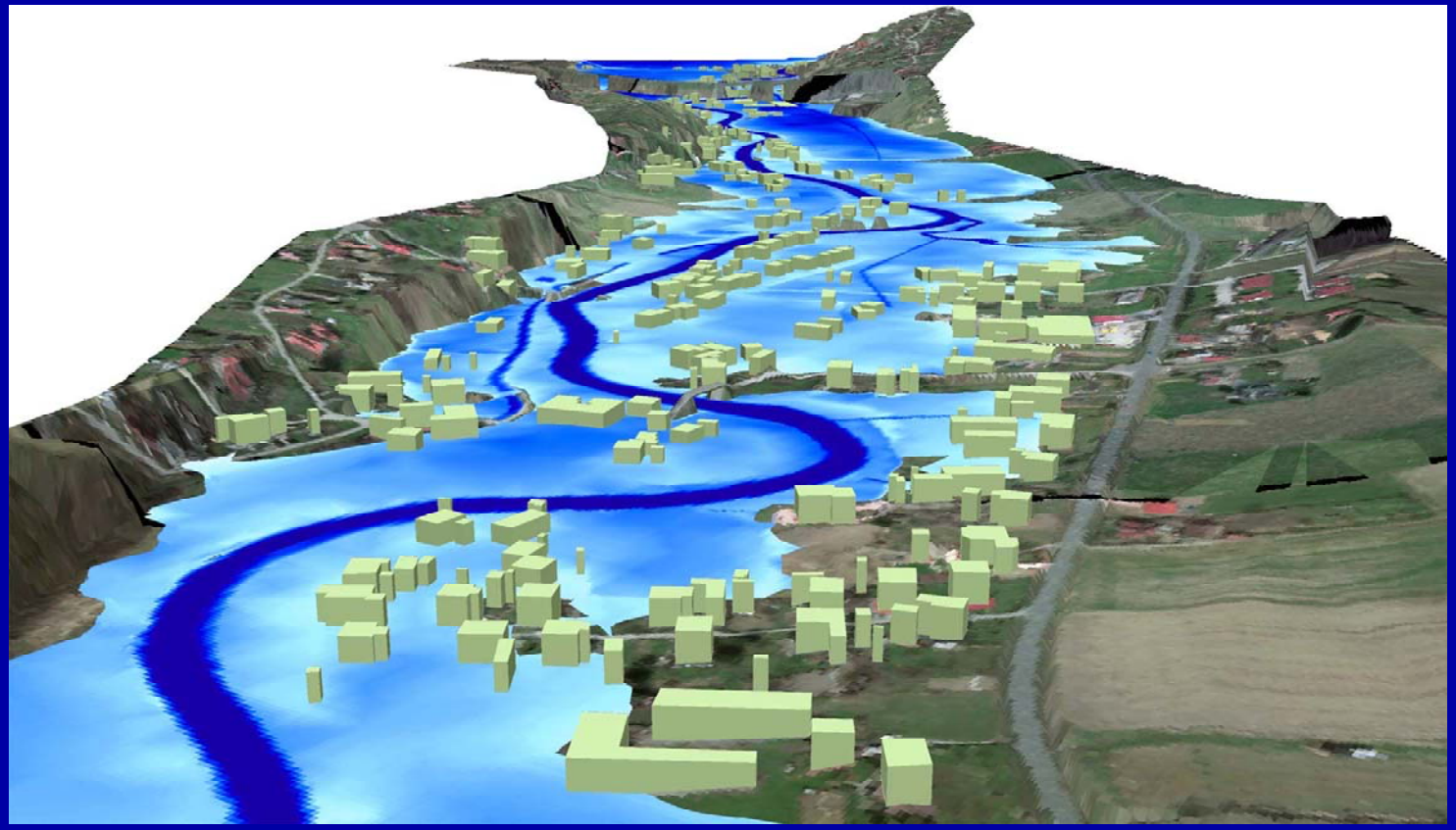
Dresden January 2006



Methods for the evaluation of potential flood losses in Methodology - application in the procedure for evaluation of economical effectiveness of flood defence measures

Doc. Ing. Ladislav Satrapa,CSc. Dr. Ing. Pavel Fošumpaur Ing. Martin Horský
CTU Prague

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Description of methods for flood loss analysis

Method I - national areas - strategy

This method is used for the identification of the flood loss potential on large areas. (Based on detail topographical and statistical data and analysis made at „green table“ without any site investigation)

Method II - regional areas – national planning, verification of Method I

This method is used for the identification of the flood loss potential on regional areas. (Based on detail topographical and statistical data and analysis, supported by site investigation in complicated parts of region.)

Method III - local areas – local planning, urban planning, verification of Method I and II

This method is used for the identification of the flood loss potential on local areas. (Based on detail topographical and statistical data and analysis, supported by detail and complete site investigation of area.)

Analysed potential flood losses

- Damage to buildings (loss curves, detail of each building)
- Damage to household equipment (ČSÚ statistic data, each building)
- Damage to equipment of municipal facilities (building detail, statistic data and flood experience)
- Damage to city infrastructure (energy, water, sewage etc. – corresponding to city roads, construction costs, flood experience)
- Damage to roads (length of roads in flooded area, construction costs)
- Damage to bridges (area of bridge, construction cost, experience)
- Damage to industry (statistical data of Czech industry recalculated to industrial areas, site investigation)
- Damage to agriculture (agriculture areas, loss curves)
- Damage to water course (statistical data of property)

- No analysis of secondary losses and no ambition to express some ecological losses in monetary units

Determination of damage to buildings

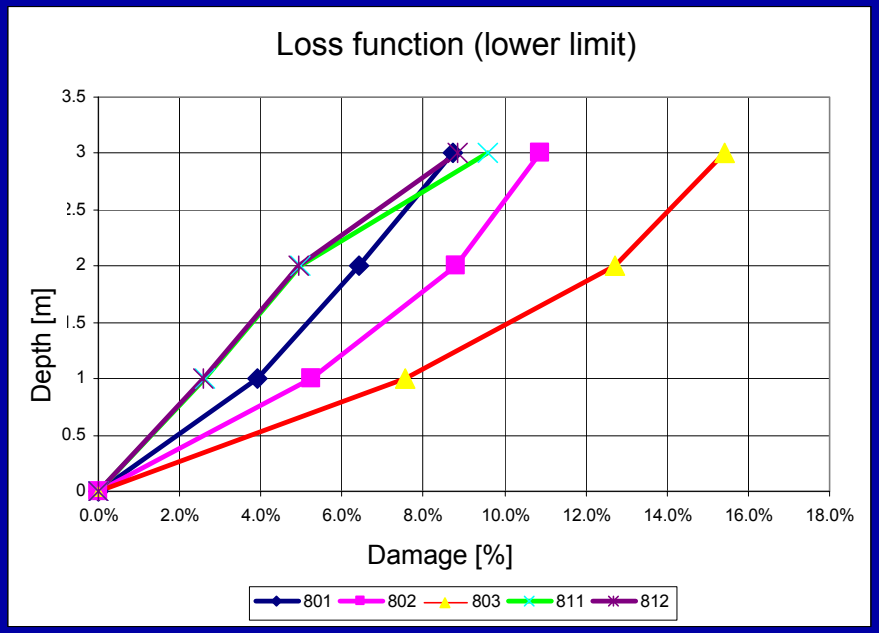
Calculation:

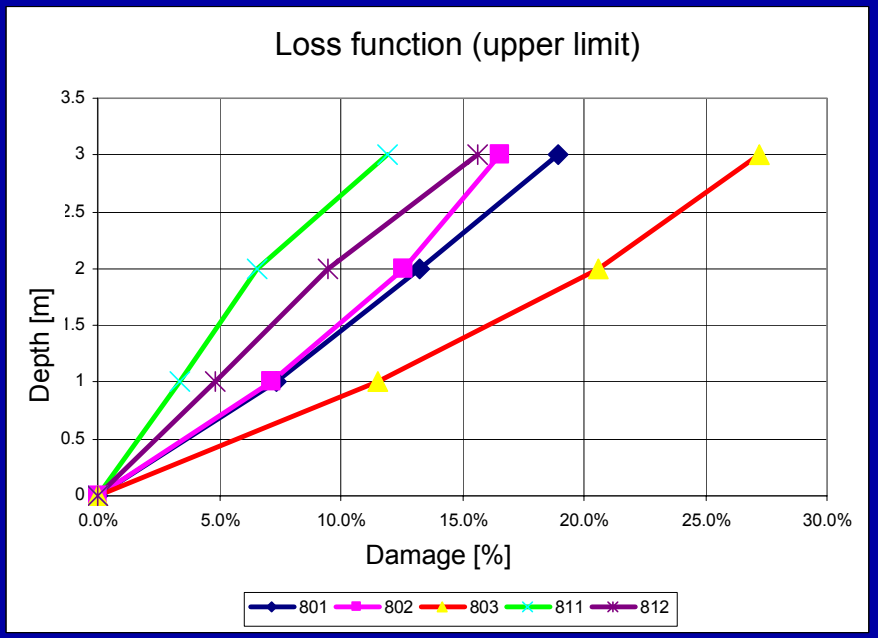
- H [m] – Height of 1 floor of the building
- C [CZK/m^3] – Construction cost per m^3 by JKSO
  (C.H = construction cost of 1m^2 of floor of building)
- %p [-] – Percent of damage to building according to loss function and height of water (source – CTU)
- A [m^2] – Built-up area of the building (GIS)

- LOSS = H . C . %p . A [CZK]

- This procedure is done for all building in the contact with water

Loss functions - buildings





Damage to household equipment

Calculation:

- N_f and N_h [-] - number of flooded flats, family houses.
- C_f and C_h [CZK] – cost of household equipment for flats and family houses, costs are determined by statistical research of social group of people (ČSÚ).

$$LOSS = N_f \,.\, C_f \;+\; N_h \,.\, C_h \,[CZK]$$

Damage to equipment of municipal buildings

Calculation:

- A [m^2] – area of flooded buildings
- C [CZK/m^2] – cost of facilities per 1m^2 , determined by detail research of CTU Prague.

