

Lot 1: Hydraulic and morphological modelling of the SRB-CRO common stretch of the Danube River

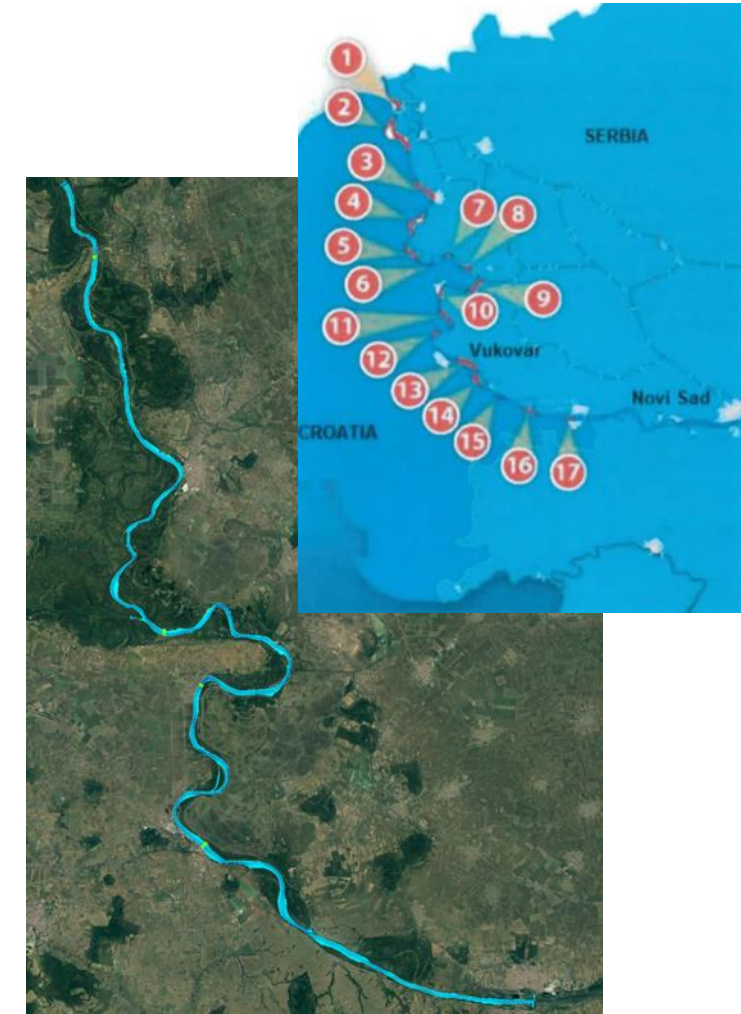
Multi-criteria analysis and 2D hydraulic modelling

Stakeholders' Forum Meeting 11 (SFHM 11)

20/11/2024






Table of Contents

- Multi-criteria analysis
 - MCA definition
- 2D Hydraulic Modelling
 - Proposed model
 - Calibration data
 - Scenarios



A3: MCA Definition

Methodology

- Mathematical formulation 
- Criteria 
- Sub-criteria 
- Indicators -> Scoring 
- Weighting coefficients 

$$Total\ score = N_1^{0.20} \cdot N_2^{0.10} \cdot N_3^{0.10} \cdot E_1^{0.10} \cdot E_2^{0.05} \cdot E_3^{0.05} \cdot E_4^{0.10} \cdot E_5^{0.05} \cdot E_6^{0.05} \cdot F_1^{0.05} \cdot F_2^{0.15}$$

Code	Criteria
N ₁	DC requirements
N ₂	Maneuverability
N ₃	Safety (can deteriorate)

Code	Criteria
E ₁	Hydro-morphology
E ₂	Sediment and water quality
E ₃	Bird population
E ₄	Fish population
E ₅	Flora
E ₆	Climate change vulnerability

Code	Criteria
F ₁	Technical aspects
F ₂	Financial aspects

Indicators -> Scoring

- Qualitative and quantitative indicators
- Expert judgment based scoring
- Limitations
- Scoring (+/-)
 - Erosion/Deposition (downstream effects -> scale of the project)
 - Periodic flooding/Flood protection (project scope?)

