. The water flow discharged from this reservoir was of 82 cubic meters/s and after the confluence with the Valsan river, the influent flow into the Budeasa reservoir was of 201 cubic meters and the discharge was of 71 cubic meters so that the flood wave on the river Arges would not overlap the flood wave on Doamnei river where the recorded flow was of 317 cubic meters/s at the Ciumeşti hydrometric station.
Downstream from the Goleşti reservoir the spilled water flows were of 60 cubic meters/s as compared to the influent water flow of 424 cubic meters/s, because, thanks to the forecasting and tracking of the transit water flows, there was the time needed to perform a pre-emptying of this reservoir.

Following these maneuvers of retention and reducing the maximum flow in the Vâlcele and Budeasa reservoirs, the maximum flow was greatly reduced on the Arges river down to the value of 424 cubic meters/s in the Goleşti reservoir, as compared to possible flows (730 cubic meters/s) without this system of reservoirs.
On the BH Arges-Vedea territory, a number of 41 reservoirs of various sizes were affected, causing floods that have damaged 3114 and destroyed 513 houses, deteriorating 4946 household annexes, destroying 397 bridges and culverts, a 11616 km road network and flooding an area of 81,192 ha of agricultural land. All these losses were valued at approximately 100 million euros.
After the floods from 2005, steps to implement project WATMAN (**WAT**ER **MAN**AGEMENT) were started, a project which will include project DESWAT (**DES**TRUCTIVE **WAT**ER) regarding the automated collection of hydro-meteorological data and forecasting of the water flows in the hydrometric stations sections (Fig. 2).
The WATMAN project is responsible for the integrated real-time management of all hydro-meteorological information and for making the best decisions for the sustainable management of water resources both during droughts as well as floods and high water.
The WATMAN project will develop in three directions: collecting and transmitting data, forecasting and water management decisions, alarm and action in affected areas by quartering means and material resources in two quick response centers in case of flooding.
The collection and transmission of hydro-meteorological information part was implemented in 2006 through the DESWAT project, comprising a total of 49 hydrometric stations in the Arges-Vedea hydrographic basin that automatically transmit information related to the water level, rainfall, air temperature, and water every hour to the Reservoir Forecasting Center. At the same time, a system of 9 radars measures the reflectivity of cloud formations and provides information on the rainfall water quantity.

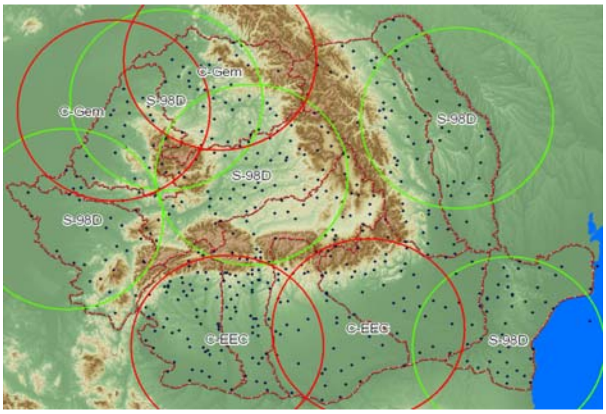

Figure 2 4 C band radar with 5 WSR-98Ds form a 9 radar SIMIN network

By implementing these projects based on hydro-meteorological input data and forecast, during the floods in the Arges-Vedea hydrographic basin, we can see the areas with an increased flood risk on a very user friendly interface built with the help of the Water Net Briefing Terminal (Fig.3).

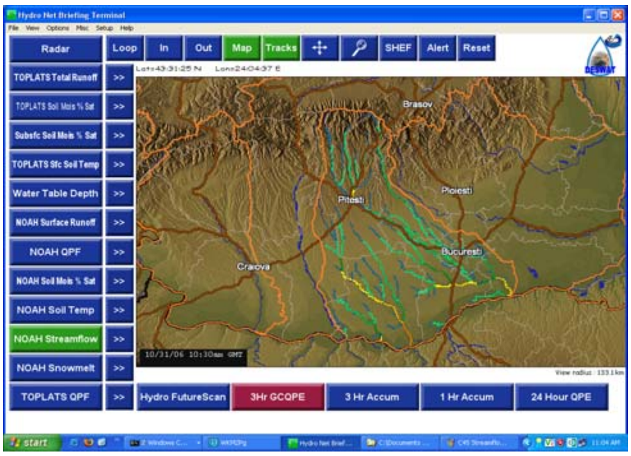

Figure 3 Distributed Models – HBT and HTN

Using the implemented mathematical models, the real-time hydro-chart of liquid flow can be issued, using as a basis the hydrodynamic characteristics of the latest 3 days, the forecast being prepared for the next 5 days (Fig. 4).