LOSS = A . C [CZK]

Damage to energy infrastructure, pipeline systems and roads

Calculation:

- L [m] or [m^2] – length (energy, pipelines) or area (roads) of flooded infrastructure
- C [CZK/m] or [CZK/m^2] – corresponding construction cost
- %p [-] – corresponding percent of damage
- N [-] – number of flooded types of infrastructure

$$LOSS = \sum_{i=1..N} L_i \,.\, C_i \,.\, \%p_i \quad [CZK]$$

Damage to bridges

Calculation:

- A [m^2] – area of damaged or destroyed bridge
- C [CZK/m] or [CZK/m^2] – construction cost of damaged or destroyed bridge
- %p [-] – percent of damage to bridge
- N [-] – number of flooded bridges

$$LOSS = \sum_{i=1..N} A_i \,.\, C_i \,.\, \%p_i \ [CZK]$$

Potential flood damage to industry

- Damage to the industry is determined by a questionnaire method – for methods II and III.
- For method I is used procedure based on statistical data of czech industry (ČSÚ) recalculated to surface area of industrial buildings in the contact with flood.

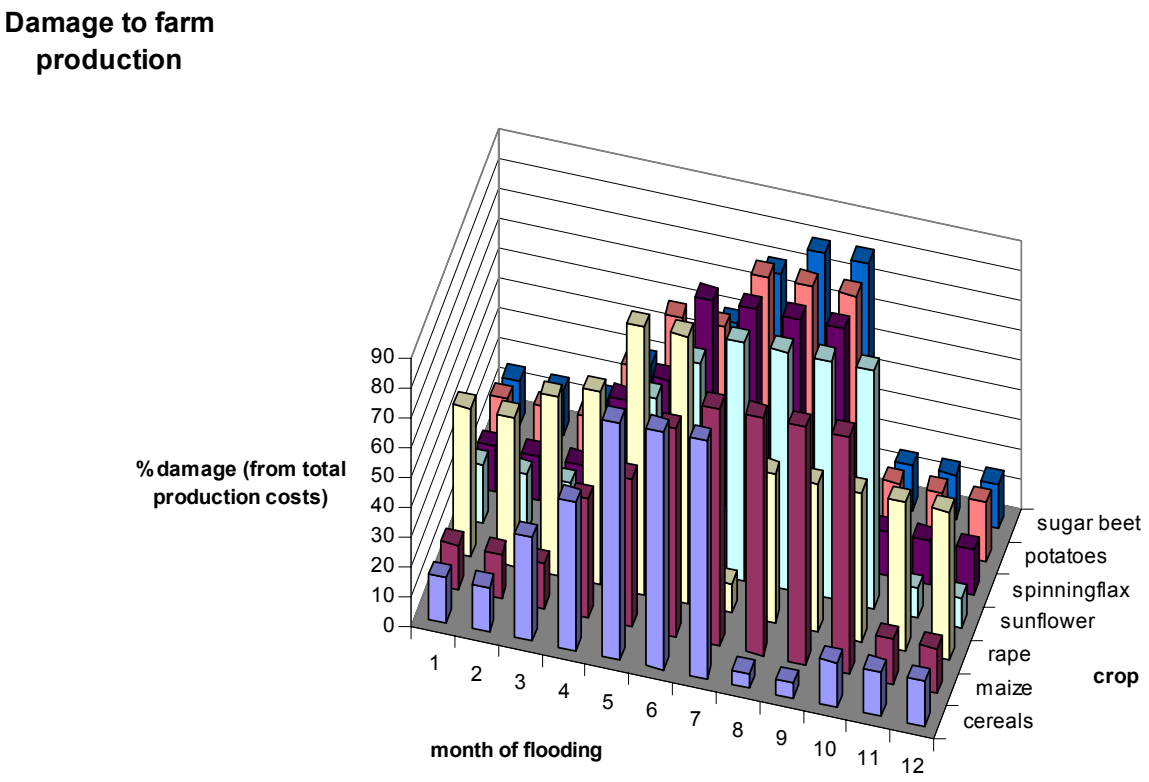
Damage to agriculture, to farm production

Calculation:

- A – area of flooded farmland [ha]
- C – costs of crops per 1 ha [CZK/ha] (statistical data)
- %p – percent of damage for each type of crop and month of flood
- N – number of crops

$$LOSS = \sum_{i=1..N} A_i \,.\, C_i \,.\, \%p_i \quad [CZK]$$

Damage to agriculture
Loss function for farm production



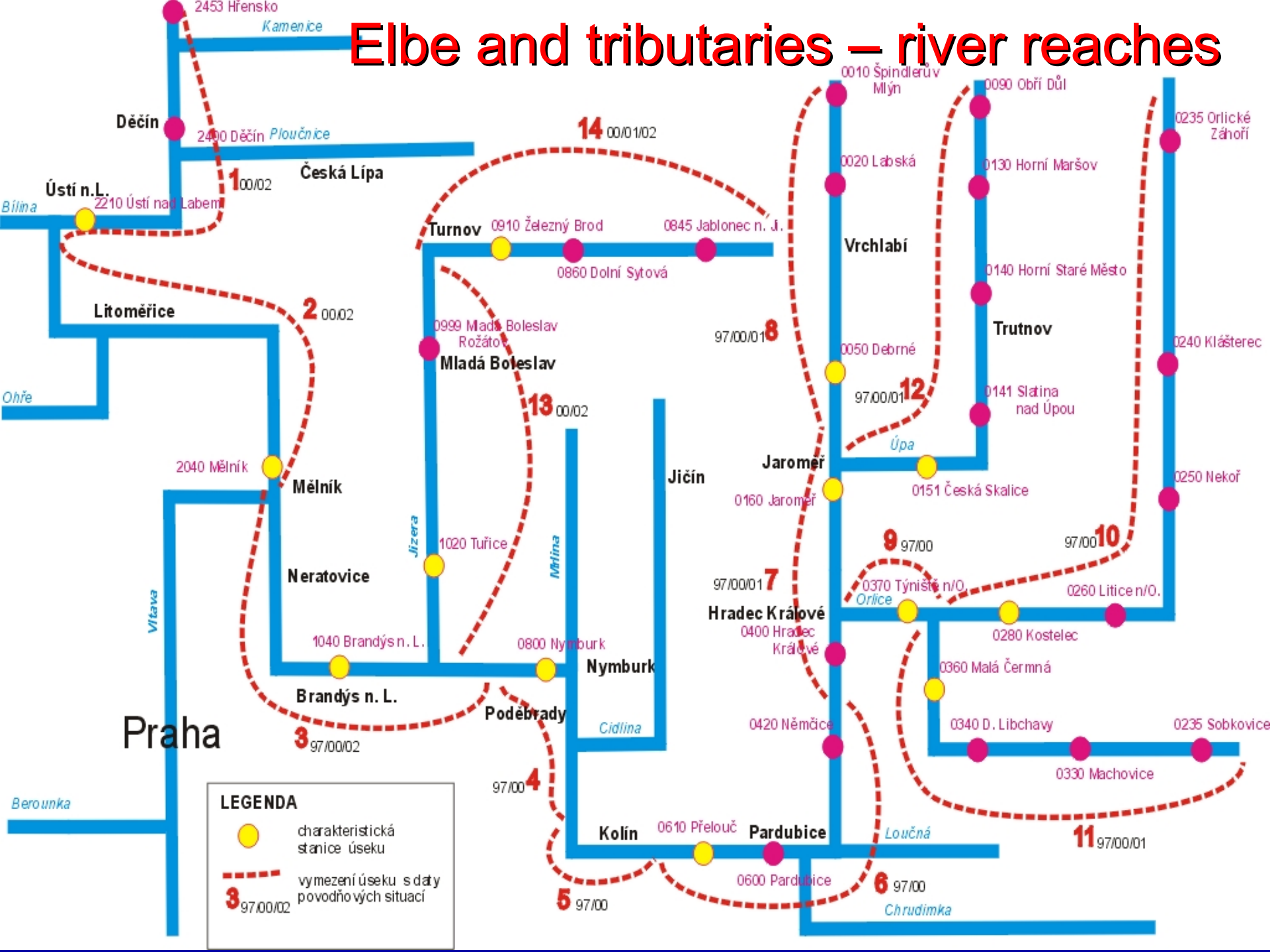
	1	2	3	4	5	6	7	8	9	10	11	12
cereals	15	15	35	50	80	80	80	5	5	15	15	15
maize	15	15	15	40	50	70	80	80	80	80	15	15
rape	50	50	60	65	90	90	10	50	50	50	50	50
sunflow er	20	20	20	40	55	70	80	80	80	80	10	10
spinningflax	15	15	15	40	50	80	80	80	80	15	15	15
potatoes	20	20	20	40	60	60	80	80	80	20	20	20
sugar beet	15	15	15	30	30	50	70	80	80	15	15	15