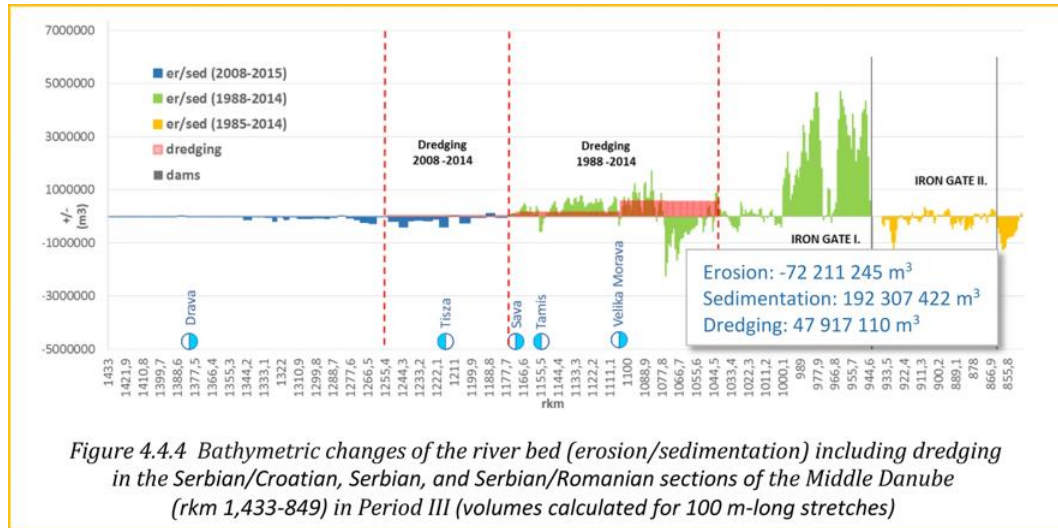


Figure 4.4.4 Bathymetric changes of the river bed (erosion/sedimentation) including dredging in the Serbian/Croatian, Serbian, and Serbian/Romanian sections of the Middle Danube (rkm 1,433-849) in Period III (volumes calculated for 100 m-long stretches)

