Quantification of morphological changes in river channels and its impact on flood risk (Topľa and Bečva River case studies)

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International Conference 2016: Towards the Best Practice of River Restoration and Maintenance
Poland, Krakow, 20th - 23rd September 2016

Project START

DANUBE REGION strategy START Danube Region Project Fund

- **Aim of the project:** quantificate morphological changes in two Carpathian river channels (Bečva in Czech Republic and Topľa in Slovakia) including channel-floodplain connectivity and its impact on flood risk for recent and historical channel settings
- **Partners:** Department of Physical Geography and Geoecology, Universitas Ostraviensis Facultas Rerum Naturalium; Geografický ústav SAV / Institute of Geography SAS; Universitas Comeniana Bratislavensis Facultas Rerum Naturalium MCMXIX
- **Project duration:** 11/2015 – 06/2016

RETENTION CAPACITY OF FLOODPLAIN

Floodplains inundated during high flow events

 - - - the storage of floodwater on floodplains can reduce flood magnitude downstream (Acreman et al. 2003)

 - - - a delay in the peak time of the flood wave

The rate of transformation depends on the planar shape, the character and the land use of the floodplain area, i.e. on its retention capacity (Valentová et al. 2010).

+ + + increase and maintain biodiversity, preserve and recharge groundwater supply and affect water quality by filtering sediments, nutrients and impurities (Wohl 2014)

INTERRUPTED CONNECTIVITY BETWEEN THE MAIN CHANNEL AND FLOODPLAINS

- - - channelisation works (channel narrowing, bank stabilisations, removal of bank vegetation and gravel mining) lead to channel degradation and progressive incision mainly during 20th century.

Deeply incised channels interrupt hydraulic connectivity of floodplains, which has been documented in many European regions including the Western Carpathians (Wyżga 1993; Galia et al. 2012; Wyżga et al. 2012; Škarpich et al. 2013)

- - - in unbuilt areas significantly affects the ability of flood transformations and may increase a flood risk for downstream urbanised areas

STUDY AREAS

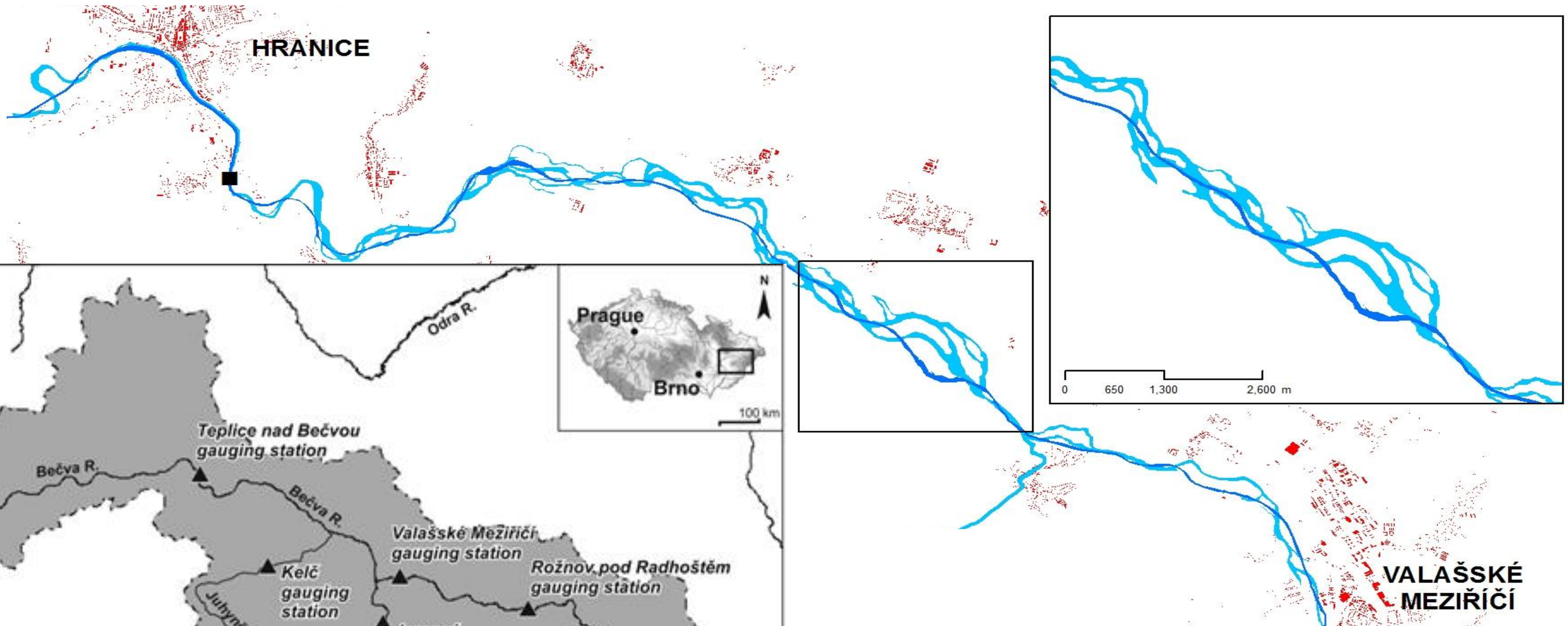
Bečva River

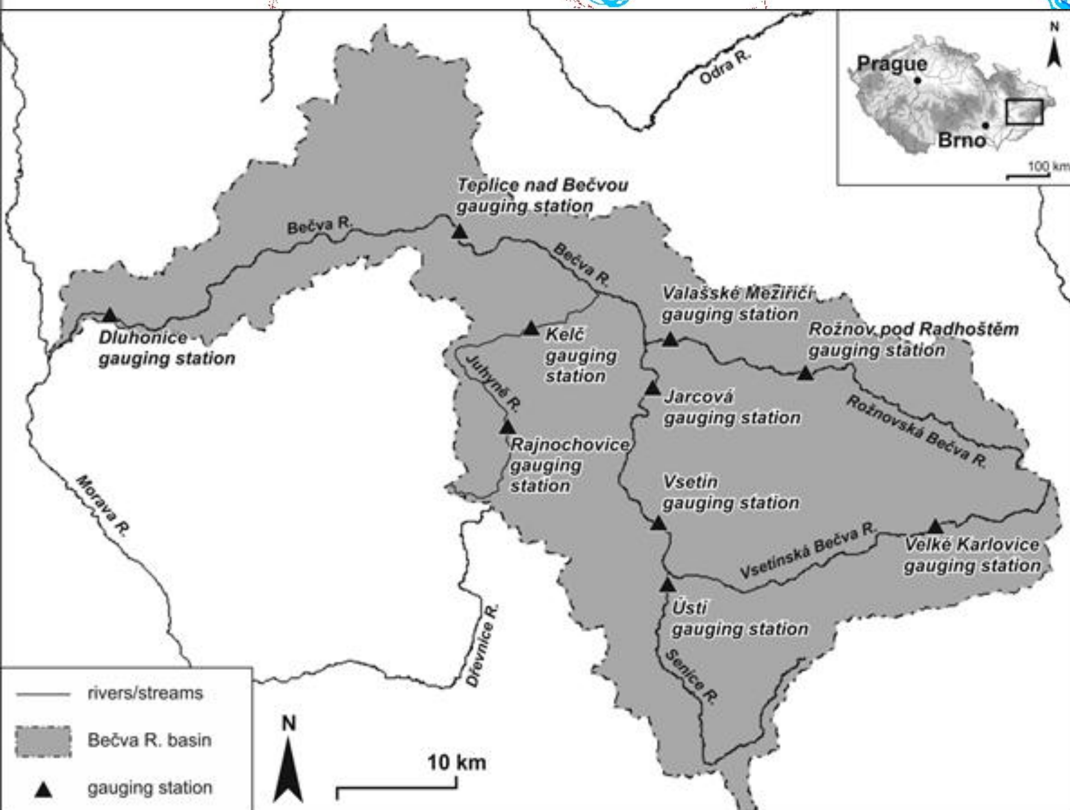
- single-threat, partially anabranching
- channel incision

Topľa River

- sinuous gravel-bed
- lateral migration

BEČVA RIVER – CZECH REPUBLIC

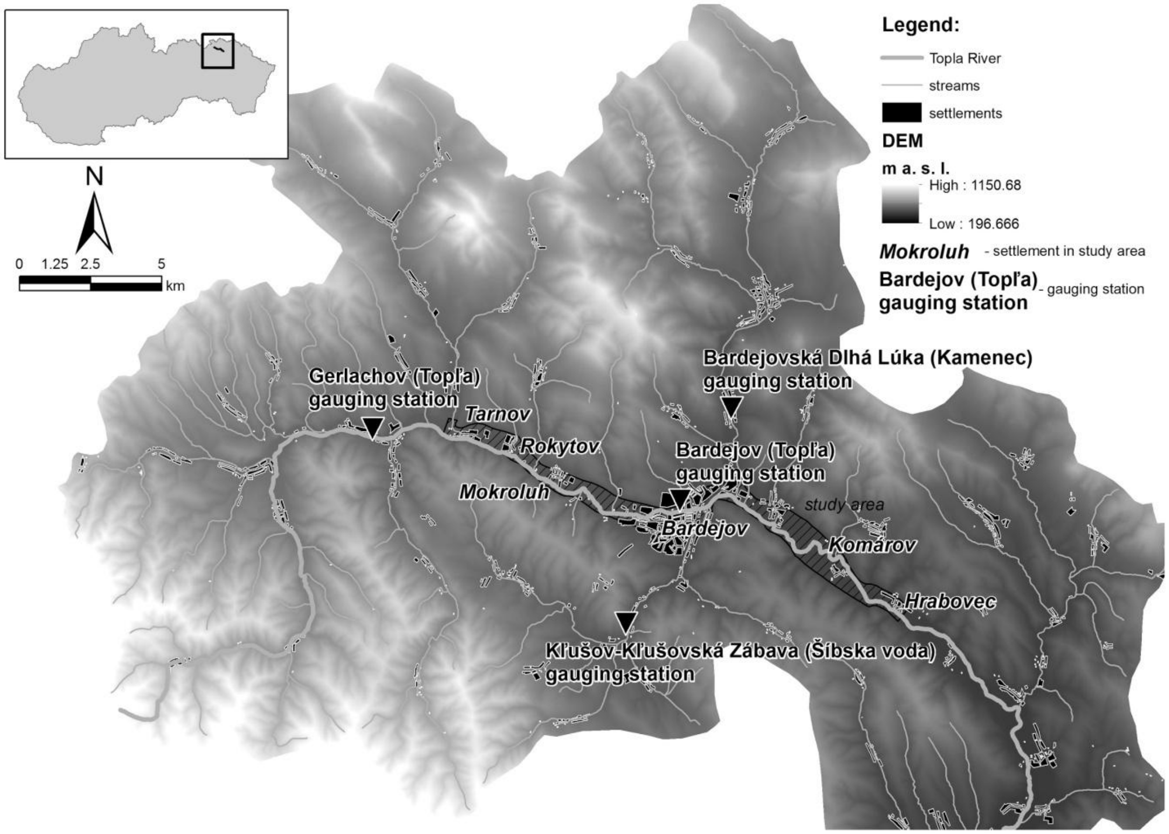




- lenght 23,5 km
- between Hranice and Valašské Medziríčí
- discharge at Valašské Medziríčí gaug. stat. : 3,79 $m^3.s^{-1}$

TOPĽA RIVER - SLOVAKIA

- lenght 21,5 km
- between Tarnov and Hrabovec
- discharge in gauging station Bardejov: 3,018 $m^3.s^{-1}$