Damage of structures and equipment at rivers

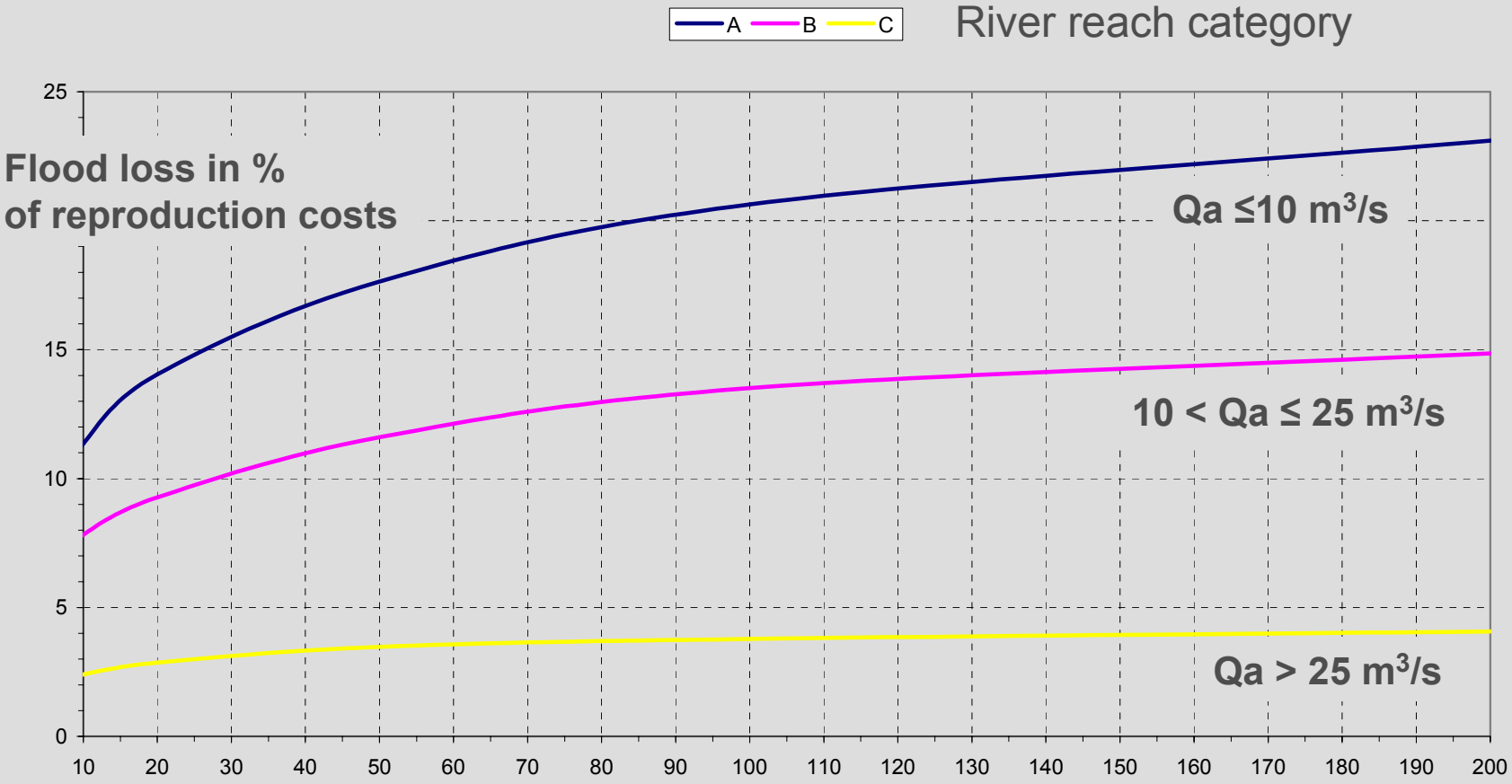
Data for the analysis of flood losses in river reaches

- present economic value of property,
- operation costs,
- estimation or evaluation of flood losses for historical floods,
- general hydrological and topographical description of river stretches,
- extreme floods.