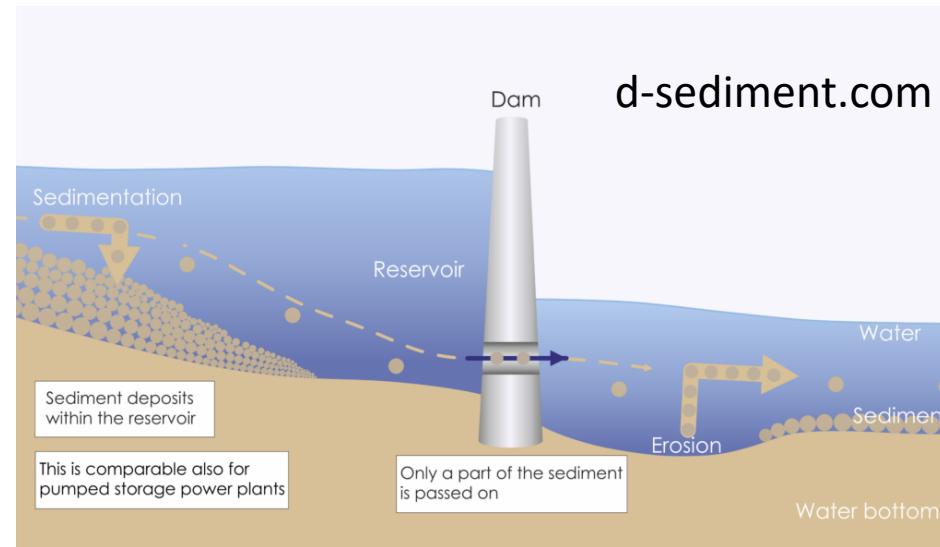
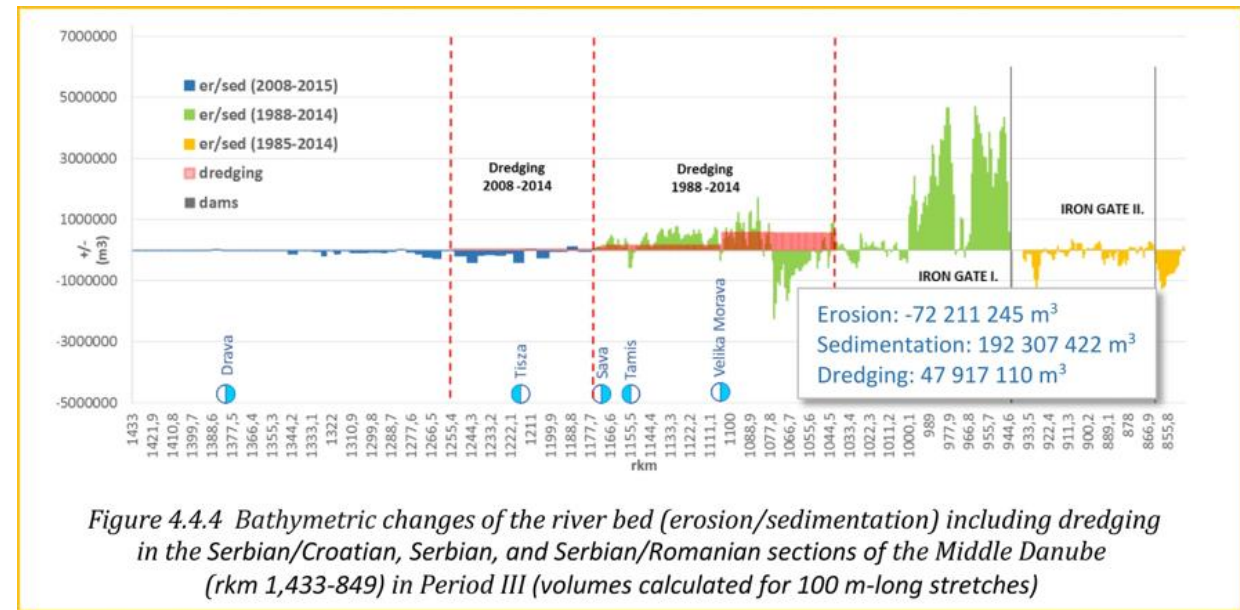
Environment group of criteria

Scenario / Indicators - Subcriteria	"Do-nothing" (Reference values/state)	Groyne system on convex side of the bend (Indicators -> Score)	Fairway realignment (Explanation -> Score)
River bed volume	ref. value: $V = -88500 \text{ m}^3$	diff. = -7000 m^3 ($V = -95500 \text{ m}^3$)	diff. = 0 ($V = -88500 \text{ m}^3$)
SHDi	ref. value: SHDi = 0.78	ratio = 0.96 (SHDi = 0.75) Negative impact on biodiversity (living organisms negatively affected)	ratio = 1.0 (SHDi = 0.78)
Length of LF channels ref. value/ratio	ref. value: $L_{lf} = 250 \text{ m}$	ratio = 0.84 ($L_{lf} = 210 \text{ m}$)	ratio = 1.0 ($L_{lf} = 250 \text{ m}$)
Z(Q _{bankfull})	ref. value: Z = 90.00 m.a.s.l.	diff. = 1 cm (Z = 90.01 m.a.s.l.)	diff. = 0 m (Z = 90.00 m.a.s.l.)
Lateral connectivity	ref. value: $V_b = 1.4 \text{ m/s}$	ratio = 0.64 ($V_b = 0.9 \text{ m/s}$) aquatic-terrestrial fluxes disturbed	ratio = 1.0 ($V_b = 1.4 \text{ m/s}$)
E ₁ - Hydro-morphology	1.0	0.25	1.0
Dredging volume	n.a.	n.a.	n.a.
Water quality parameters	n.a.	slightly negative effects since local stagnant water introduced	n.a.
E ₂ - Sediment and Water quality	1.0	0.5	1.0
Nesting	ref. state	no changes if groyne system is proposed along shallow banks/ negative effect for steep banks	no changes
wintering	ref. state	n.a.	no changes
E ₃ - Birds	1	1 / 0	1
Spawning	ref. state	n.a.	no changes
Migration	ref. state	n.a.	no changes
Growing	ref. state	sheltered	no changes
Living	ref. state	negative due to siltation	no changes
E ₄ - Fish	1.0	1.0	1.0
Creation of new areas for distribution	ref. state	no significant change	no changes
E ₅ - Flora	1.0	1.0	1.0
Climate change sensitivity	ref. state	moderate sensitivity	no changes regarding reference state
Climate change adaptivity	ref. state	moderate adaptivity	no changes regarding reference state
E ₆ - Climate change vulnerability	1.0	0.5	1.0