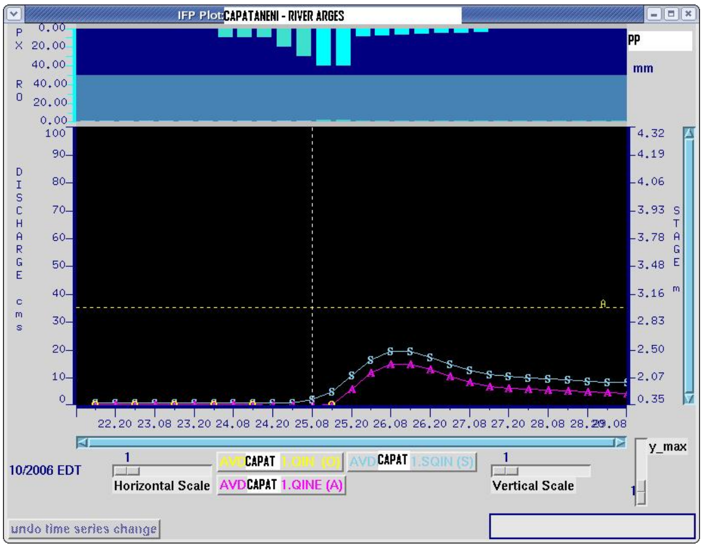

Figure 4 View and Modify RFS Inputs, Parameters and Outputs

At the same time, we will receive information from 20 reservoirs regarding the level and volume of the water stationed in these reservoirs, the use of hydro-mechanical equipment and the flows discharged downstream of the dams.

Based on all this hydro-meteorological and operational information on the hydroelectric works, using computer applications, all the decisions regarding the management of the situations occurring along water courses and reservoirs of hydropower interest are taken at the Reservoir Center for Flood Control and, if need be, the settlements that would be affected will be alarmed by an acoustic system located in areas of interest.

At the quick response centers, there is a supply of defense materials, vehicles and mobile dams that can be used for assistance in disaster areas as soon as possible. At the same time, every settlement with high flood risk has its own minimum supplies for immediate response.

Considering that the Arges hydrographic basin is one of the most equipped in the country and that the north and west areas of the city of Pitesti is a major confluence area (here the Arges river receives as influents the Valsan and Doamnei rivers with a surface of 1836 sqkm and its influents Targului and Argeşel rivers) a non-permanent reservoir was required (Mărăcineni reservoir) whose main purpose is the defense against floods by storing a volume of 38.5 million cubic meters if the dam is closed.

By closing this dam and blocking the flood wave on the Doamnei river, the transit of the flood on the Arges river is possible without overlapping the two floods. Also, upstream of the city of Pitesti, Vâlcele and Budeasa reservoirs were built which are able to retain, at the normal retention level, 110 million cubic meters and 37 million cubic meters in the reservoir, which allows cutting the flood peak on the Arges river in order to reduce the flow downstream of Pitesti after the confluence with the Doamnei river.

These hydropower facilites were absolutely necessary to prevent flooding on the Arges river in the plain area but also for the retention and use of the water supplied to the population and industry during the periods of low flow.

Downstream of this confluence with the Doamnei river, considering that the surface of the in the Arges hydrographic basin is 3158 sqkm, the Golesti reservoir was built which is able to retain at the normal retention level a volume of 78 million cubic meters.

Structure and design of the Watman project and informational system

The project was implemented in Romania with the support of USAID, U.S. military engineers providing the model that has a graphical user interface and an input and output data storage and retrieval program. The program called ResSim simulates a tank and all operations and features of a downstream tank and a drain channel (Figs. 5, 6). The model allows the user to define alternatives and compare the simulations in order to choose the optimal drainage of water downstream (Fig. 7).