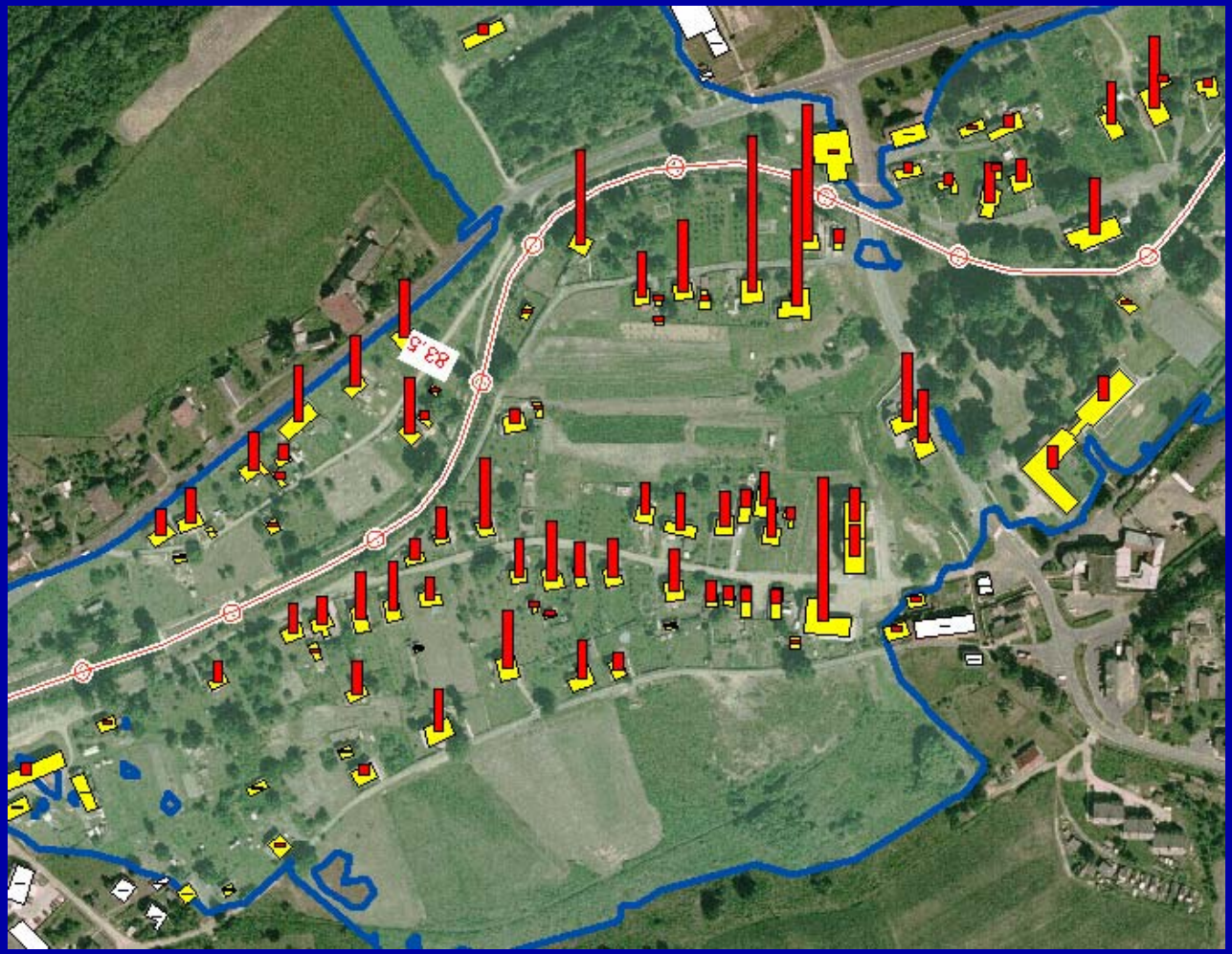
Elbe and tributaries – river reaches



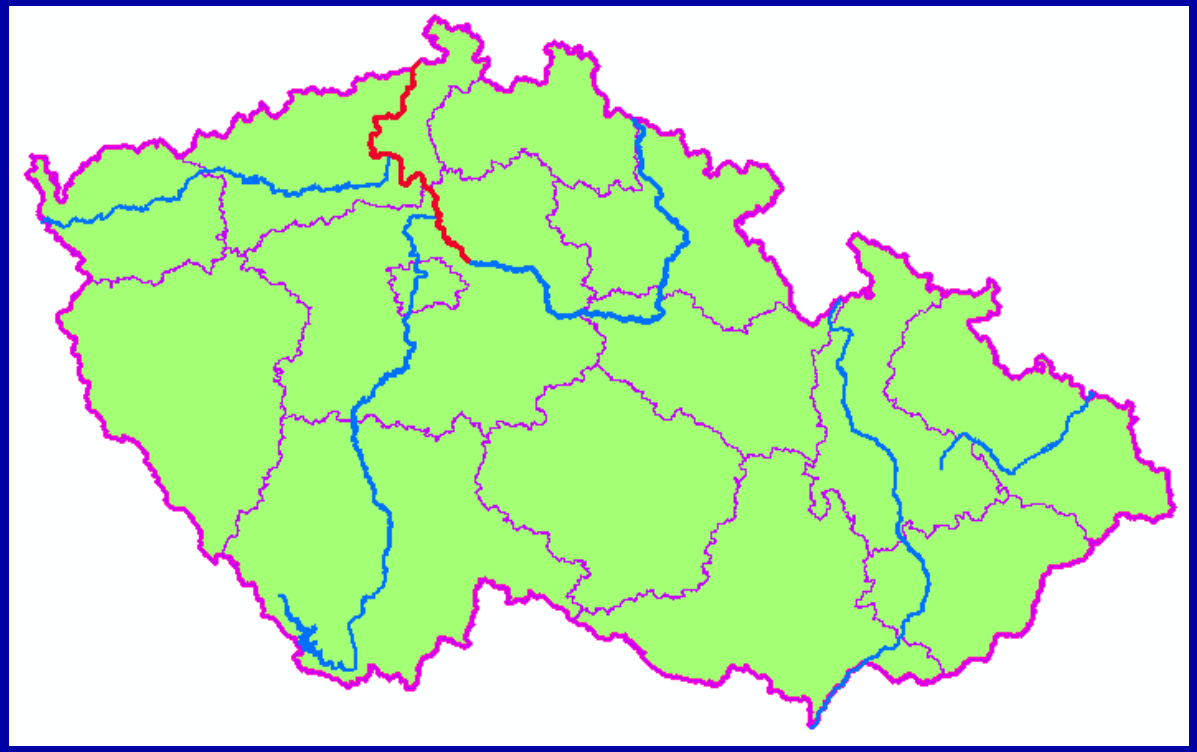
Flood losses – loss functions

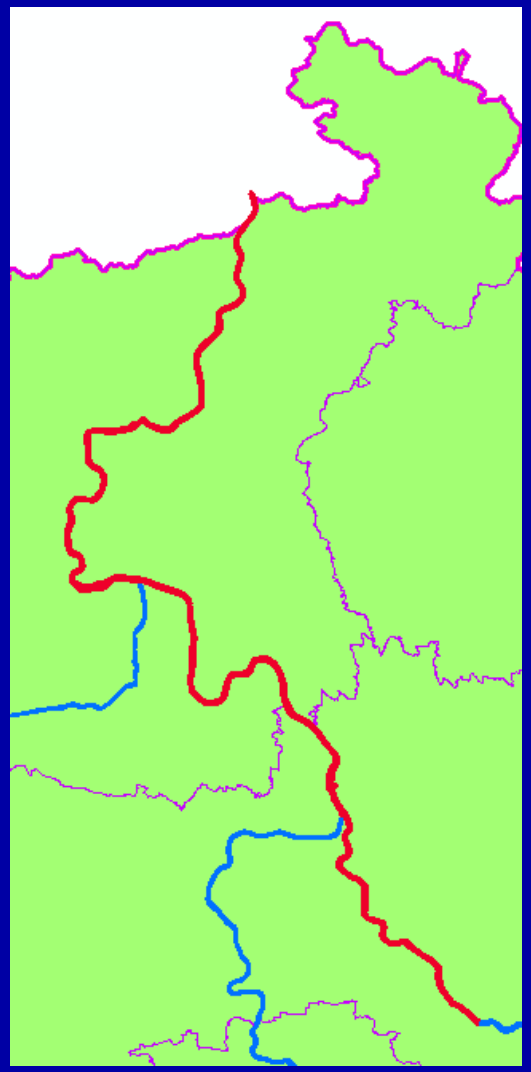


GIS presentation of flood losses - buildings



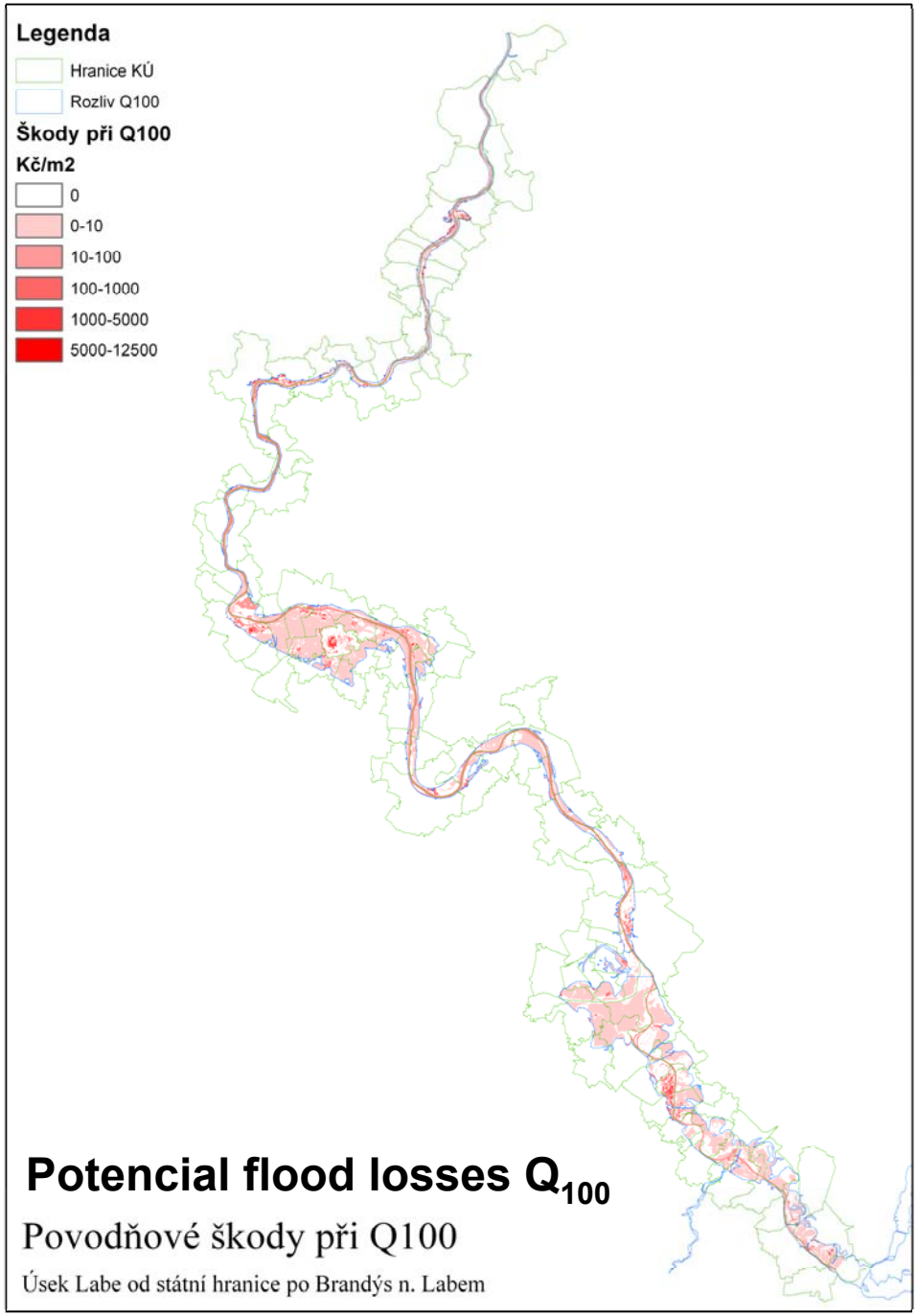
Results of the applied methods for analysed area



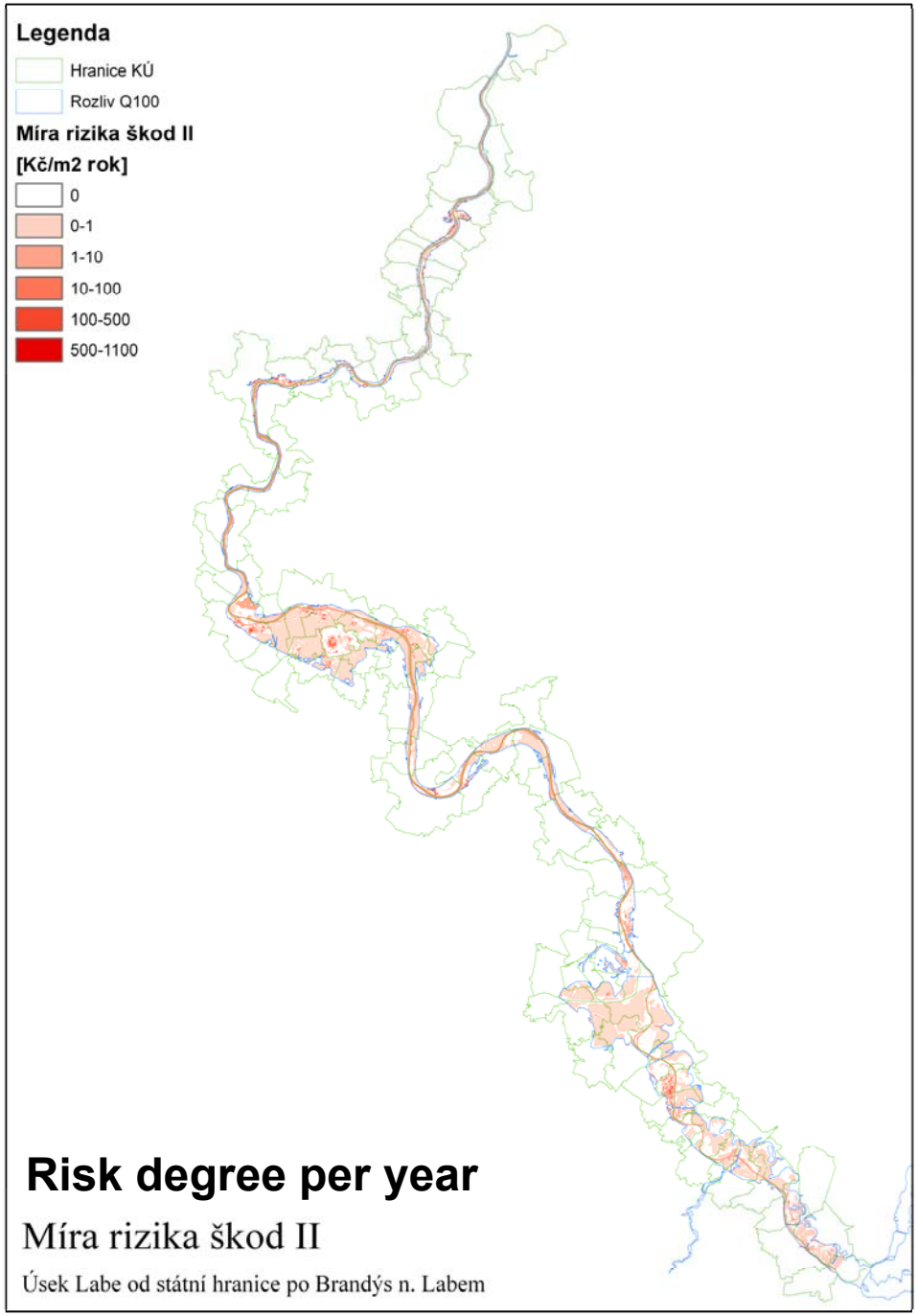


Potential flood losses

Metod I - complete analysed area from Brandýs to Hřensko	Damage Q20 [thousands EURO]		Damage Q100 [thousands EURO]	
type of flood loss	min	max	min	max
Buildings	26 245	43 845	100 846	170 256
Household equipments	5 897	13 093	21 808	48 417
Equipment of municipal buildings	3 702	4 525	8 539	10 437
Industry	26 820	40 237	81 674	122 532
Equipment of nonrecognised buildi	3 753	4 587	12 415	15 174
Roads	2 006	4 012	5 534	11 068
Railways	264	413	754	1 180
Bridges	830	1 164	1 307	1 832
Infrastructure (energy, pipeline etc.)	1 107	1 586	3 060	4 382
Agriculture	467	1 168	1 656	4 140
Sport's areas	1 456	2 135	2 820	4 136
Structures and property at rivers	12 881	12 881	17 293	17 293
Total	85 429	129 645	257 706	410 847



Analysed potential flood losses



Economical risk potential

ECONOMICAL RISK ANALYSIS AS A SUPPORT IN FLOOD PROTECTION POLICY

Strategy of Flood Protection:

- Flood protection management should cover all the preferences of the society = need of optimization of flood protection policy.