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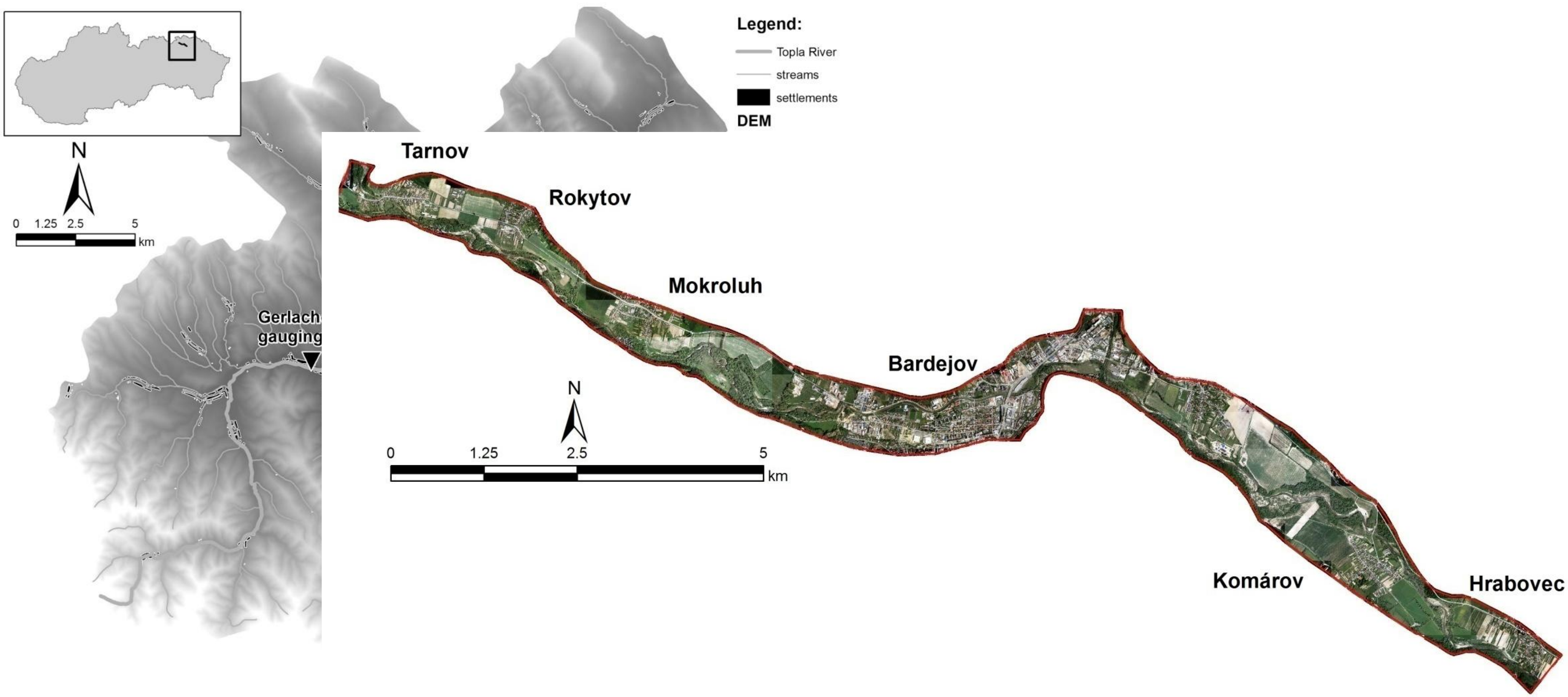
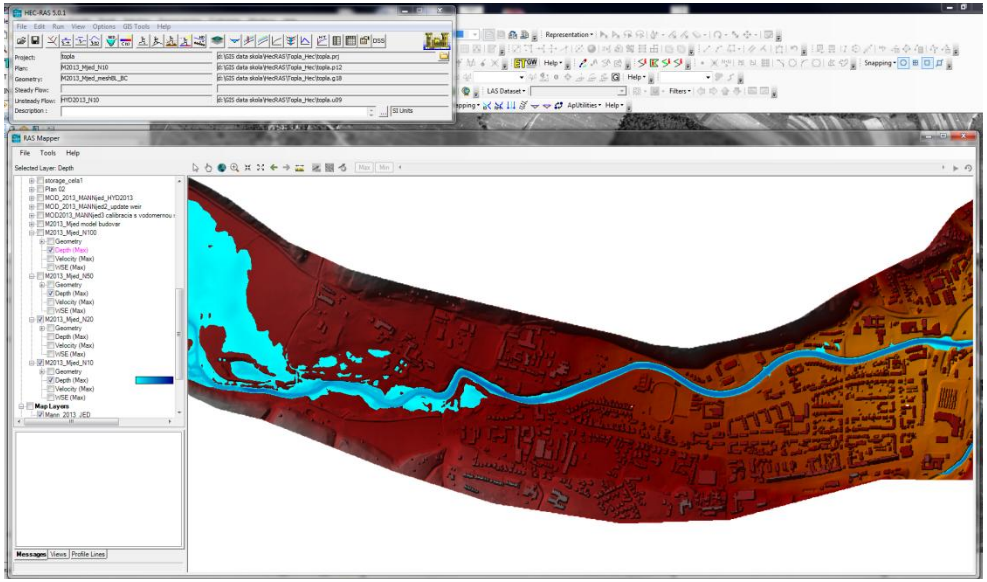


METHODS

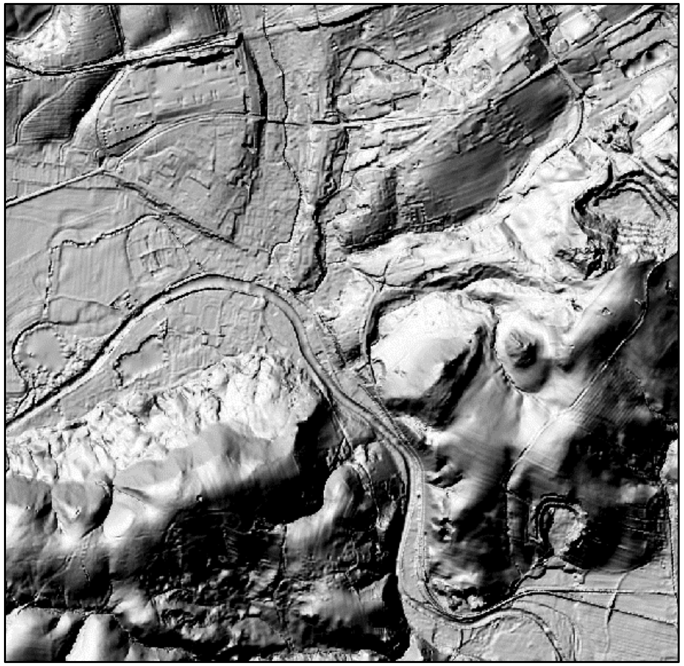
- preparation of source data and field work
- hydraulic modelling
- model calibration and validation
- simulation of discharges
- results interpretation for Bečva and Topľa Rivers



SOURCE DATA

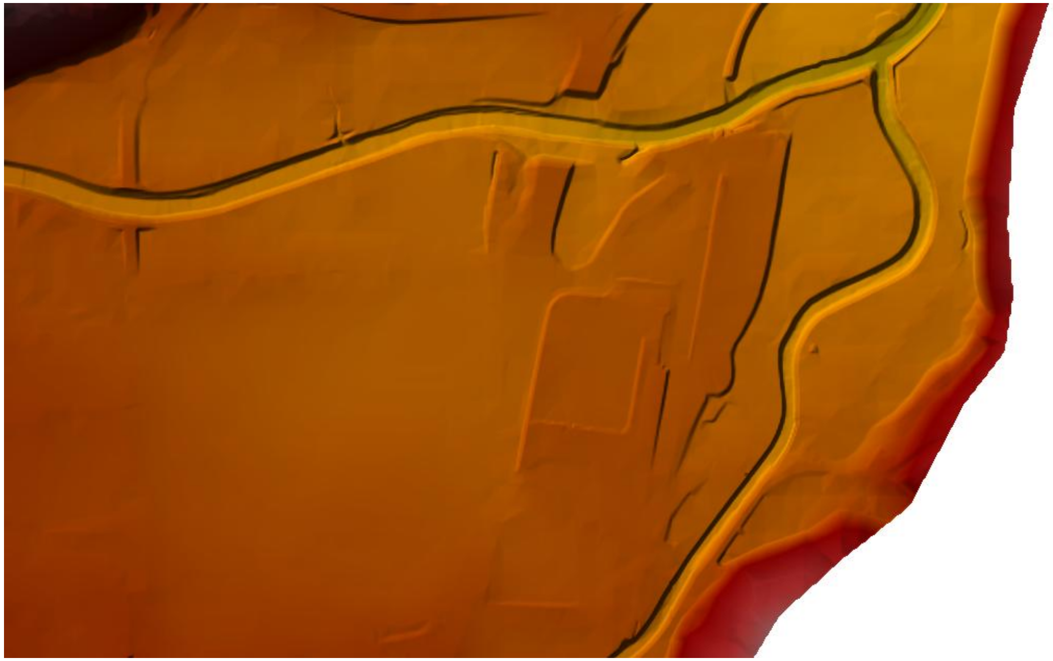
- Digital terrain model (2013)

DTM 4G (CUZK) – 5 x 5 m



Bečva River

photogrametric DTM (TIN, 10 cm)



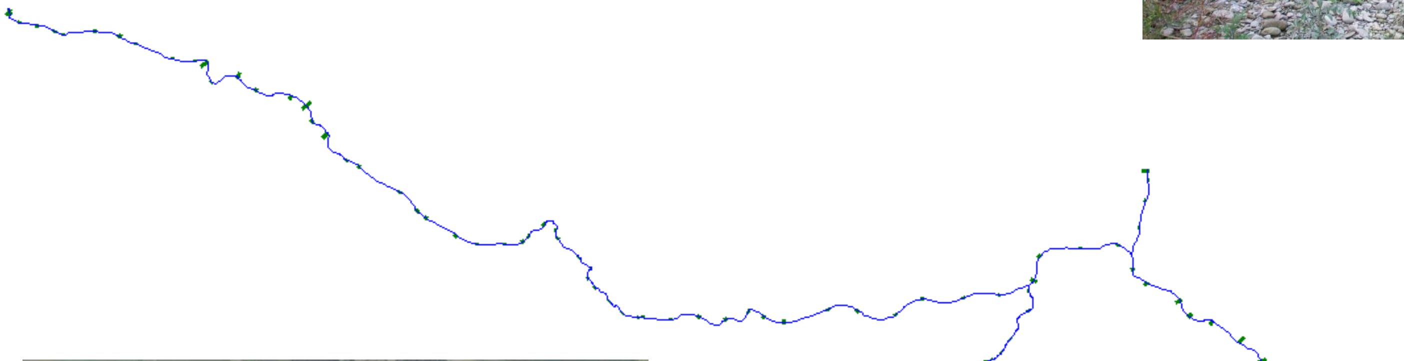
Topľa River

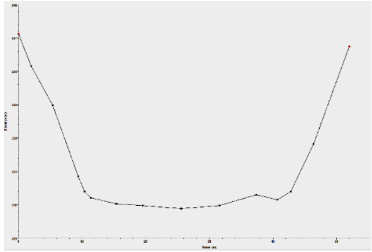
SOURCE DATA

- Digital terrain model (2013)

+ **cross-sections**

(52 for Bečva, 95 for Topľa)



