LAND USE CHANGES AND FLOOD PROTECTION
- CASE STUDY OF RIVER JELAŠNICA -

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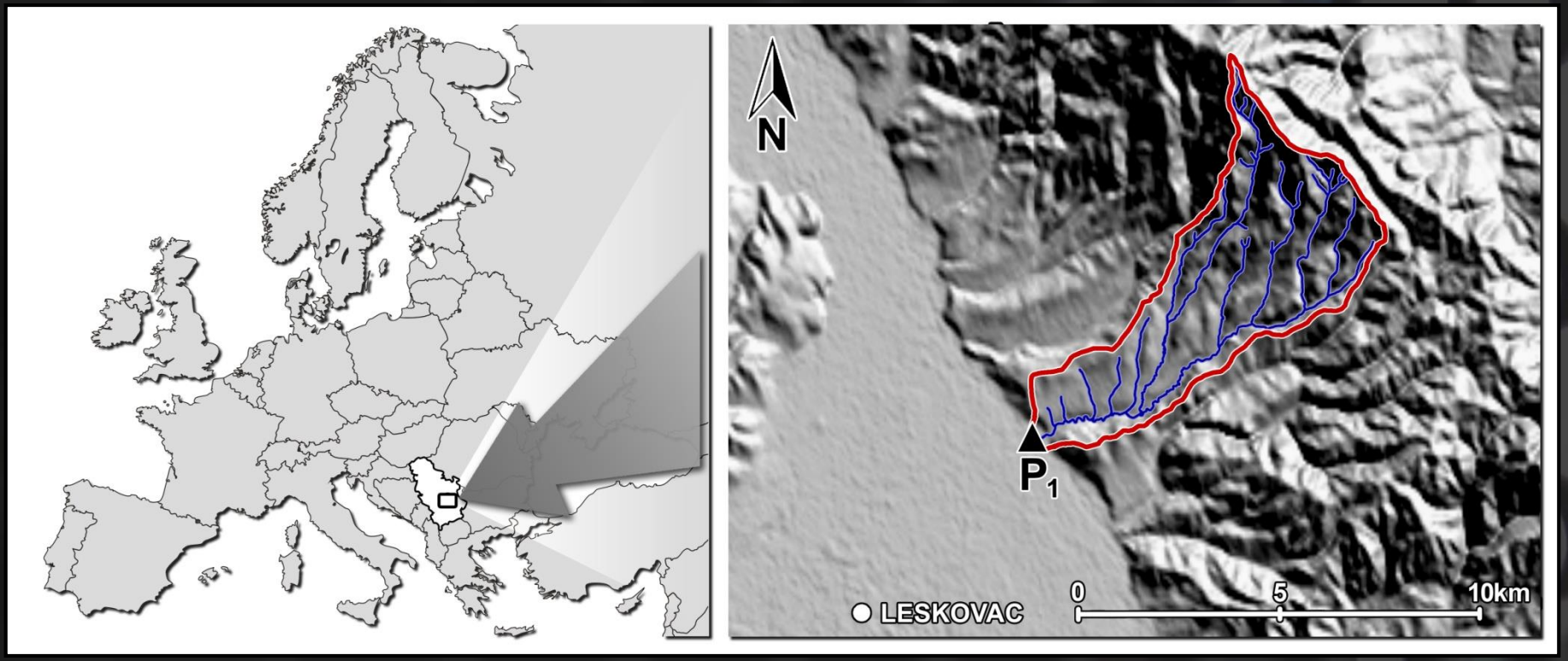
LOCATION OF THE WATERSHED OF RIVER JELAŠNICA



Southeastern part of Serbia

PROBLEMS

Frequent flooding:

- **May 2005**
- **November 2007**
- **November 2009**

River Jelašnica and main tributaries are not regulated

FLOOD May 2005.

Improvised crossing over the river

FLOOD May 2005.

Endangered houses

FLOOD May 2005.

Destroyed local road (300m)

FLOOD May 2005.

Destroyed retaining wall and sewerage outflow

FLOOD May 2005.

Landslide above the right river bank

FLOOD November 2007.

Destroyed local road (200m)

FLOOD November 2007.

Endangered local bridge

FLOOD November 2007.

Destroyed local road

FLOOD November 2007.

Destroyed local road

FLOOD November 2007.