- **The EU Water Framework Directive**: contains a very basic background of flood protection policy.

- In the Czech Republic general rules are included in document: **Strategy of Flood Protection in the Czech Republic**

Question:

- Does exist any reliable measure to objectify the decision making process when dealing with the flood protection optimization?

Answer:

- YES – the Costs Benefits Analysis (CBA).

CBA in flood measure optimization

- **Costs** : are generally computed by standard method,

- **Benefits :** are generally given by the value of protected assets – damage evaluation.

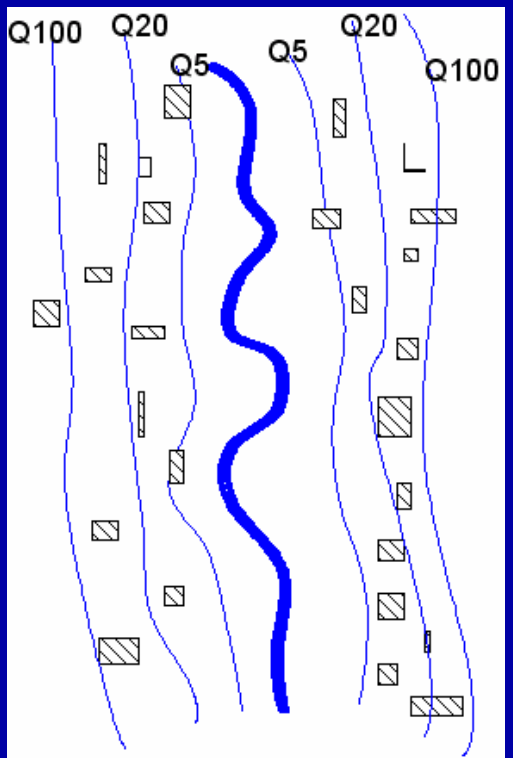
↓

- This approach isn't complete – it doesn't comprise all respective criteria,
- It is necessary to involve total risk by largen number of hazard scenarios (floods, peak flows)

Solution: the Risk Analysis

Risk = Flood loss x Occurrence probability

Risk can be computed for varying floods according to their return periods.



Peak Flow	Damage
Q_5	D_5
Q_{20}	D_{20}
Q_{100}	D_{100}

How can be the risk assessed ?

Risk evaluation

Risk is computed as the weighted average of yearly losses (weights equal occurrence probabilities).

$$R = E(D) = \int_{Qa}^{Qb} D(Q).f(Q)dQ$$

Where

Q_a … non-damaging flow (damages would start to appear from this value of discharge)

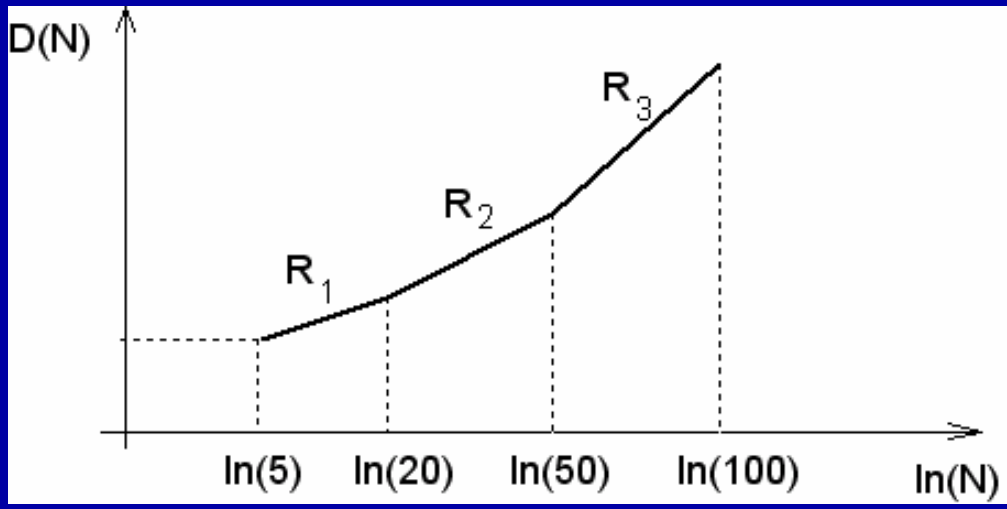
Q_b … theoretically $+\infty$ (practically the flow with very low occurrence probability)

E(D) … average yearly loss

Risk evaluation: Monte Carlo method

Inputs:

- Flow – Flood loss relation
- Probability distribution of yearly peak flows



N … return period

Outputs:

- Synthetic series of yearly peak flows (10 000 years)
- Synthetic series of yearly losses
- Risk = average yearly loss

Capitalized Risk evaluation

- Present value of the risk is given by the formula:

$$Ra = \frac{R}{DS}$$

Where

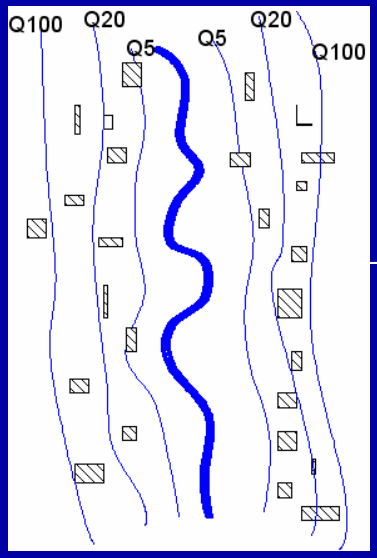
Ra … capitalized risk (present value of the risk)

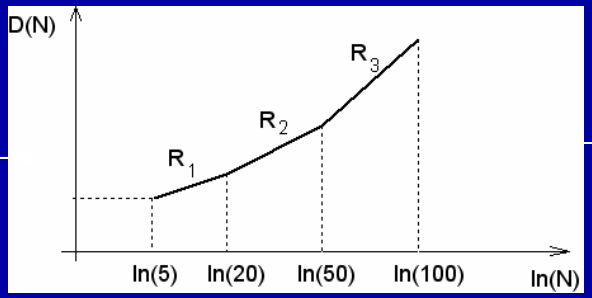
R …. average yearly loss (risk)

DS … discount rate (bank rate).

Effectiveness evaluation of a flood preventive measure (FPM)

A) Before FPM has been implemented



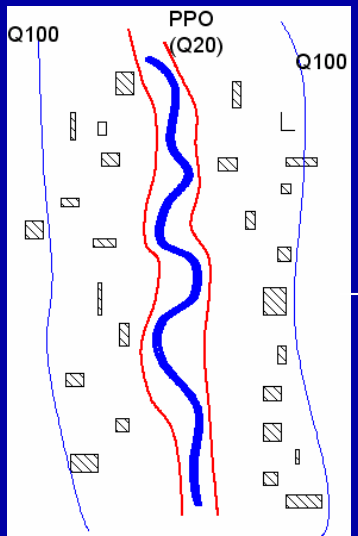


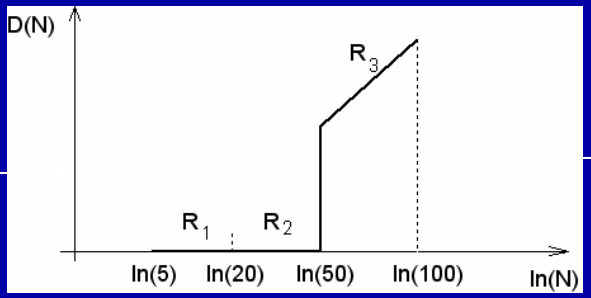
Average yearly loss

Cap. Risk

Ra$^{\text{Before}}$

B) After FPM realization





Average yearly loss

Cap. Risk

Ra$^{\text{After}}$

Costs – Benefits Analysis Criteria

1) **Investment recovery** [years]

   PP = Costs / [Ra(before) – Ra(after)]

2) **Relative effectiveness** [-]