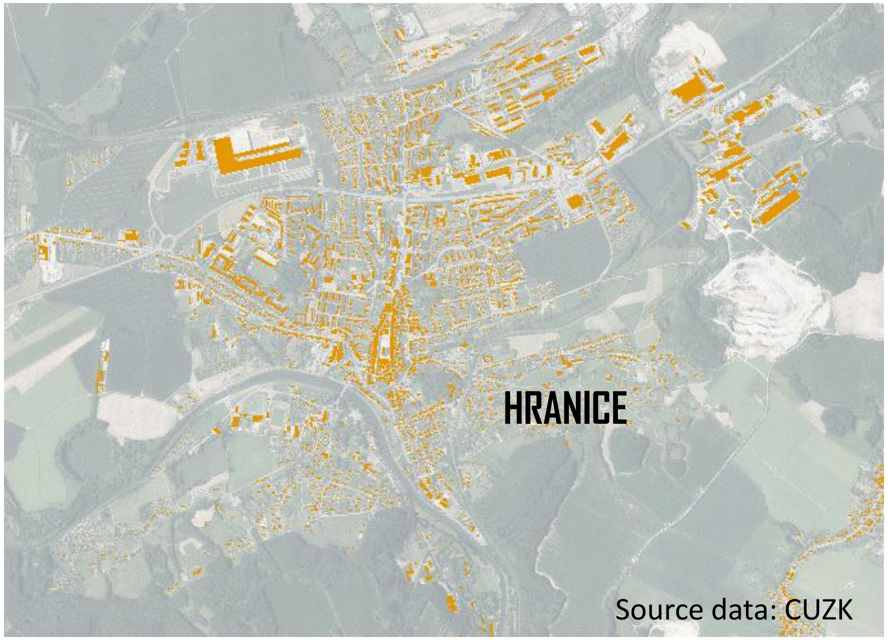


SOURCE DATA

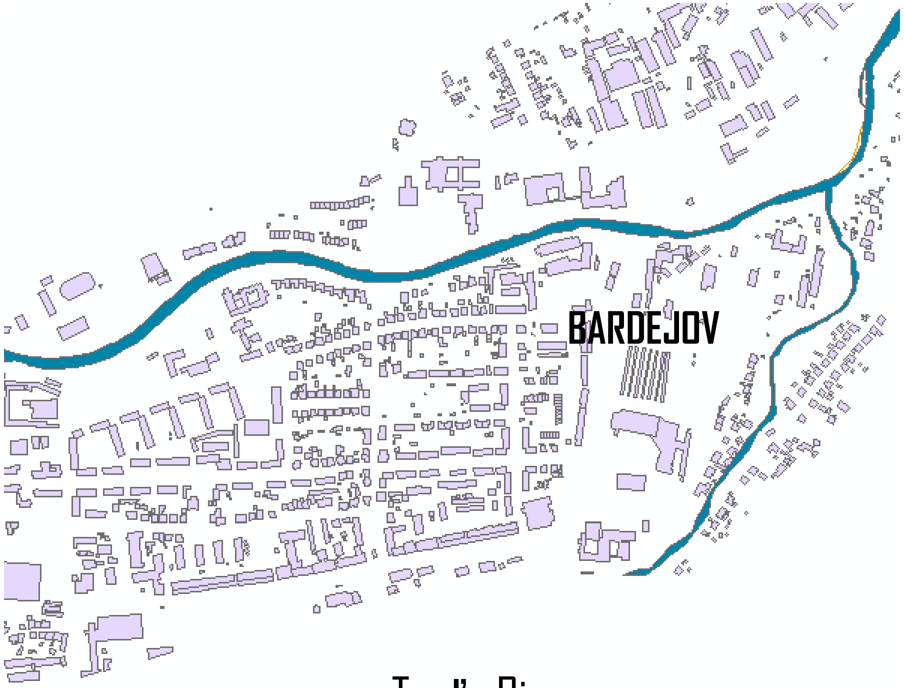
- Digital terrain model (2013)

+ cross-sections

+ polygon layer buildings



Bečva River

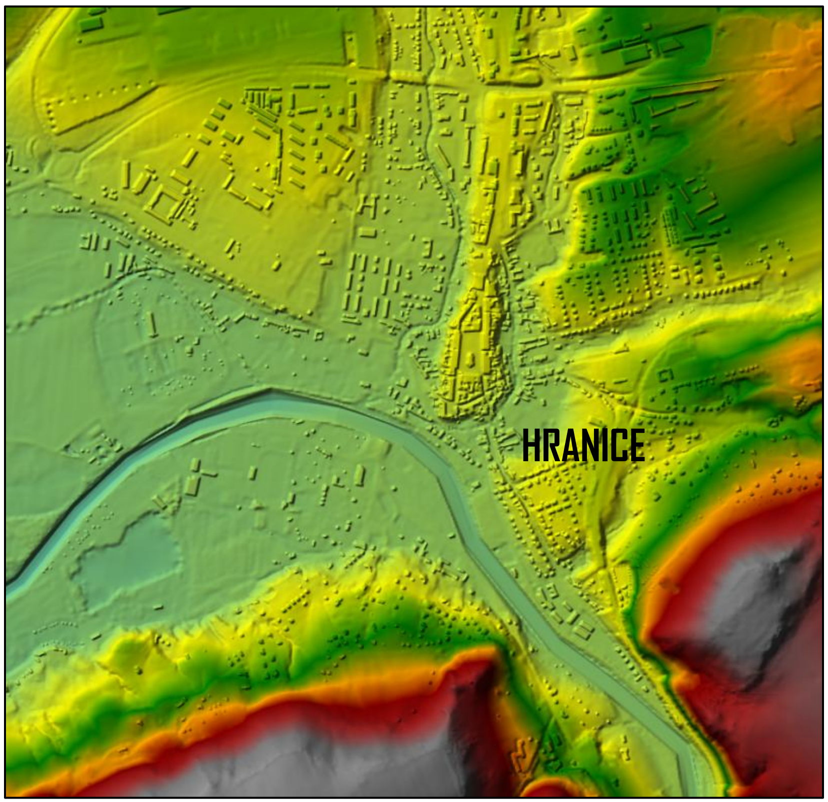


Topľa River

SOURCE DATA

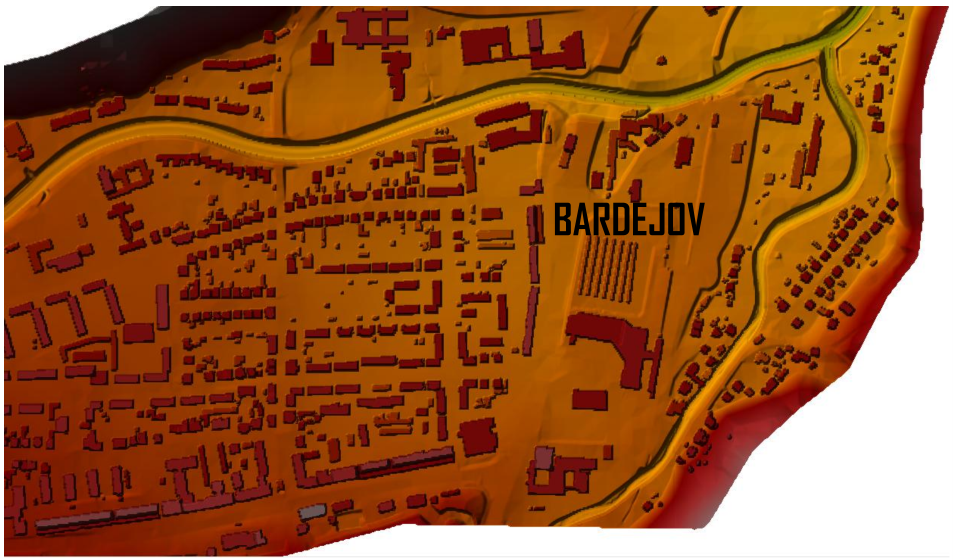
DTM + CSs + buildings = final DTM

Bečva River



DTM 4G (1 x 1 m)

Topľa River



DTM (0.5 x 0.5 m)

SOURCE DATA

+ hydrological data - BEČVA

Flood in 1997

Source: www.hranicky.denik.cz

Flood in 2010

Source: www.mesto-hranice.cz

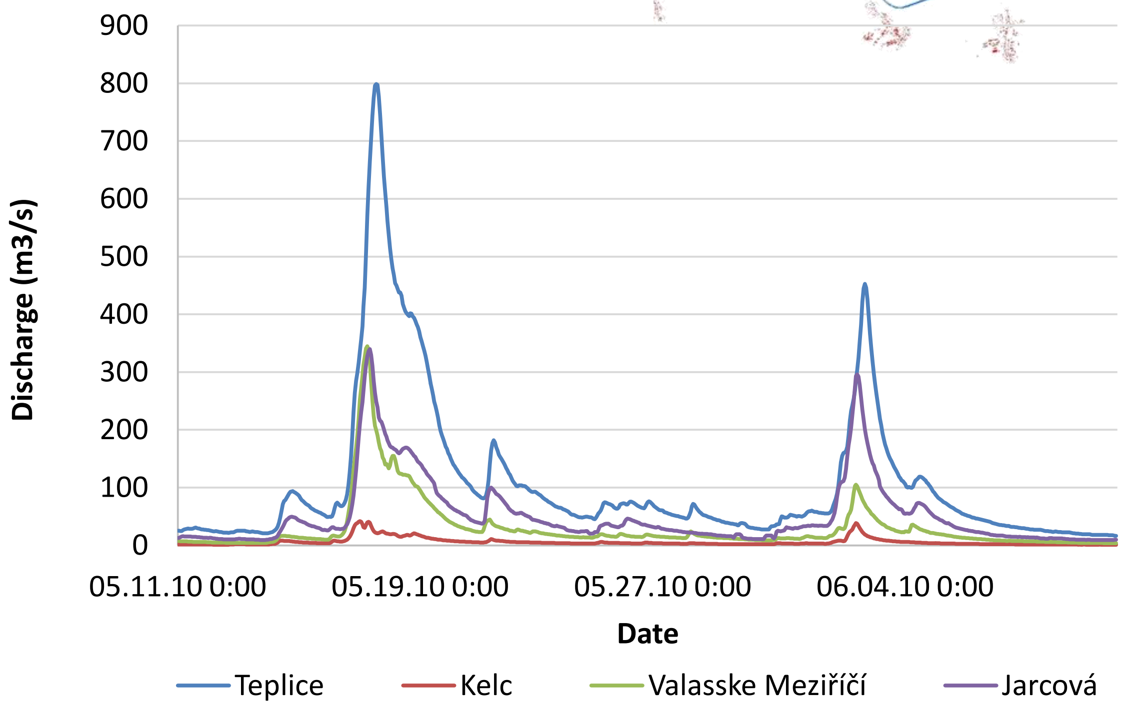
- Vsetínská Bečva: Jarcová (1)
- Rožnovská Bečva: Valašské Meziříčí (2)
- Kelč (3), Teplice (4)