The program deals with the water resource only in terms of quantity, not quality, biodiversity or other functions such as tourism and leisure.
The pilot program of this stage of modernization and development of integrated water management at national level has been implemented experimentally at the Arges-Vedea Water Department. Since BH Arges – Targului river Sub-basin was chosen as the pilot in the WATMAN project, the following activities were carried out:

1. At the Râuşor – Targului river dam, sensors were installed to continuously monitor the technical condition of the dam, the data being transmitted directly to the basin dispatcher.
2. At the Râuşor – Targului river dam, an application was installed for data collection and, through the Dispatcher Application, the data are available countrywide - Romanian Waters National Agency.
3. At the Râuşor – Targului river, the old siren dam was modernized, which is automated and in Lereşti, located downstream of the dam, a modern electronic siren was installed with dual operability (local and from the dam).
4. In 2006, Pitesti DAAV purchased the following intervention equipment, which was divided between water management systems under its orders:
    - Inflatable dams 1000 ml
    - Bag filling machines 2 pcs
    - Portable generator 1 pc
    - Inflatable motor boats 10 pcs
    - Multifunctional truck 1 pcs
    - Buldo-excavators 5 pcs
    - Front charger 4 pcs
    - Road vehicles 8 pcs
    - GPS Station 1 pc

Starting October 2007, within the funds allocated by the Ministry of Environment and the Romanian Waters National Agency for the WATMAN project, Pitesti DAAV try drafting a project for a Rapid Intervention Center (SGA Arges) and, in the coming years, to find the funds needed to build it.
Romanian Waters National Agency and Pitesti DAAV strategy regarding flood control should be consistent with the new EU regulations - the European Parliament and Council Directive on flood risk assessment and management.