River bed volume

Integrated sediment management planning

- Integrating different use-related needs (Environmental and socio-economic aspects)
- Catchment -> **Local scale** (Deposition at one sector -> more erosion along downstream sector)



Lateral connectivity

- The domain of measures influence
- Main channel <--> Inundation (out of project scope)
- "Hydraulic" indicator related to mass exchange and conveyance
- Additional qualitative indicator

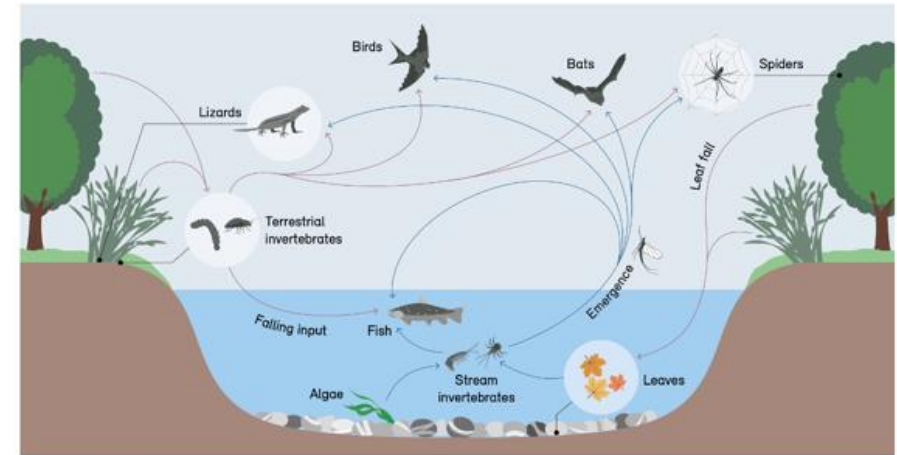


Figure 5: Illustration for aquatic-terrestrial fluxes (Baxter, Fausch and Saunders 2005)