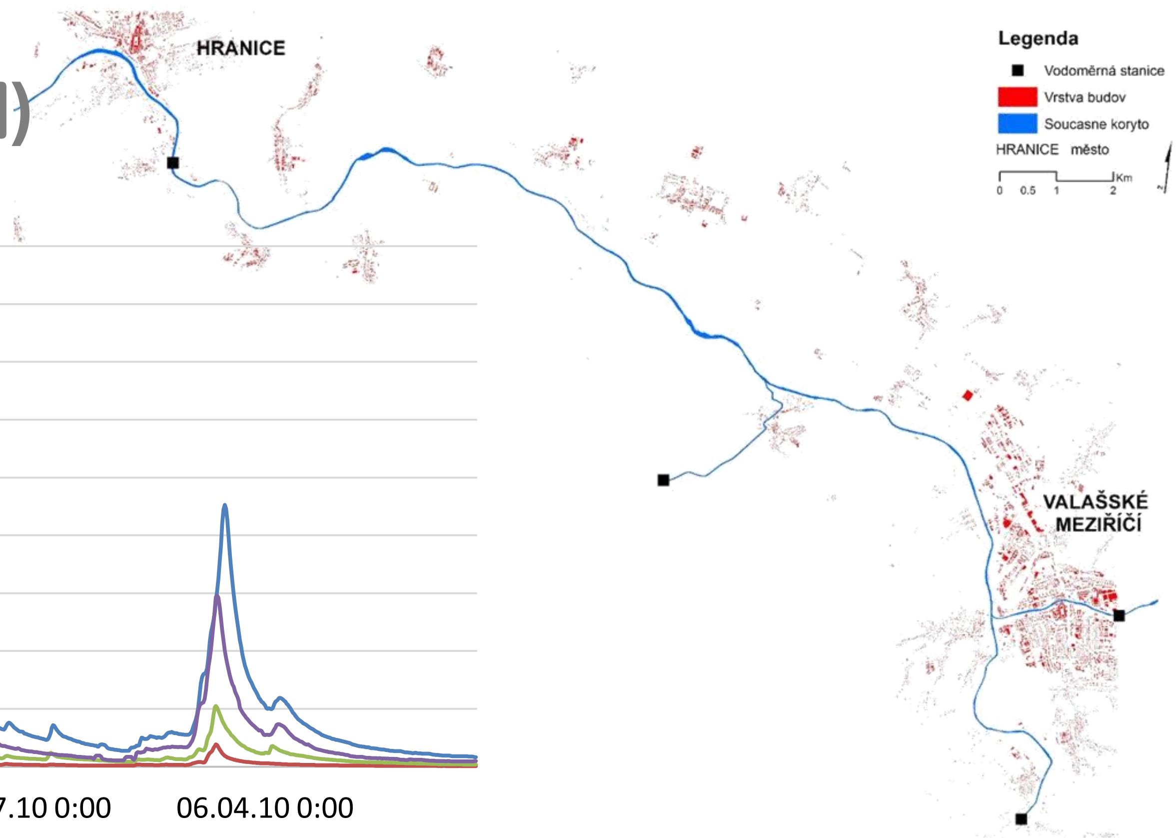
SOURCE DATA

+ hydrological data - BEČVA

flood in 2010

(11.5. 00:00 - 10.6. 23:00)



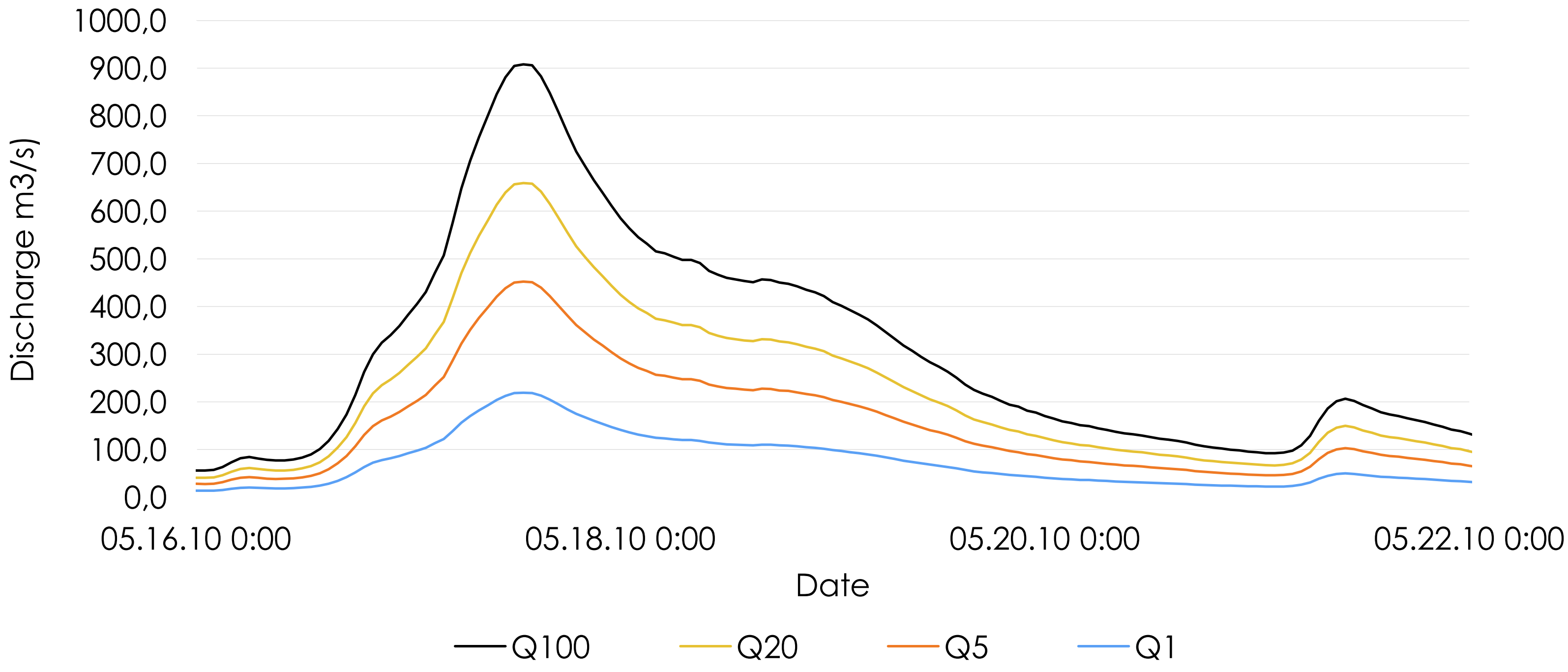


SOURCE DATA

+ hydrological data – BEČVA

RI from Teplice gauging station

N - letost	100	20	5	1
Hodnota průtoku (m³/s)	908	659	452	219

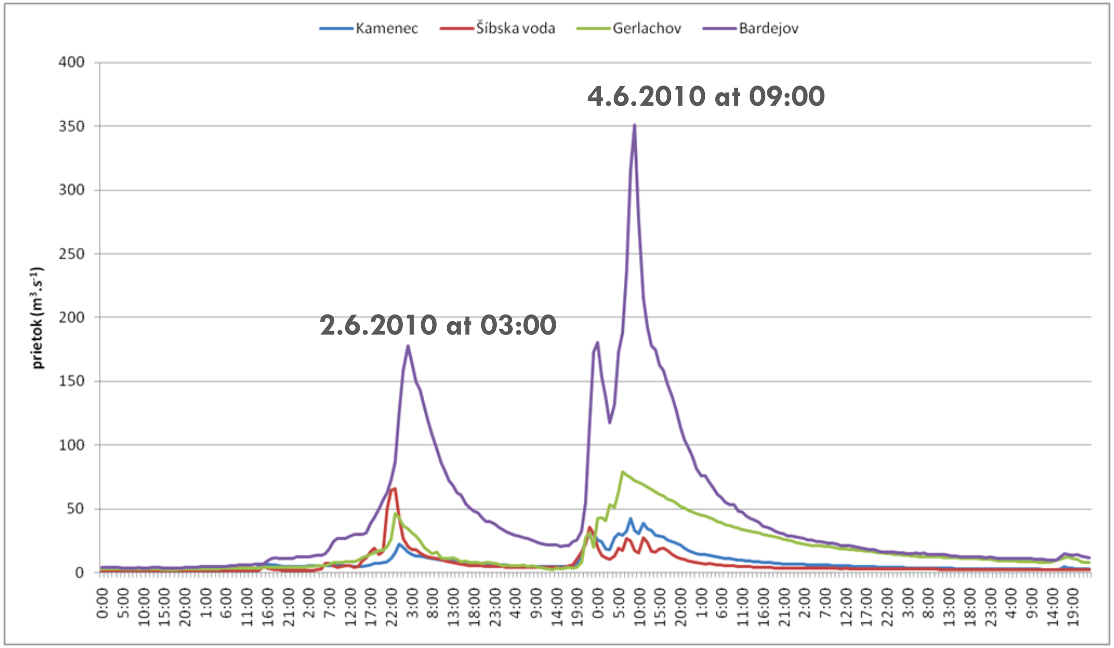


SOURCE DATA

+ **hydrological data - TOPĽA**

flood in 2010 **(30.5. 00:00 - 8.6. 23:00)**

- Topľa: Gerlachov (1), Bardejov (2)
- Kamenec: Bardejovská Dlhá Lúka (3)
- Šíbska Voda: Kľušov-Kľušovská Zábava (4)

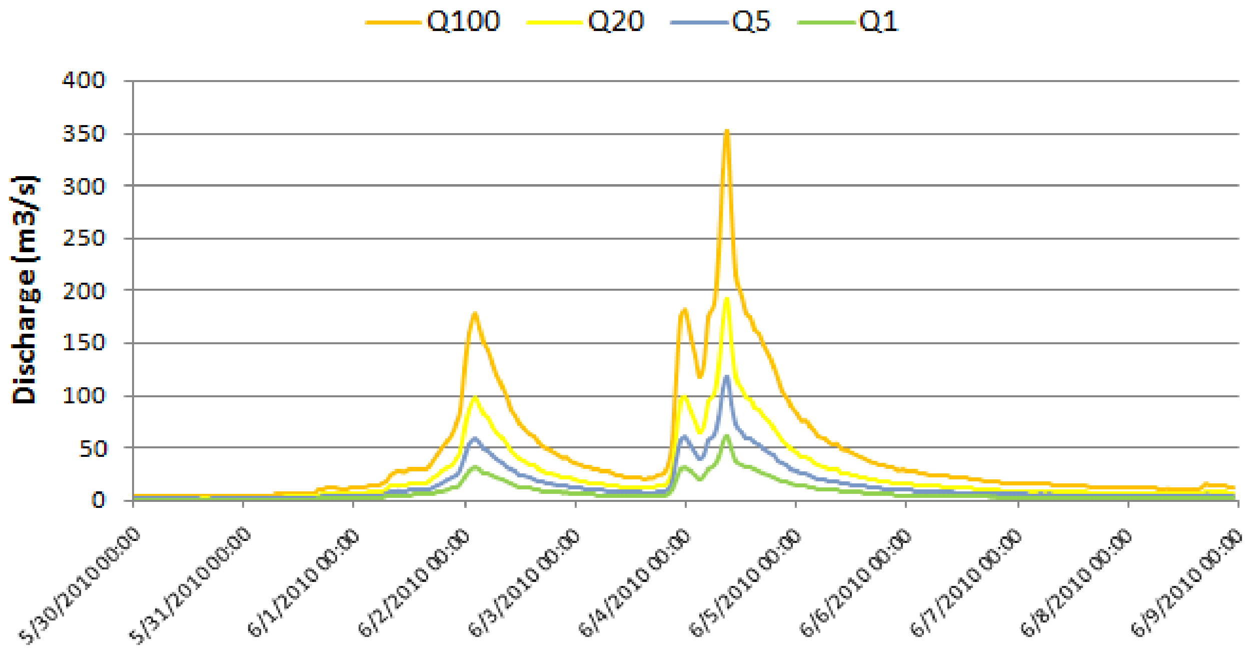


SOURCE DATA

+ hydrological data - TOPĽA

RI from Bardejov gauging station

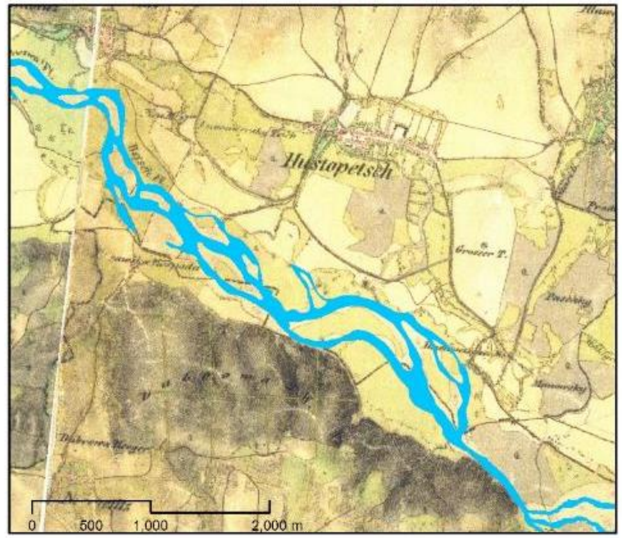
	Q100	Q50	Q20	Q10
prietok	330	260	180	140