HLarge quantities of bed load sediment

SOLUTION

RIVER TRAINING WORKS
October 2010.

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- Technical measures are just a part of the solution;

- Restoring watershed to its optimal hydrologic conditions;

- Reducing the amount of “effective rain” (fast surface runoff) and sediment yield;

- Sustainable and controlled land use;

STUDY METHODS

- Changes of land use were analyzed on the basis of field investigations, usage of aerial and satellite photo images, topographic, geological and soil maps. Land use classification was made on the basis of CORINE methodology (EEA, 1994.);

- Area sediment yield and intensity of erosion processes were estimated on the basis of the “Erosion Potential Method“ (EPM). This method was created, developed and calibrated in Serbia (Gavrilović, 1972), still in use in all countries originated from former Yugoslavia, with high degree of reliability of calculation of sediment yield, transport and reservoir sedimentation;

- Computation of maximal discharge, in hydrological conditions before and after restoration of the watershed, was done using a synthetic unit hydrograph theory and SCS methodology (SCS, 1972). This is the most frequently used procedure in Serbia for computations of maximal discharges at small, unstudied watersheds, enriched by regional analysis of lag time (Ristic, 2003), internal daily distribution of precipitation (Jankovic, 1994) and classification of soil hydrologic classes (Djorovic, 1984). Computation was carried out for AMC III (Antecedent Moisture Conditions III-high content of water in soil, and significantly reduced infiltration capacity);

- The aim of this investigation is to show how land use changes in the watershed can cause various and strong environmental impacts as well as certain improvements.