   RE = [Ra(before) – Ra(after)] / Costs

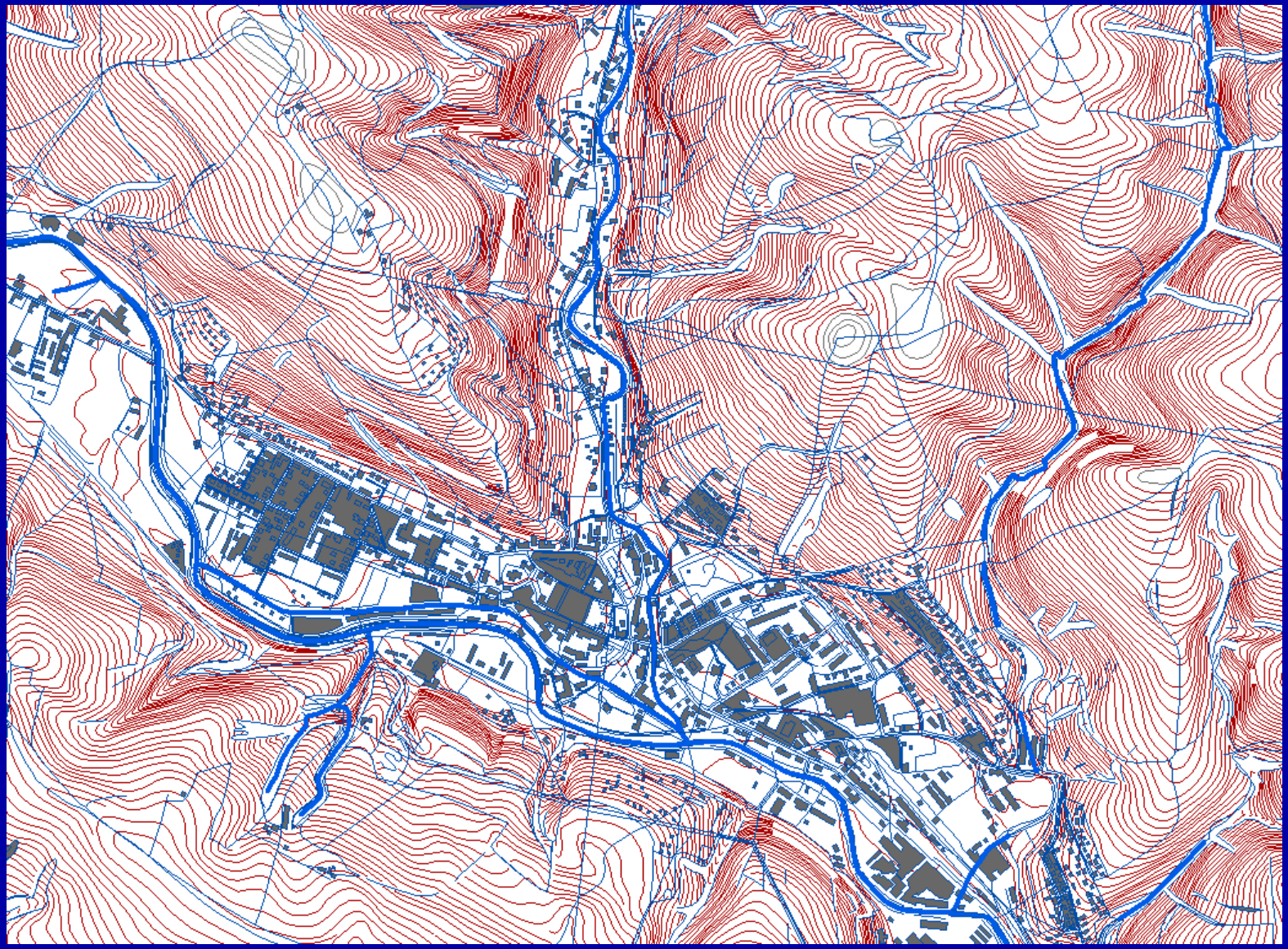
3) **Total effectiveness** [CZK]

   TE = Ra(before) – [Costs + Ra(after)]

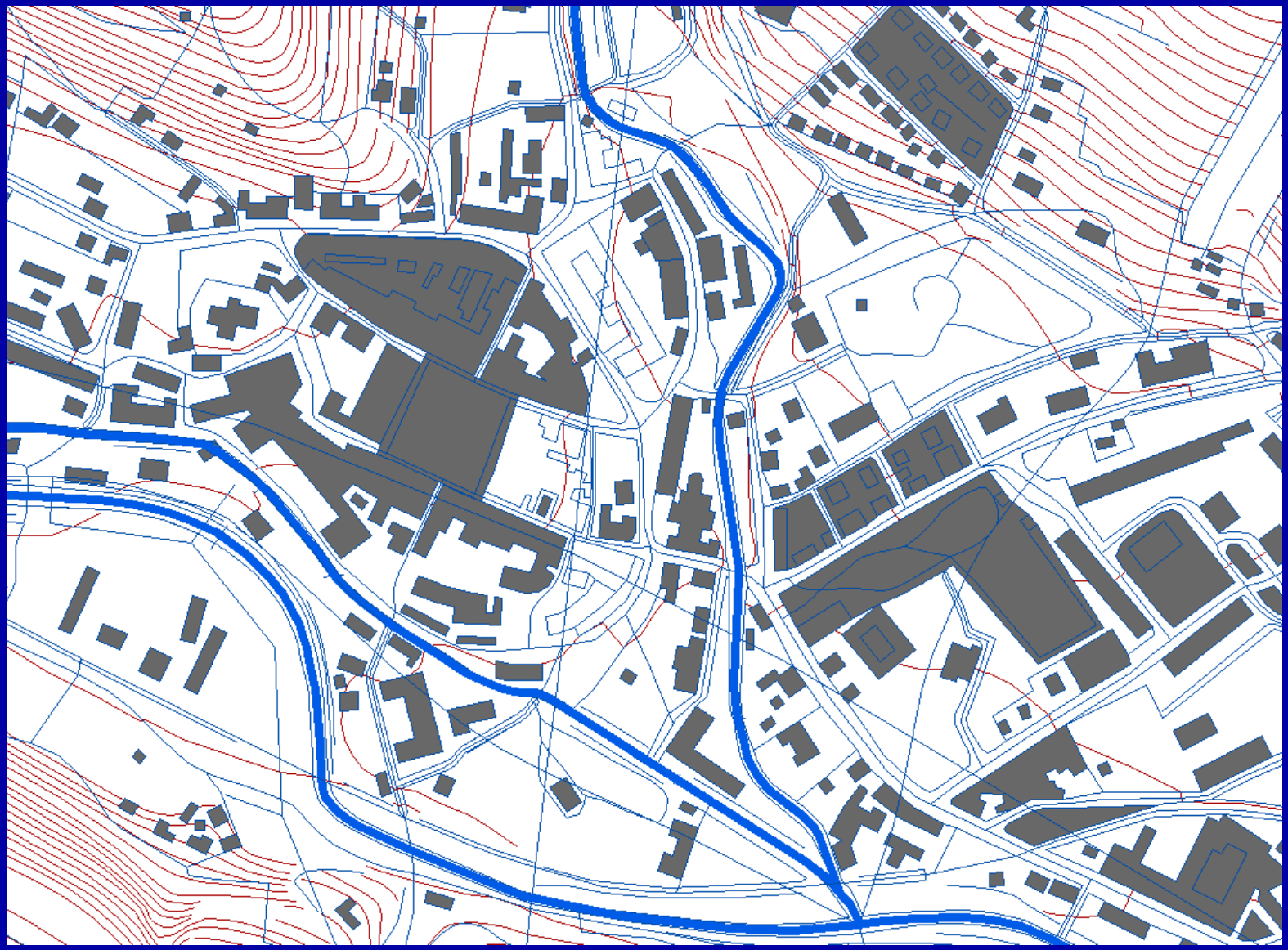
CASE STUDY
The flood defence measures in the Hostinné municipality on the Cista River (the Elbe tributary)

Is the proposed flood defence measure economically efficient?