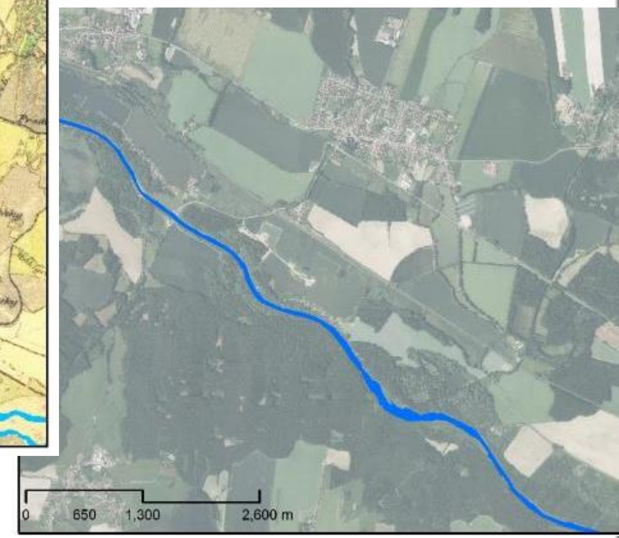


SOURCE DATA

+ historical scenario

Bečva – 2nd military survey
(1836-1852)

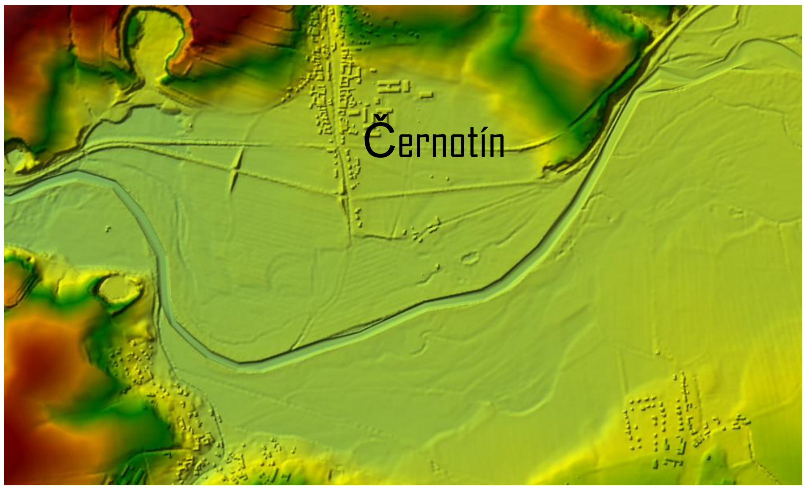
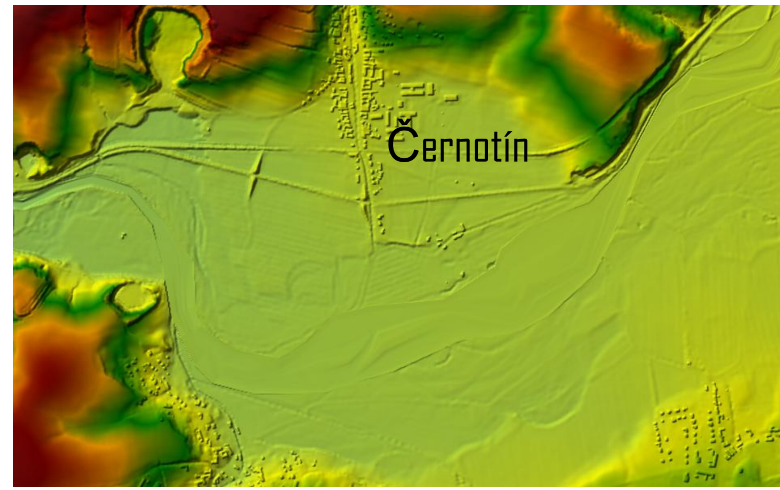
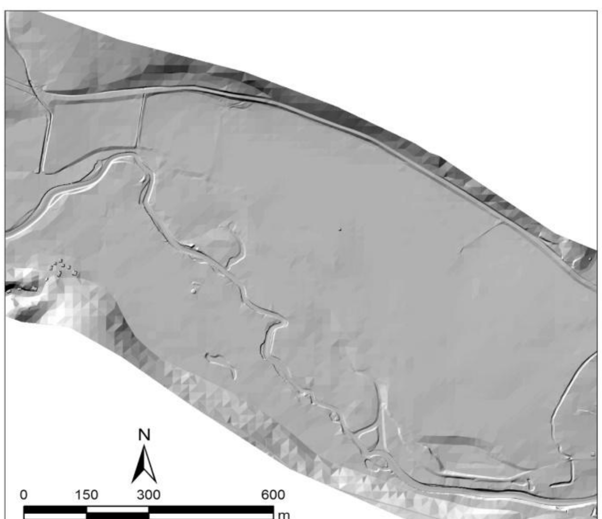
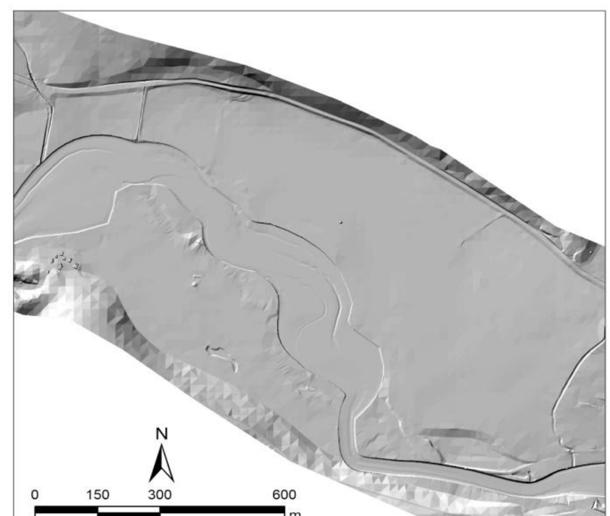




Topľa – aerial photographs
(1949)

- historical channel model
(cross-sections modification)

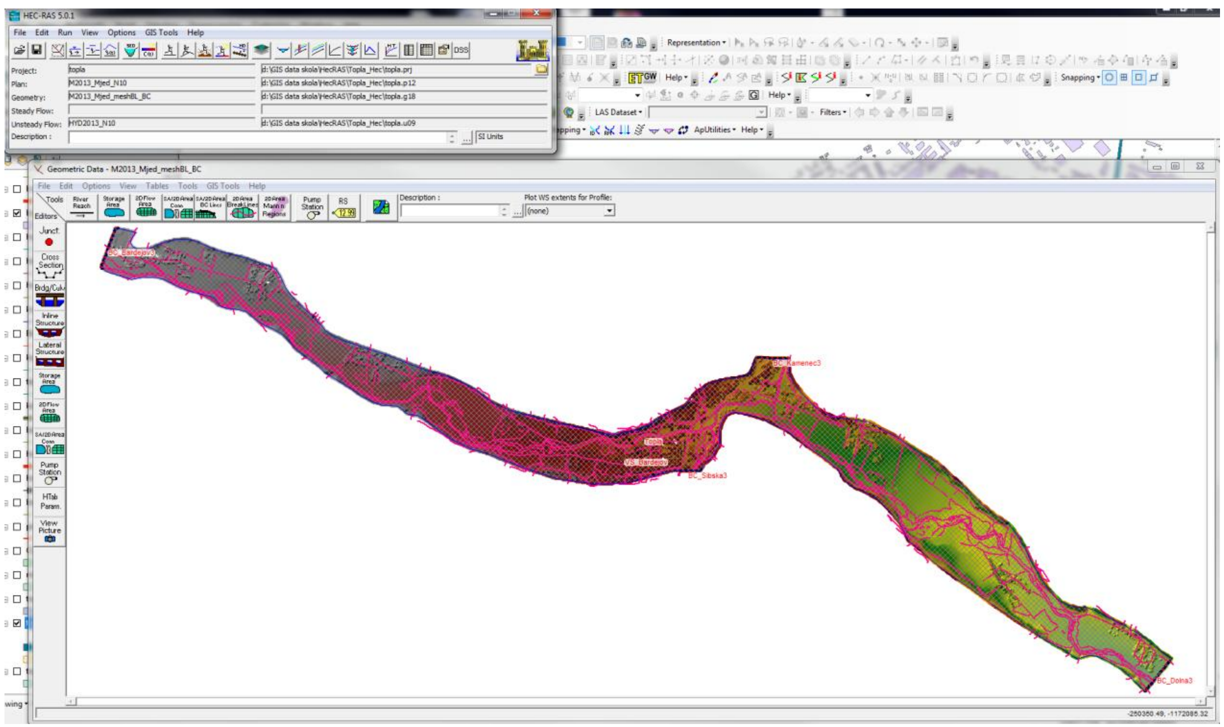
SOURCE DATA

	Recent state	Channel change
Bečva		
Topľa		

source data: EUROSENSE, s r. o.

HYDRAULIC MODELLING

- 2D hydraulic modelling **HEC-RAS** with two different DTM
- creating of the cell network - MESH (cc 110 000 cells)
- schematic channel objects (bridges)

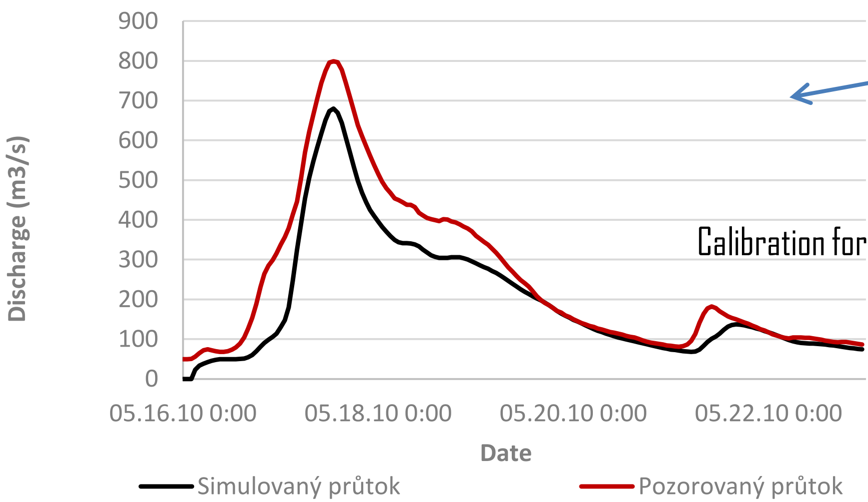


MODEL CALIBRATION

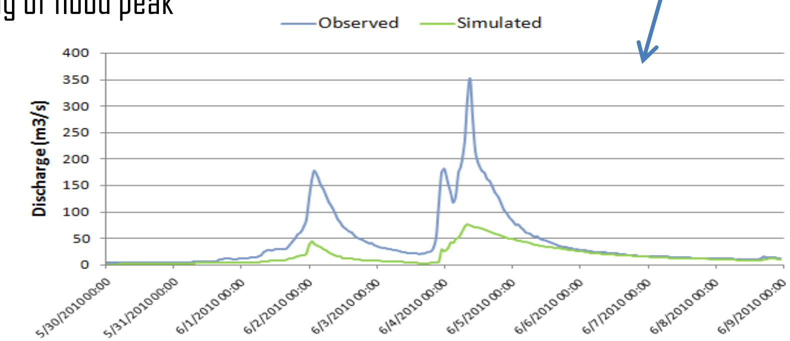
- based on **Manning coeficients** (channel: 0.035, floodplain: 0.06)