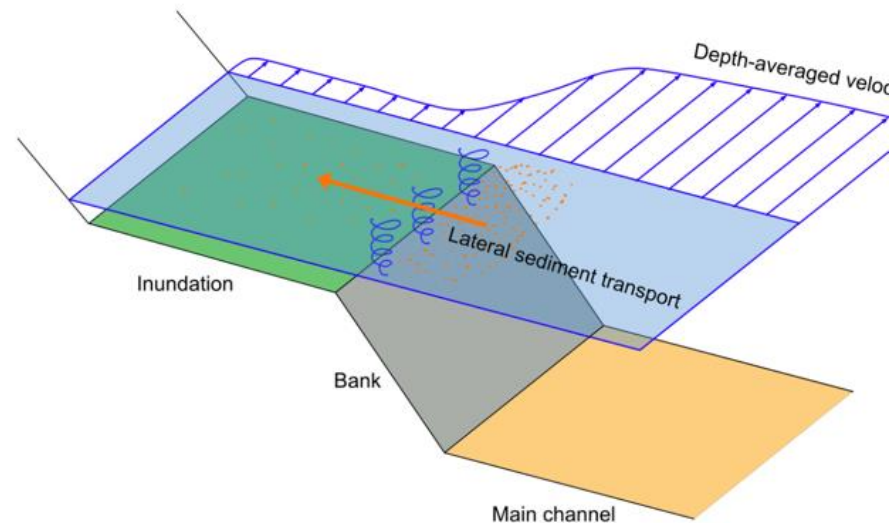


Figure 6: Lateral sediment exchange between main channel and inundation

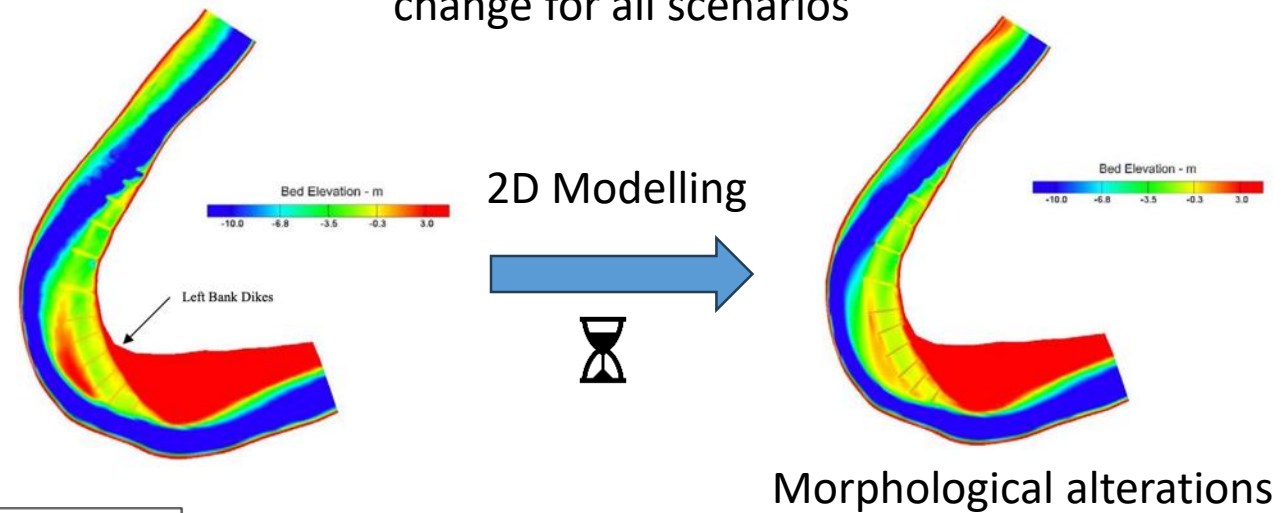
A4: 2D Hydrodynamic and Morphological Modelling

Purpose of the Modelling activity

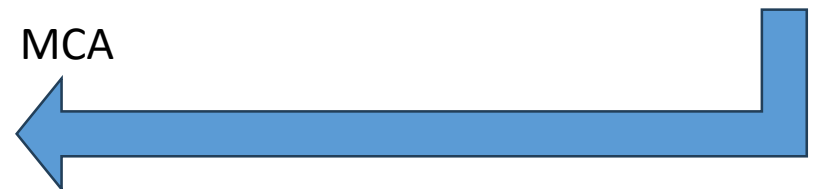
- Evaluation of solutions whose impact is considered over time (scenarios)
- „Do nothing” is base solution (zero alternative)
- 2D Sediment transport model for morphological changes prediction (effects of solutions compared)
- Expert judgment

Do nothing – scenario without measures (even operational or maintenance measures not included)