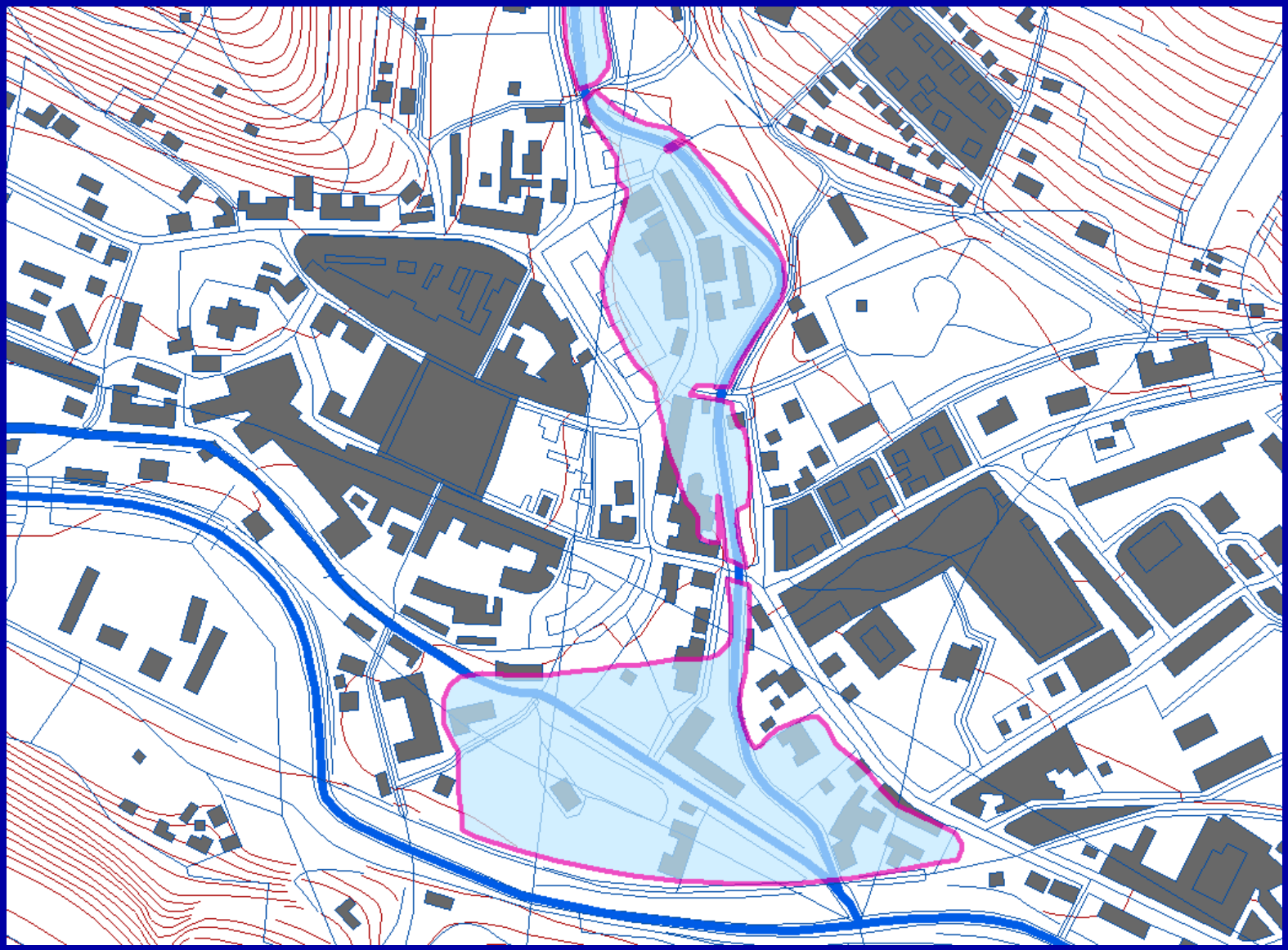
HOSTINNE - Cista



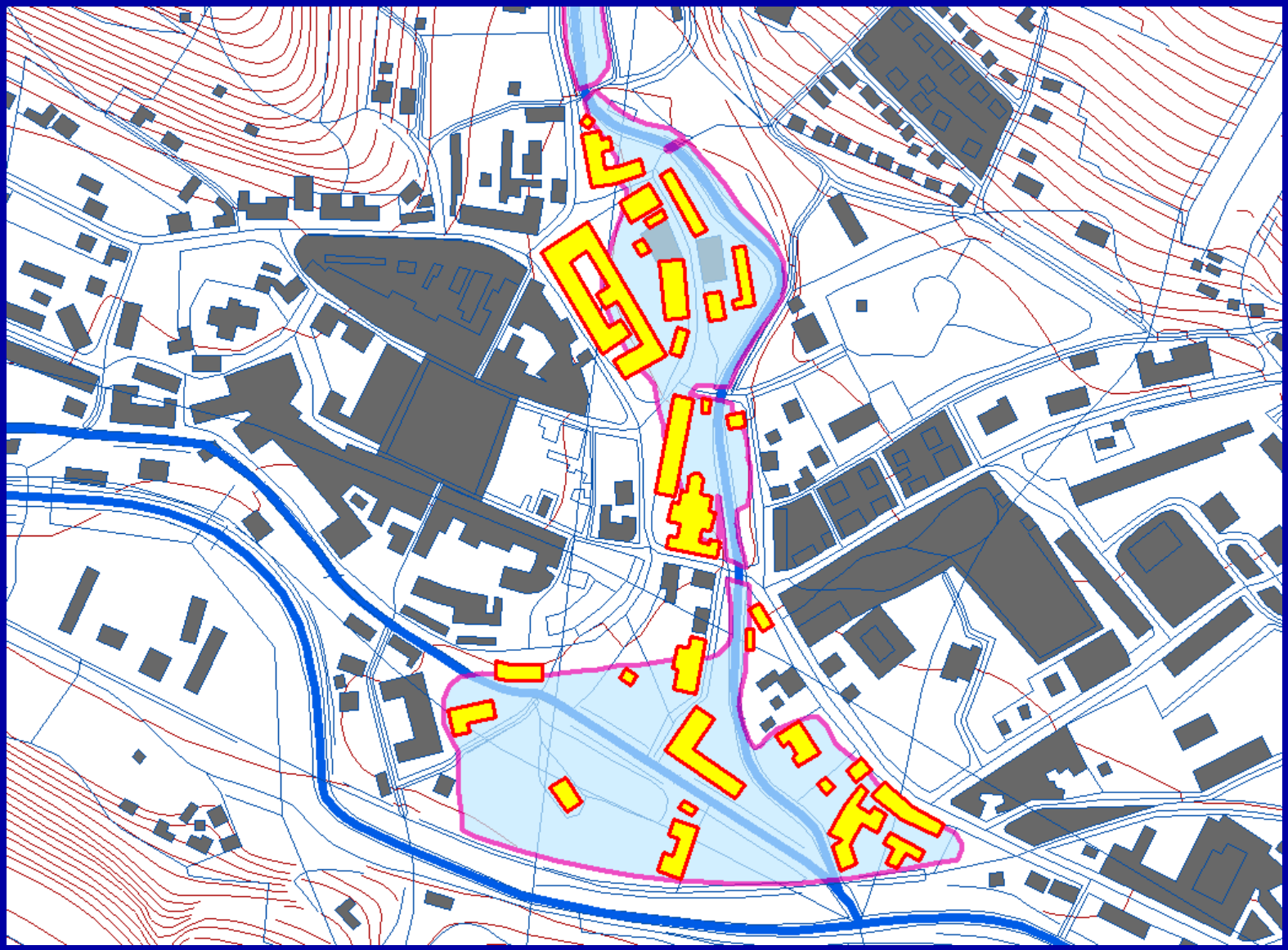
Flooded area in GIS



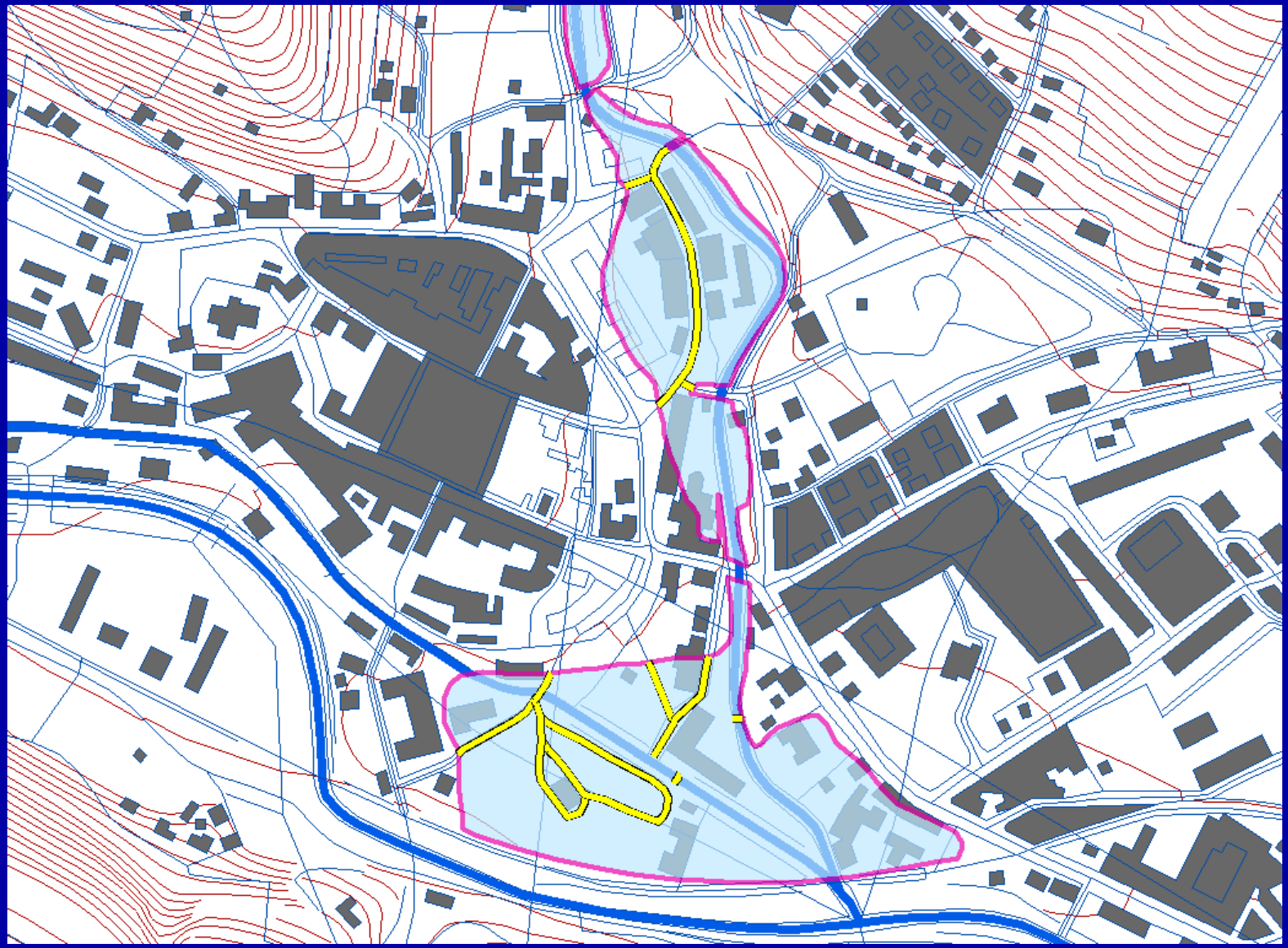
The flooded area for Q_{100}



Affected structure selection ZABAGED - Q_{100}

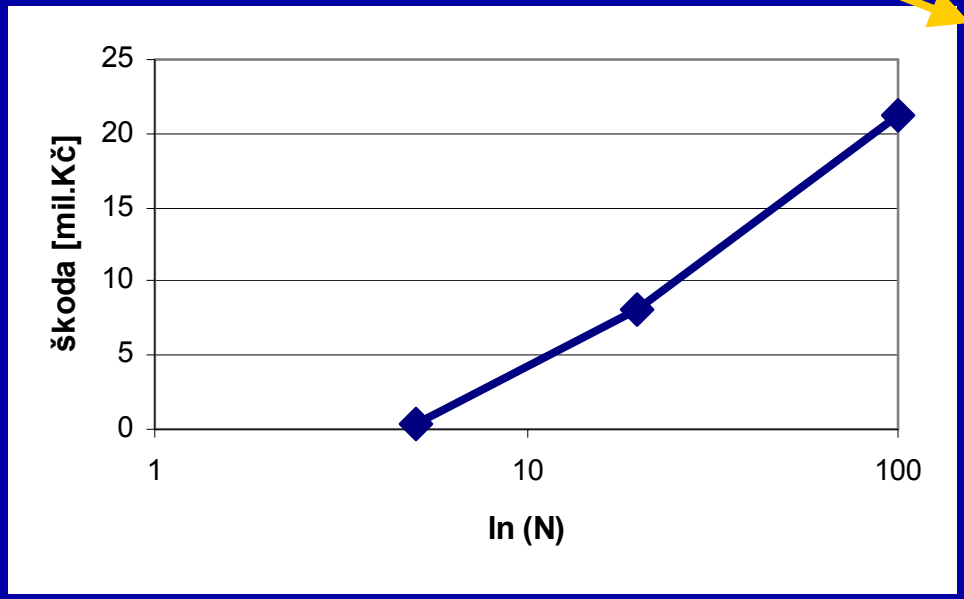


Affected infrastructure selection ZABAGED - Q_{100}



Affected resident selection - Q_{100}

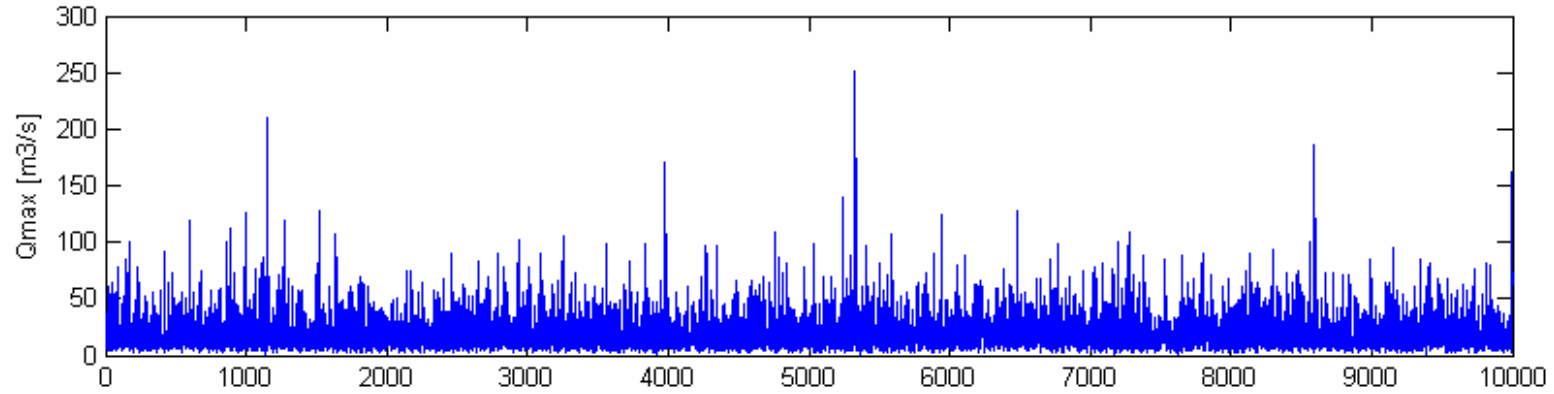
Flood losses evaluation



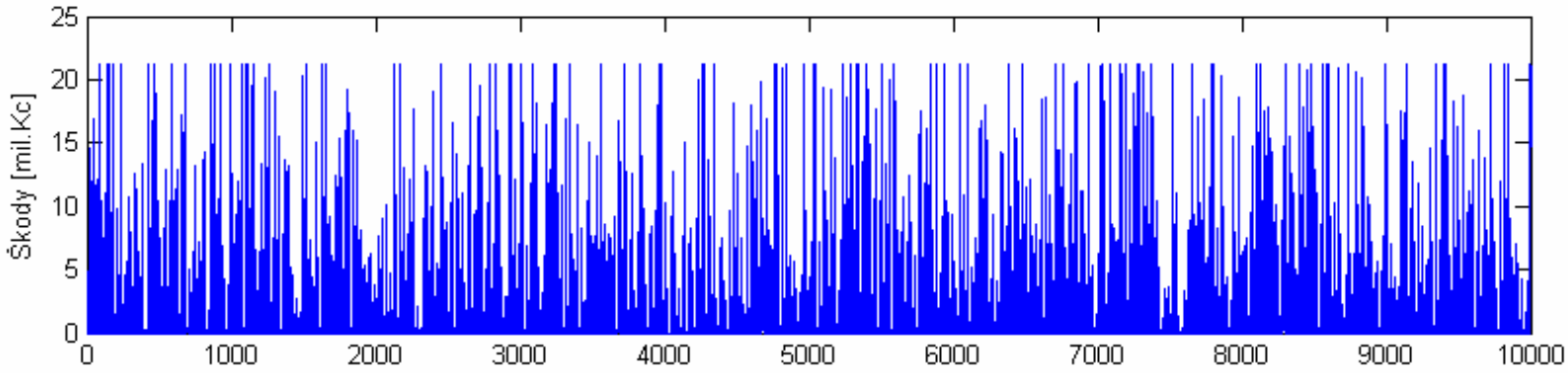
N … return period

Stochastic flood losses simulation

Synthetic series of yearly peak flows



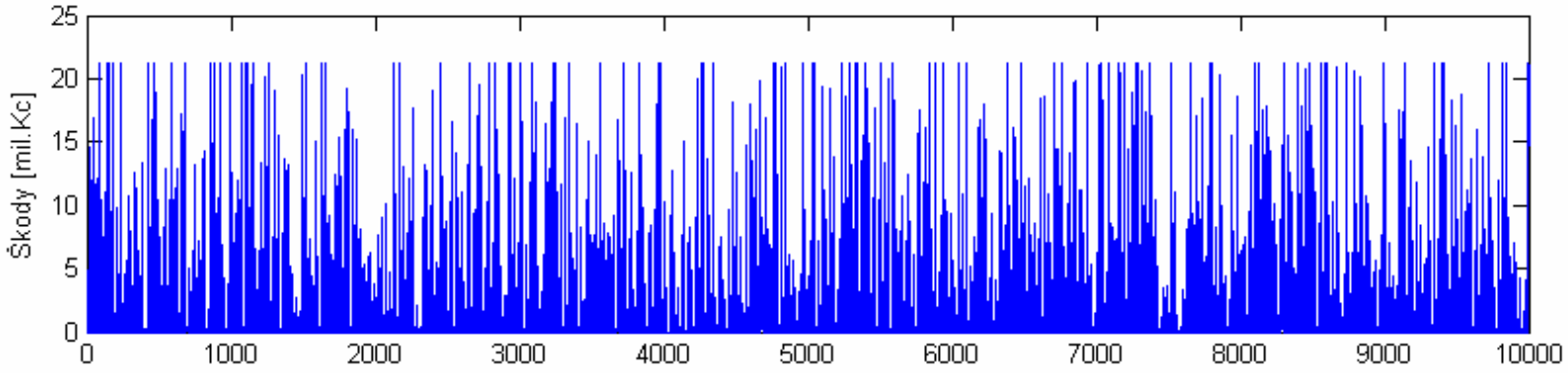
Yearly losses series (before Flood protective measure)