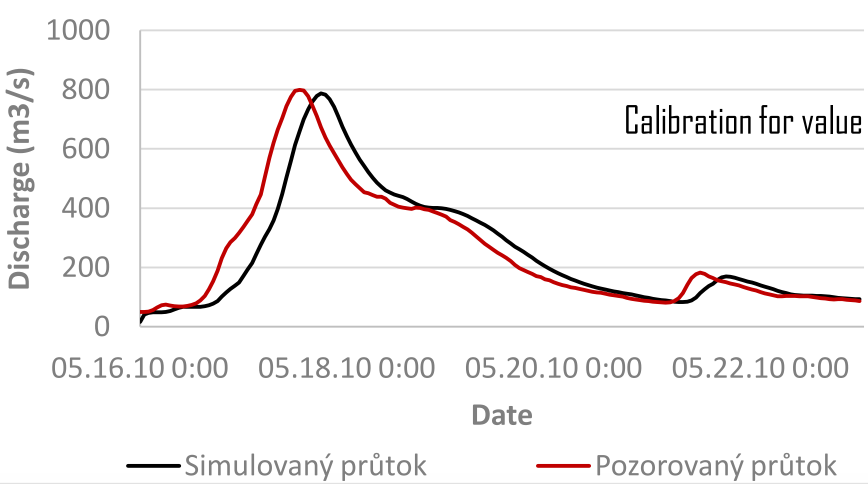
Teplice Gauging station - **Bečva**

Bardejov gauging station - **Topľa**

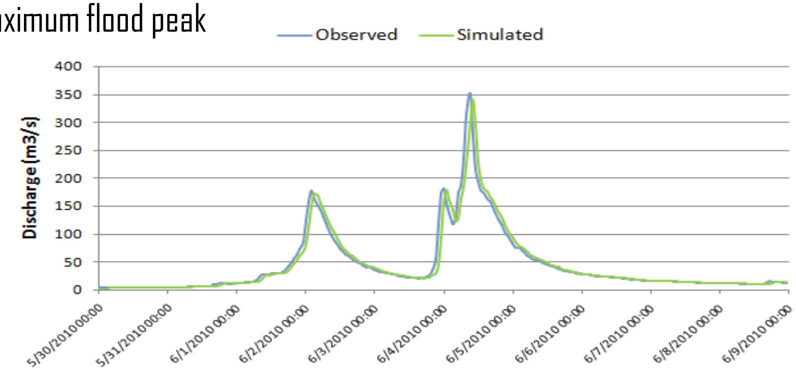


Calibration for timing of flood peak



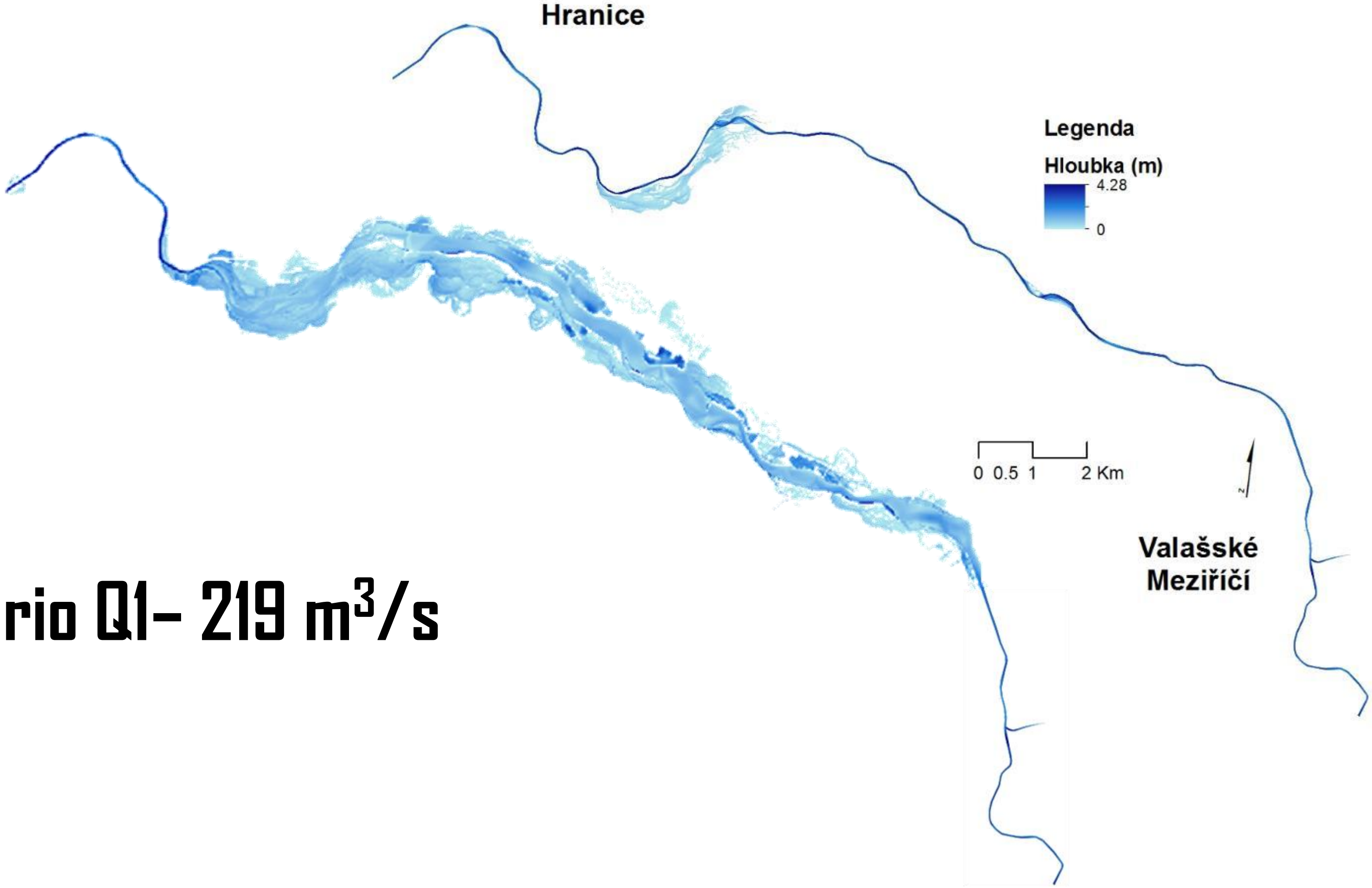


Calibration for value of maximum flood peak



RESULTS

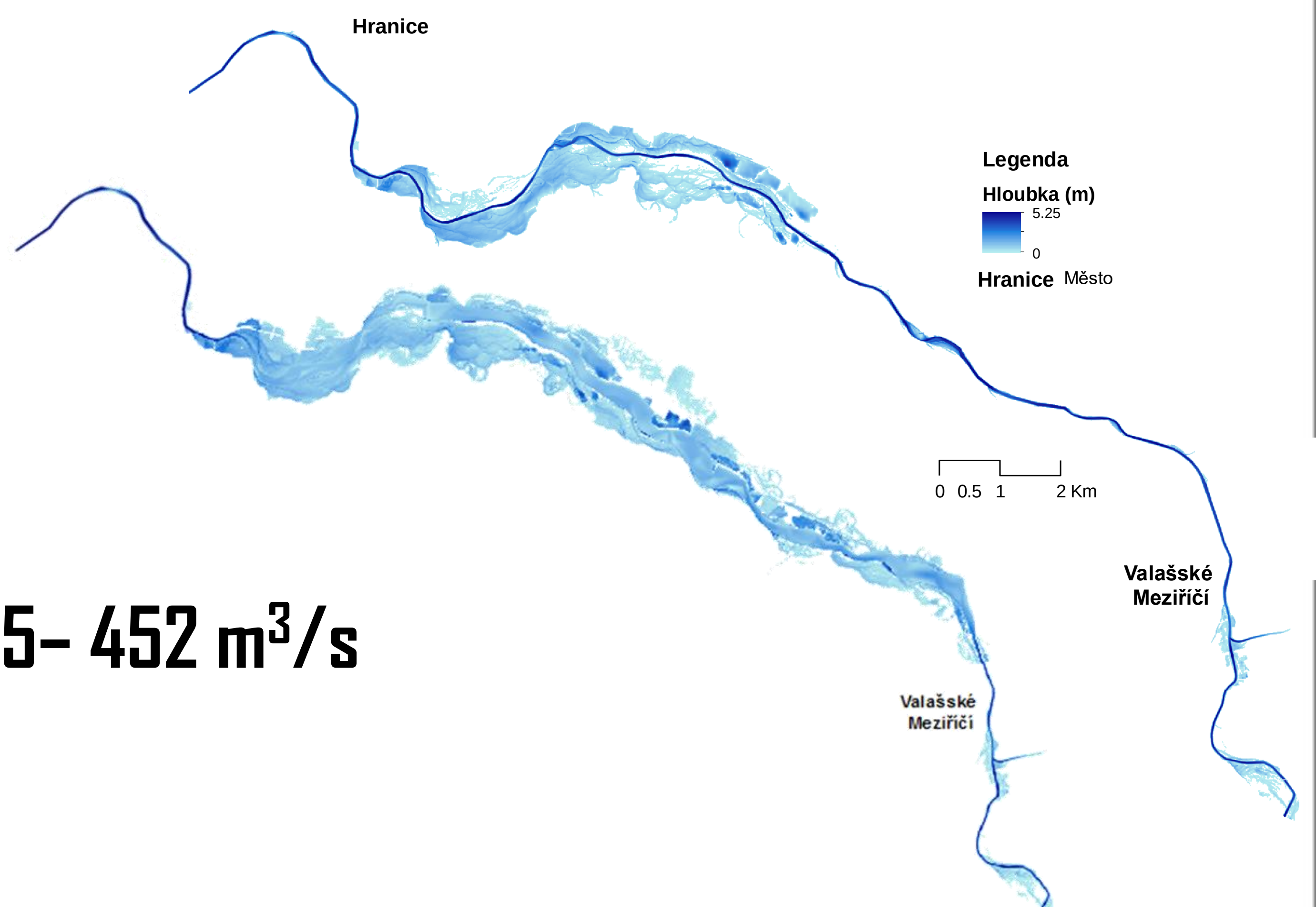
- model of inundation area - **Bečva**



scenario Q1– 219 m^3/s

RESULTS

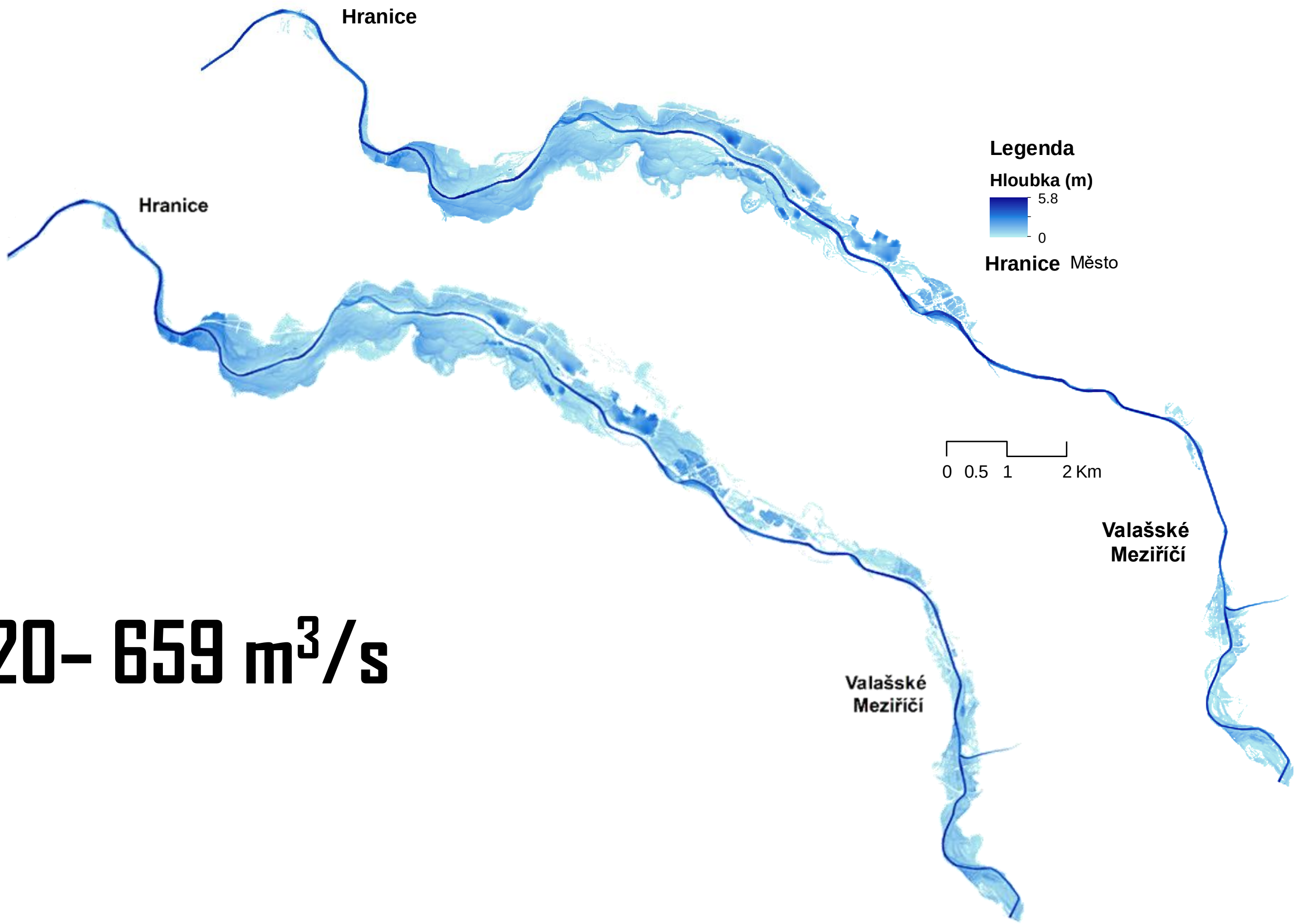
- model of inundation area - **Bečva**



scenario Q5– 452 m^3/s

RESULTS

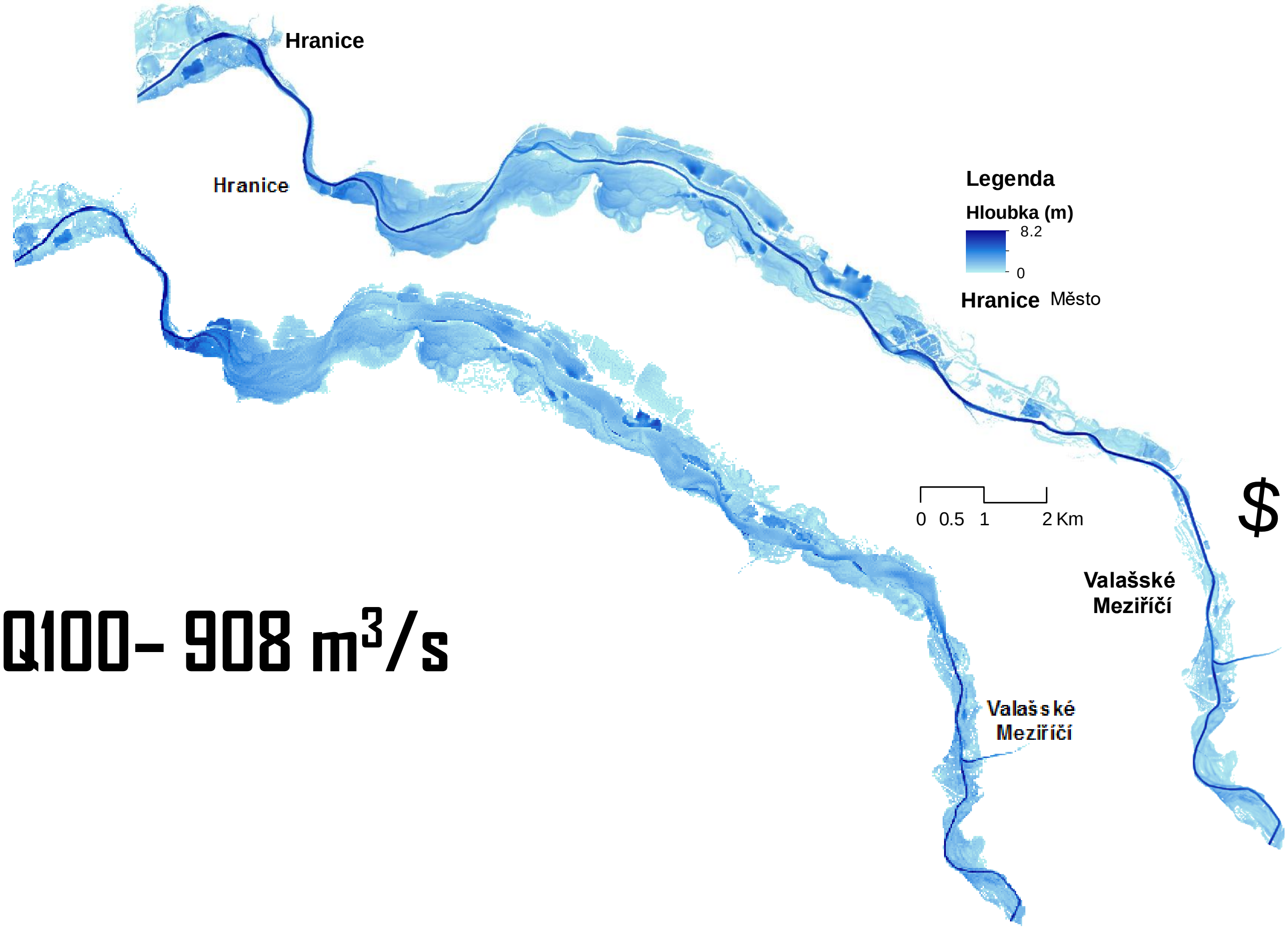
- model of inundation area - **Bečva**



scenario Q20– 659 m^3/s

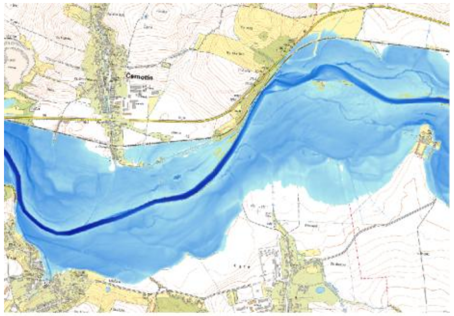
RESULTS

- model of inundation area - **Bečva**

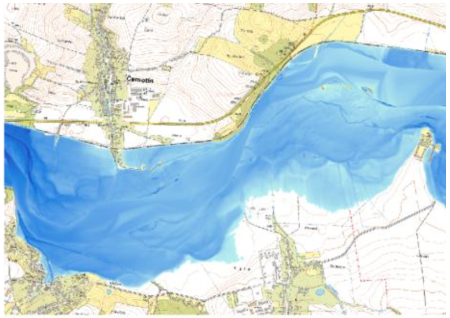


scenario Q100– 908 m^3/s

RESULTS



Source data: CUZK



Source data: CUZK

present (I.) vs. historical (II.) scenario

Bečva