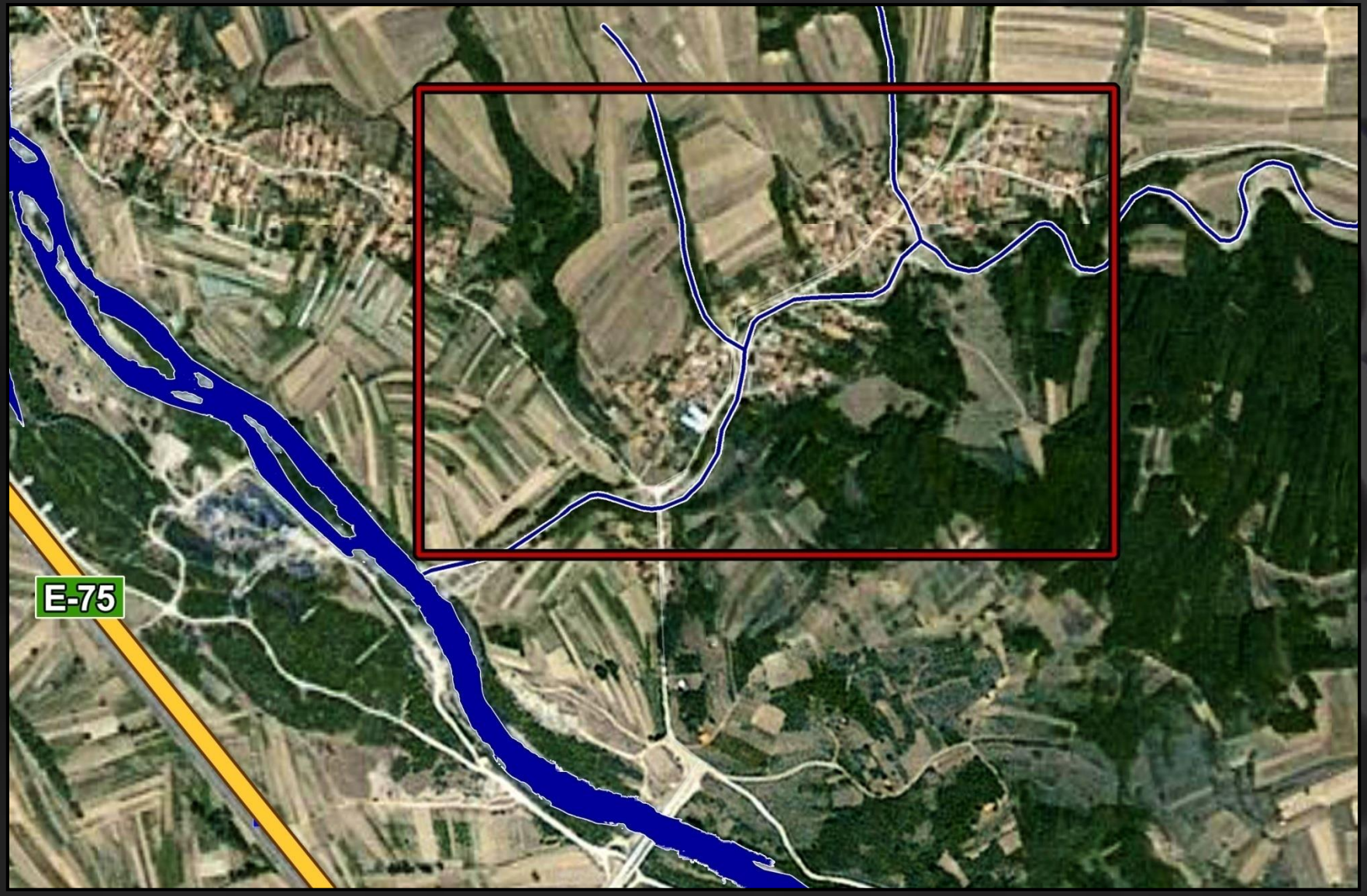
CONDITIONS IN THE WATERSHED

- Higher parts of the watershed (600-1055 meters above sea level) are covered with quality beech forest;
- Land is principally occupied by agriculture, with significant areas of natural vegetation. Complex cultivation patterns and non-irrigated arable land dominate in the middle and lower parts of the watershed;
- Almost unpermeable geology formation (schists) dominates;
- Soil types with significant content of clay particles;
- Continental climate, mountainous type, with mean annual temperature of air tsr=10.7ºC dominates; mean annual precipitation amounts to 649mm.