Numerical simulations of morphological change for all scenarios



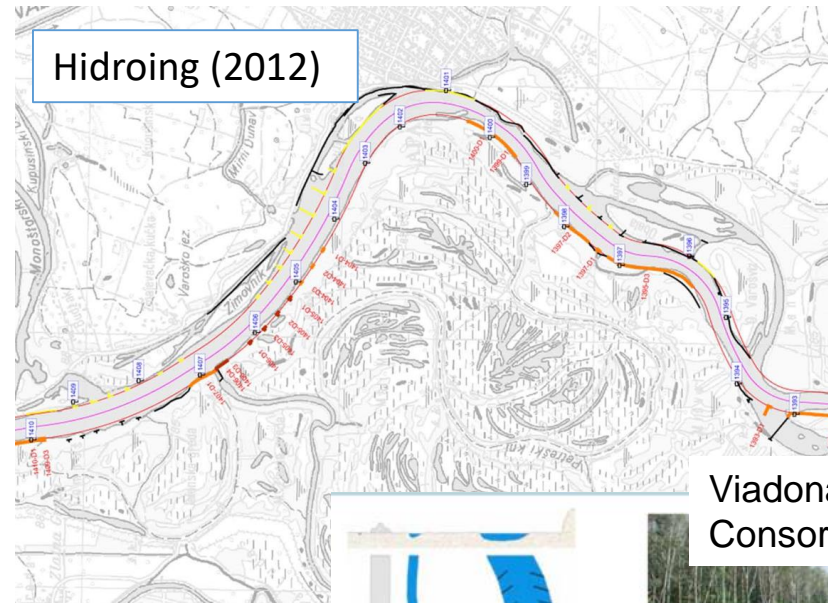
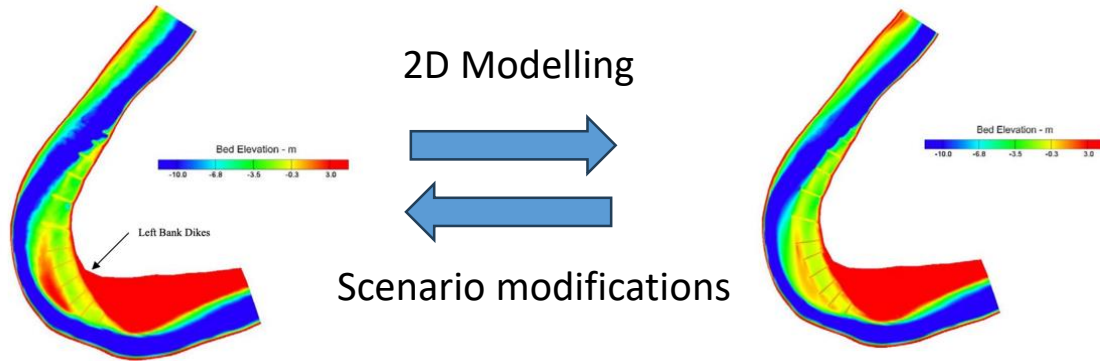
MCA



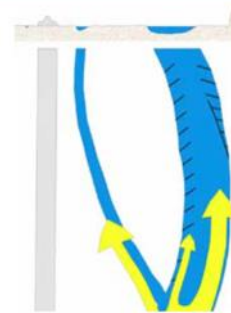
	Group score for navigation	Group score for environment	Group score for feasibility	Total Score
"Do nothing"	1.00	1.00	1.00	1.00
Groyne system	1.07	0.81	1.04	0.90
Fairway realignment	1.05	1.00	1.06	1.12

Scenarios

- Doing nothing
- Structural measures
- Non-structural measures
- Hybrid measures
- Scenario definition <-> Simulation results