N-year recurence interval discharge	Q_1		Q_5		Q_{20}		Q_{100}	
Scenario	I.	II.	I.	II.	I.	II.	I.	II.
Inundated Area (km^2)	2.45	10.63	6.56	13.43	10.63	14.33	15.59	20.38
Time of maximum peak flow	16:00	21:00	18:00	20:00	18:00	19:00	18:00	18:00
Maximum peak (m^3/s)	216	215	439	443	631	650	878	894

RESULTS

N-year recurrence interval discharge	Q_1		Q_5		Q_{20}		Q_{100}	
Scenario	I.	II.	I.	II.	I.	II.	I.	II.
Inundated area (km^2)	1.61	2.55	2.52	2.93	3.43	3.50	4.68	4.48
Time of maximum peak flow	12:00	12:00	12:00	12:00	12:00	12:00	12:00	11:00
Maximum peak (m^3/s)	116	113	163	165	231	230	378	383

Topľa

present (I.) vs. historical (II.) scenario

Bečva

N-year recurence interval discharge	Q_1		Q_5		Q_{20}		Q_{100}	
Scenario	I.	II.	I.	II.	I.	II.	I.	II.
Inundated Area (km^2)	2.45	10.63	6.56	13.43	10.63	14.33	15.59	20.38
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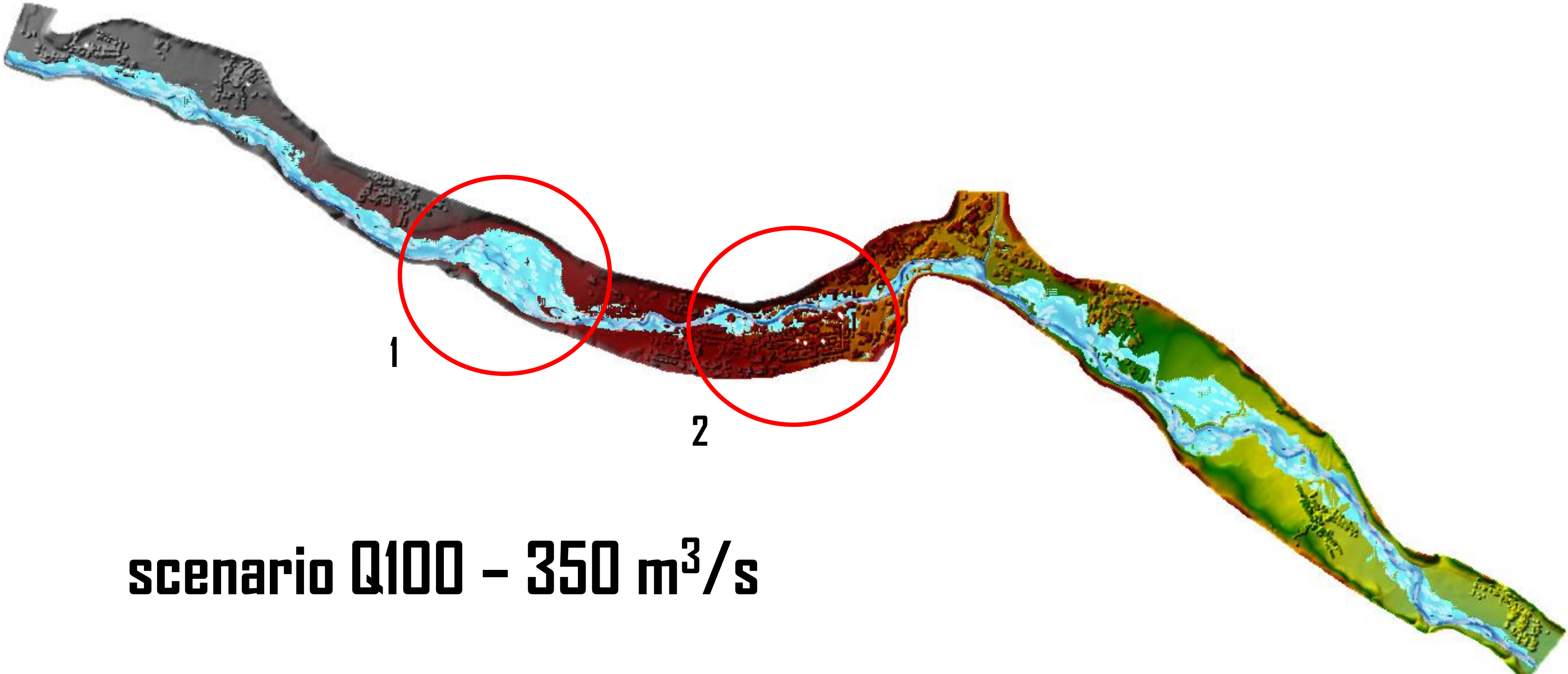
RESULTS