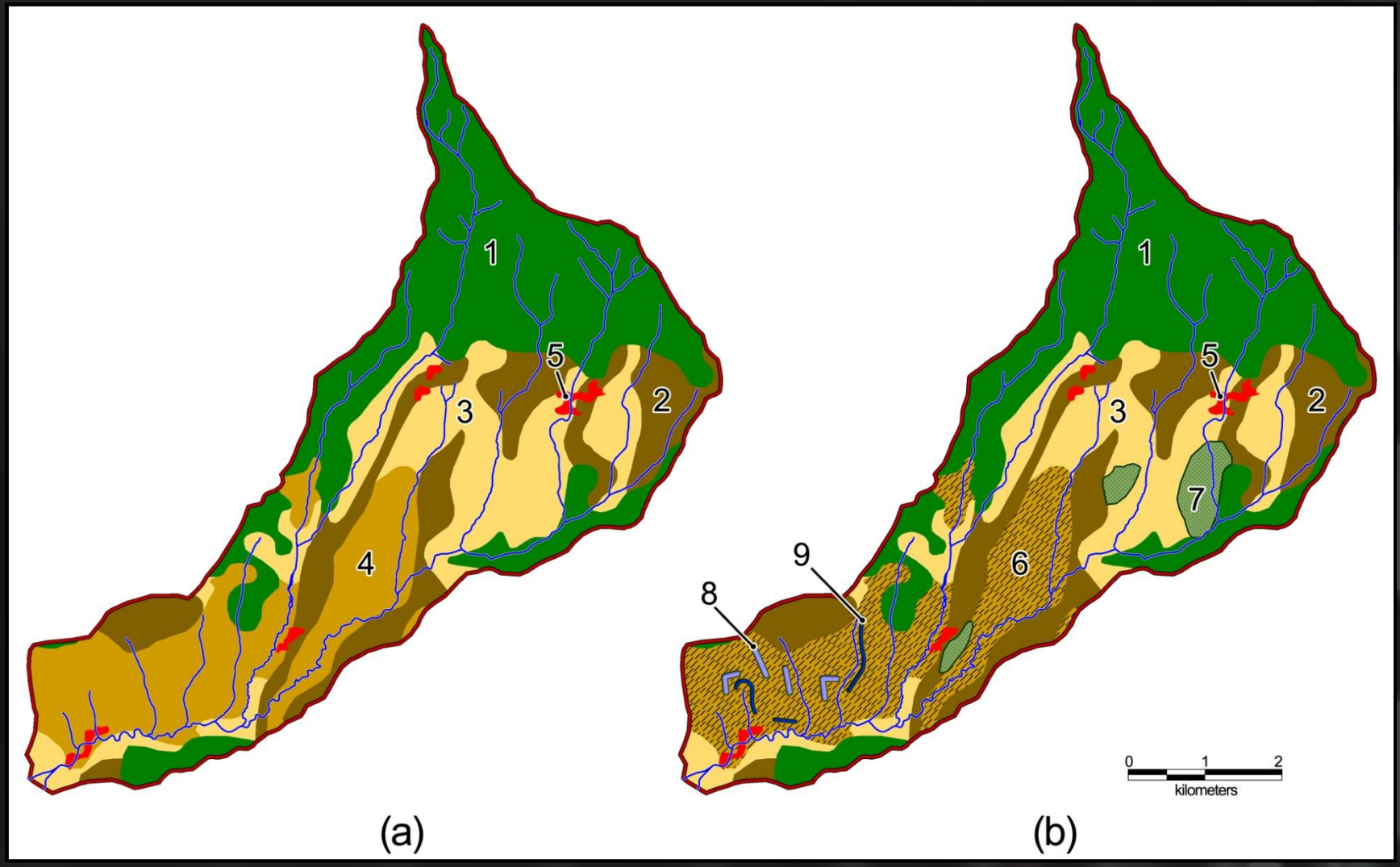
MAIN PHYSICAL CHARACTERISTICS OF THE JELAŠNICA RIVER WATERSHED

Parameter	Mark	Unit	Value
Magnitude	A	km^2	30.04
Peak point	Pp	m.a.s.l.	1051
Confluence point	Cu	m.a.s.l.	220
Length of the main stream	L	km	13.86
Absolute slope of river bed	Sa	%	6.0
Mean slope of river bed	Sm	%	3.28
Mean slope of terrain	Smt	%	20.12

INADEQUATE URBANISTIC SOLUTIONS



The most endangered section of the river valley (about 1500m long)



Land use in the Watershed of river Jelašnica

(a-before restoration; b-after restoration)

1- Broad-leaved forest; 2- Land principally occupied by agriculture, with significant areas of natural vegetation; 3- Complex cultivation patterns; 4-Non-irrigated arable land; 5-Discontinuous urban fabric; 6-Reclaimed non-irrigated arable land; 7-Afforested surfaces; 8-Forest belts; 9-Silt filtering strips

Biotechnical measures:

Afforestation: 0.75 km^2
Forest protective belts: 0.06 km^2
Silt filtering strips: 0.04 km^2

Technical measures:

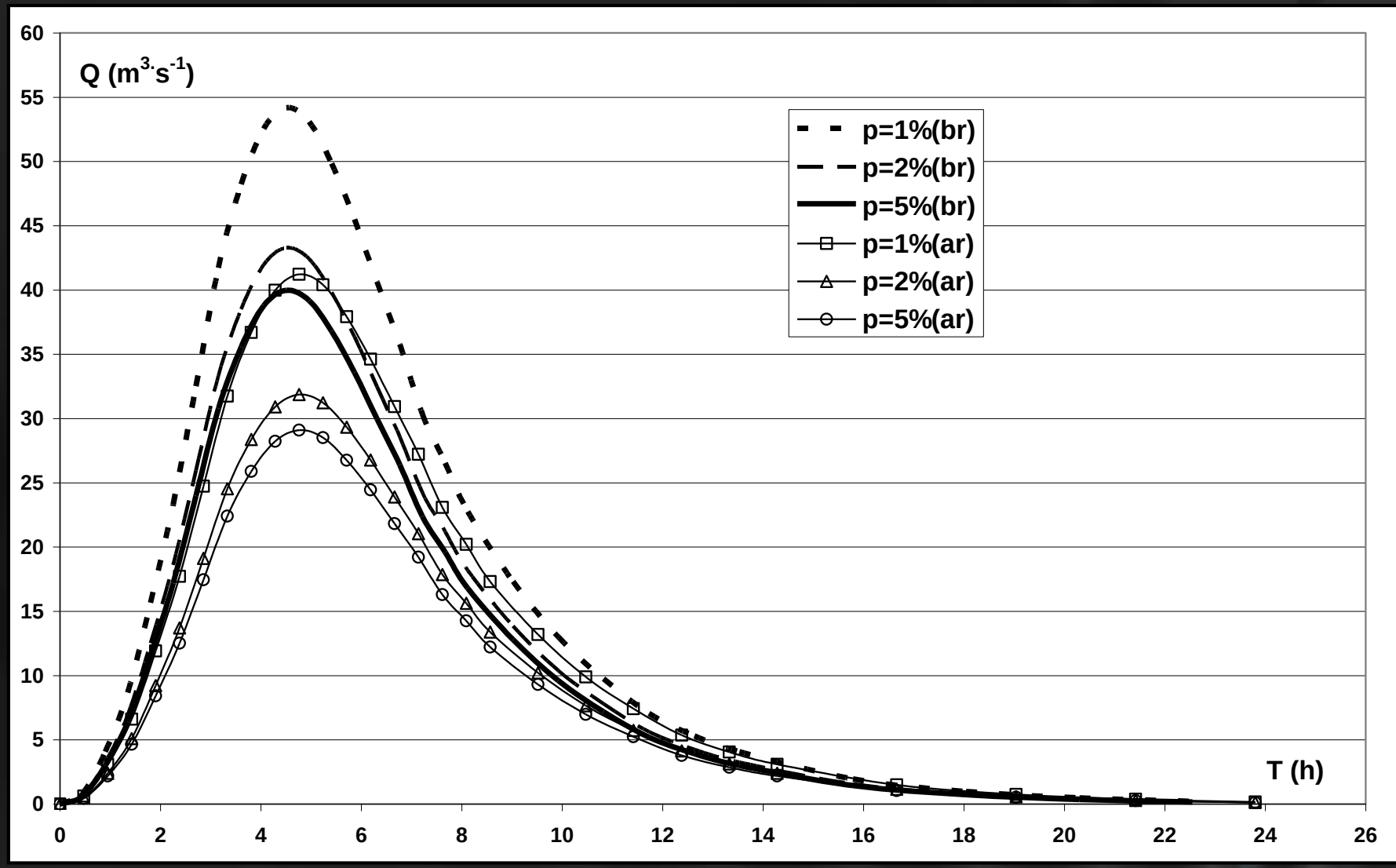
River training works: 1200 m
Check dams: 5

Administrative measures:

Plan of announcement of erosive regions
Plan of protection from torrential floods

Erosion and sediment transport

	Before restoration	After restoration
W_{god} [m^3]	27631.5	15437.5
W_{godsp} [$m^3 \cdot km^{-2} \cdot god.^{-1}$]	910.82	513.9
W_p [m^3]	11929.6	6730.8
W_{psp} [$m^3 \cdot km^{-2} \cdot god.^{-1}$]	397.12	224.1
W_{vn} [$m^3 \cdot god.^{-1}$]	2863.1	1615.4
W_{sn} [$m^3 \cdot god.^{-1}$]	9066.5	5115.4
Z	0.555	0.379



Hydrographs of maximal discharge in hydrological conditions before (br) and after restoration (ar) of Jelasnica river watershed, for probabilities p=1, 2 and 5%

OUTPUTS OF MAXIMAL DISCHARGES CALCULATION

	Before restoration	After restoration
CN_{III}	88	83
$Pe_{1\%}$[mm]	33.24	26.70
$Pe_{2\%}$[mm]	27.05	21.36
$Pe_{5\%}$[mm]	24.99	19.83
Tp [h]	4.51	4.76
Tr [h]	5.82	6.14
Tb [h]	10.33	10.90

CONCLUSIONS

- Biotechnical works on the slopes (afforestation, protective forest belts, silt filtering strips) increase infiltration and retention capacity of soil, providing smaller amount of fast surface runoff, stop sediment;

- Effectiveness of technical structures without biotechnical works in the watershed is very limited, and often insufficient to provide protection by torrential floods;

- Proposed agro forestry systems through barrier approach (live fences, hedgerows, grass stripes), with optimization of livestock numbers and controlled grazing (rotation), contour farming, and terracing will provide much beter hydrologic conditions on the slopes;

- **Best management practices could be obtained with specific combination of biotechnical, technical and administrative measures, through concept of ″natural reservoires″;**

- **Revitalization of Jelašnica headwater is based on identification of endangered areas; specifying of land use limits; application of BMPs; permanent control by experts.**