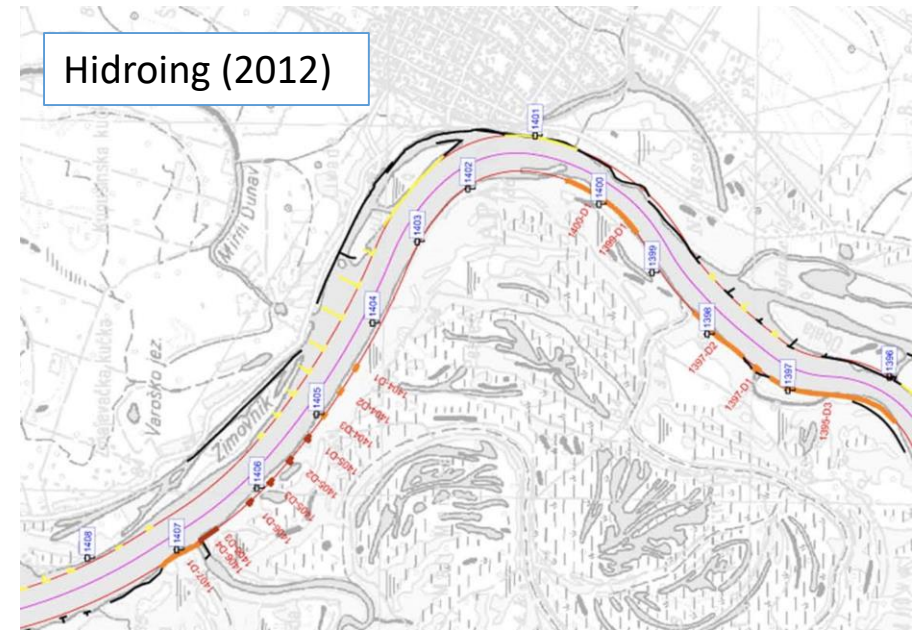
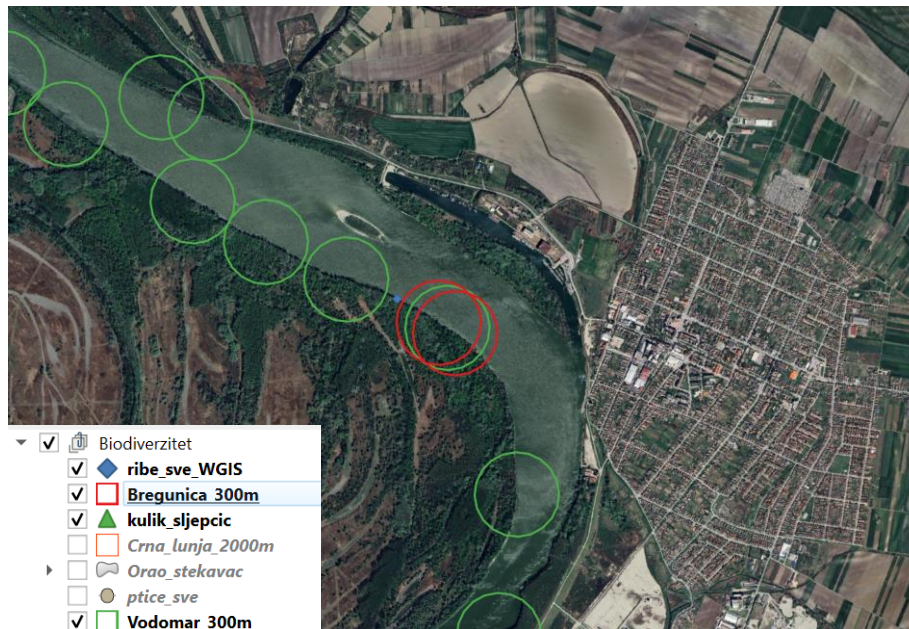
Viadonau & IREP Planning Consortium (2009)