- model of inundation - **Topľa**

2013

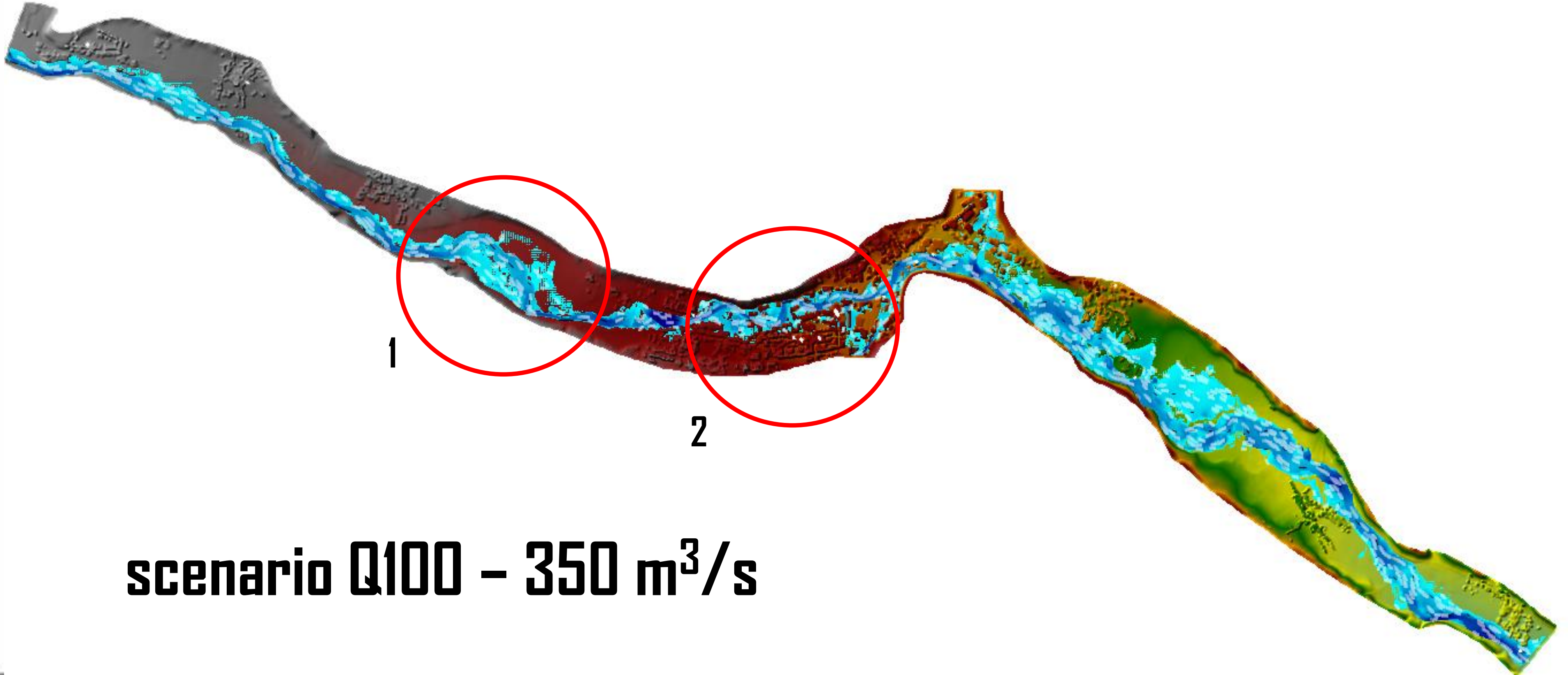


scenario Q100 – 350 m^3/s

RESULTS

- model of inundation - **Topľa**

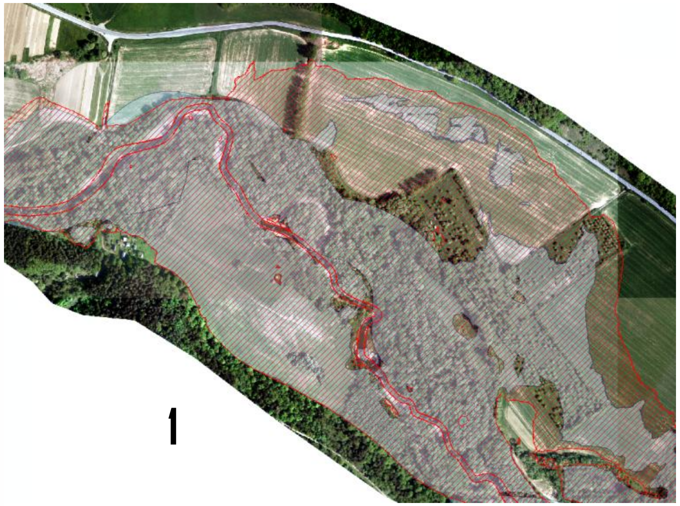
1949



scenario Q100 – 350 m^3/s

RESULTS

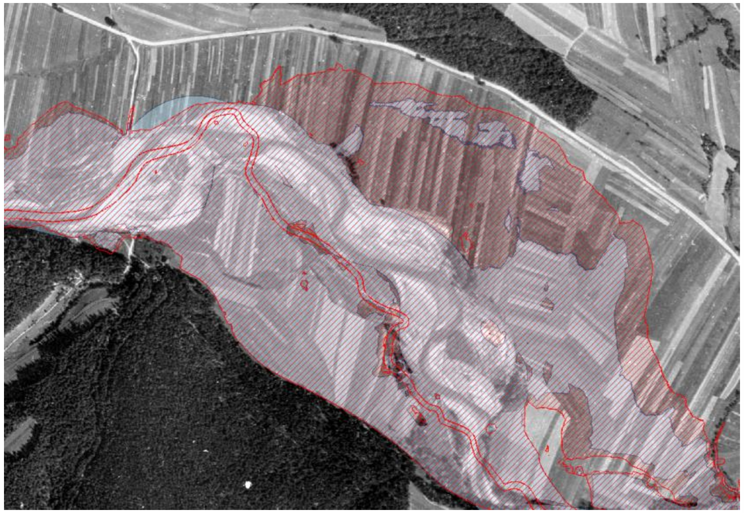
Topľa

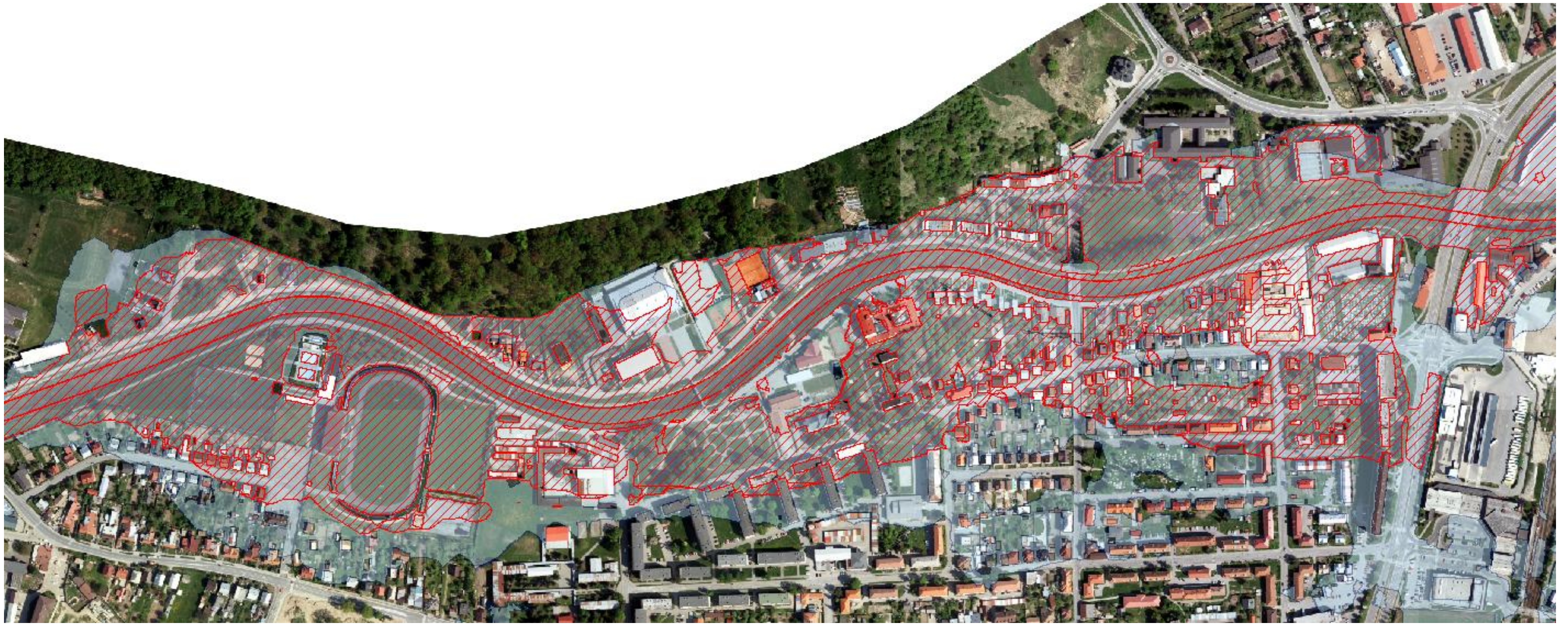


1

2013 red

1949 blue





2

CONCLUSIONS

- The project represents **the pilot study** estimating changes in flood risk by restoration of original river patterns and reconnection of floodplains to channels.

- **Original floodplains were probably not able to significantly transform high-magnitude floods.** Hydraulic simulations in studied river reaches show, that lowering of peak flood discharges by restoration of the original channel and increased flood inundation is important only for high-frequent low magnitude flows <Q5.

- **All flood inundations are more intensive in the case of historical scenarios for the Bečva River** when compared to present situation. On the other hand, **the Topľa River displayed different behaviour with larger inundated areas during present scenario and high-magnitude (>Q50) floods**; for smaller flood events the inundations were larger for historical scenarios.

CONCLUSIONS

- Obtained results are rather untypical for assumed flood wave transformations by floodplains in the European context. We hypothesize that high discharge variations in flysch-based watersheds connected with high water depths in **floodplains during large floods probably play important role in decreased ability of floodplains to lower and delay flood culminations.**

- Other benefits of floodplain inundations (increased biodiversity and water quality in watercourses and preservation of groundwater supply).

- Understanding channel morphology changes and its effect on floods **is important for flood risk management** what help us to find the strategy to mitigate the floods for the future.

DANUBE REGION strategy START Danube Region Project Fund

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INSTITUTE OF GEOGRAPHY SAS

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