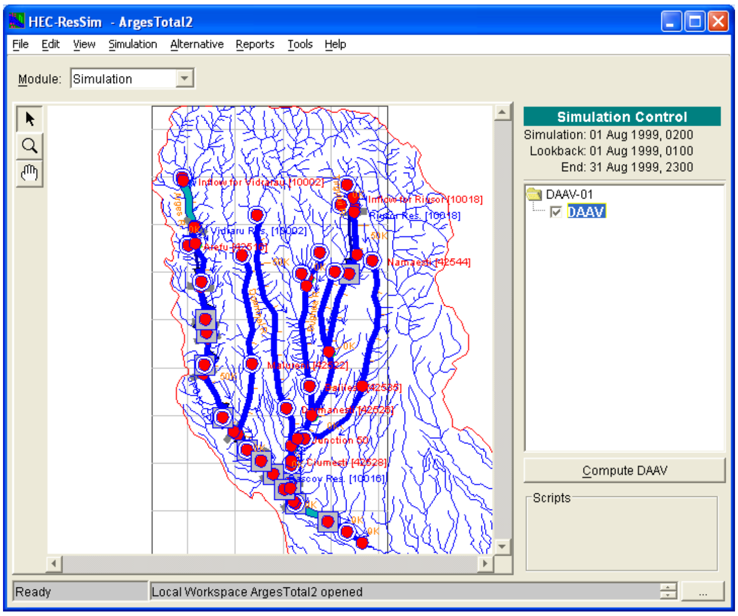

Figure 5 Sections of monitoring and regulating flows

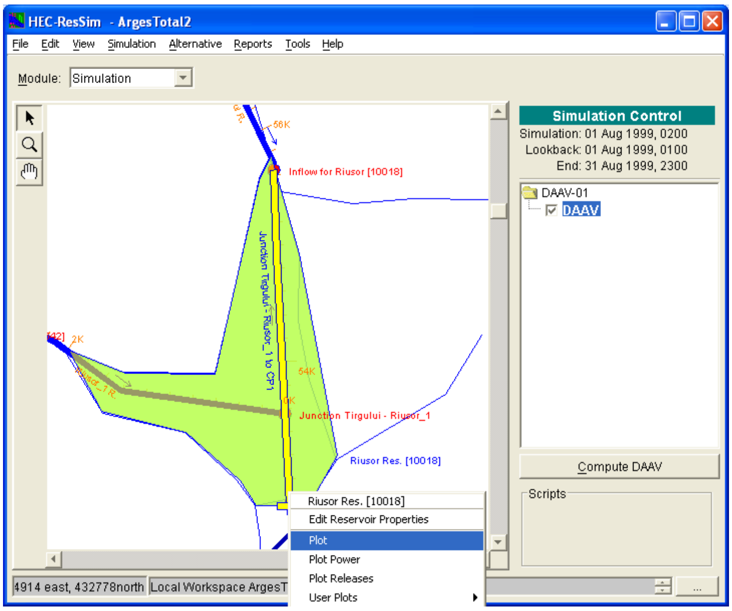

Figure 6 Râuşor reservoir – river Târgului

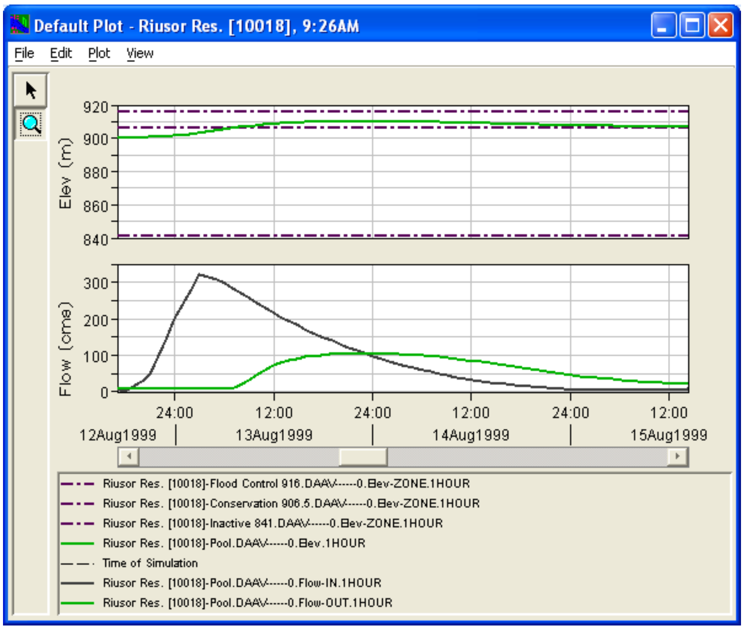

Figure 7 Basin leak after attenuation in Râuşor reservoir

Taking into account the provisions of the Framework Directive on flood risk management, the main objective for 2010 of Pitesti DAAV regarding flood control are:

1. Issuing guiding framework schemes - River basin planning.
2. Implementing the Plan for the Prevention, Protection and Mitigation of Floods, both of which are analyzed at the level of the entire hydrographic basin.

Information and public participation plays a key role in the management of emergencies arising from floods, the responsibility of every citizen who lives or works near a water course, and particularly in areas that are subject to flooding, is to adjust the lifestyle to the risk of flooding.

Authorities must ensure that information on prevention and flood protection are presented in a transparent and understandable way to the public. Local and county flood control plans must be developed in a uniform, understandable way and accessible to the public. In accordance with the Directive on flood risk assessment and management, European Union Member States must provide the public with the following documents: **preliminary assessment of flood risk, hazard maps, flood risk maps and flood risk management plans**.

Conclusions

Analyzing floods management system under implementation in Arges river basin, we can mention certain elements which do not satisfy the technical and economic requirements of an effective management activity, such as:

- ❖ The calculation was not designed for a large number of water accumulations located in cascade. If, when stored water is used for electricity generation, the water management system operates properly, but should, during floods, each accumulation be individually operated in order to reduce peak flows transit, thus leading to errors;
- ❖ Lack in updating volumetric curves (more accumulation laking limnimetrical updated keys since they were firstly put in service);
- ❖ Even if the dams allow pre - discharge processes according to the maximum flow forecast, it can not be used to maximum capacity because of the large buildings located in flood prone areas of the water courses (ex. Satic town on the Dambovita River, or downstream of the reservoir Vidraru on the river Arges, where from flow rate of 90 m3 / s only 45m3/s can be evacuated);
- ❖ Least, but not last the high maintenance costs of the measuring sensors (due to the clogging degree, sensors for measuring the level are not working during floods, the cloud degree of the water is very high), lack of the transmission equipment and of trained personnel for the operation system converge to a weak recovery of the principle for which it was created.

To improve the model that is intended to be implemented in Arges river basin, as well as in all river basins in Romania, we propose to take into account the following suggestions:

- ❖ Installing a water level measuring system using Doppler-type plants. Even if the initial investment is higher in time the maintenance costs are reduced and the data obtained are very accurate, info checked during 2006-2009 under DESWAT program, which compared with classical level measurements did not generate errors of more than ± 2 cm;
- ❖ Data transmission to take place mainly in the GSM system, because during extreme phenomena the radio system does not work (power fluctuations);
- ❖ Improving the information and operating data storage systems to increase working speed (currently the operating system used is working heavy because is making use of all databases).
- ❖ Undertake further and more detailed training in order to fully maximize the use of the existing software used to manage hazardous hydro-meteorological phenomena.

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