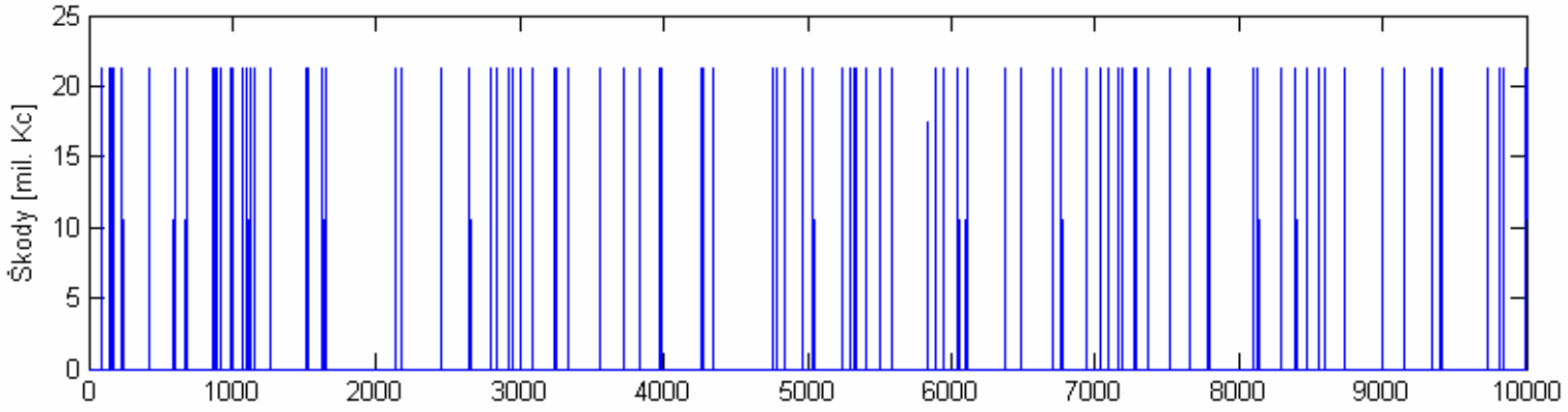
E(D) = 1,30 mil. CZK/year

Damage series comparison

Flood losses **before** FPM implementation:



Flood losses **after** FPM implementation:



E(D) = 0,21 mil. CZK/year

Costs – Benefits criteria

	Before FPM	After FPM	
Yearly average damage (Risk)	1.30	0.21	**[mil.CZK/year]**
Discount Rate	3%	3%	
Capitalized Risk	43.27	6.96	**[mil.CZK]**
Costs	0	13.34	**[mil.CZK]**
Investment recovery	12		[years]
Relative effectiveness	2.72		
Total effectiveness	22.97		**[mil.CZK]**

-> Proposed flood measure is highly effective.

-> However, it may be compared with variants and the best proposal can be easily selected regarding costs-benefits criteria.