By © Steffen Schmitz (Carschten) / Wikimedia Commons

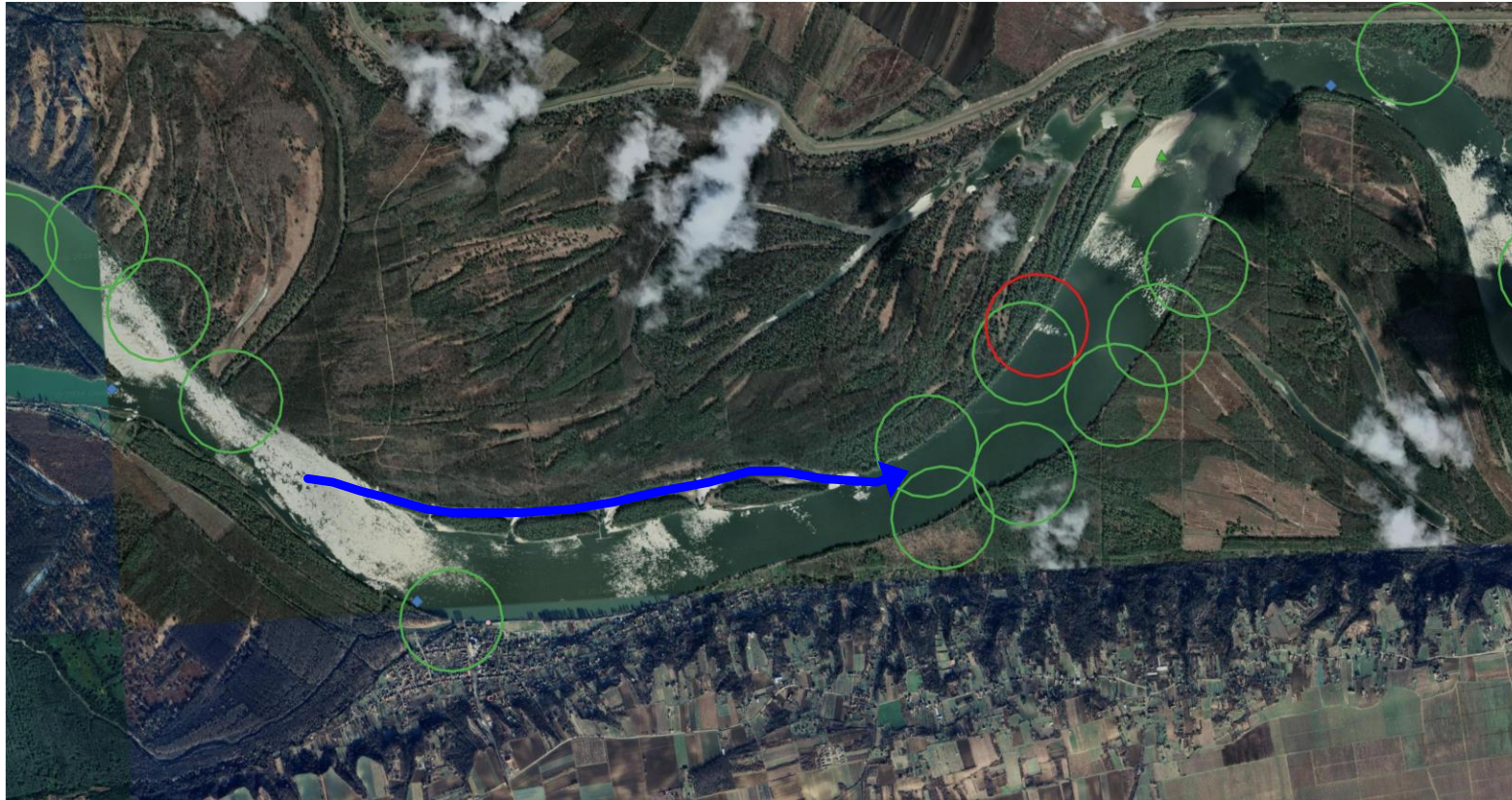
Measures under consideration – Apatin

- Groynes, parallel constructions with traverses, chevrons and sills
- Avoiding nesting areas
- Fish migration corridors



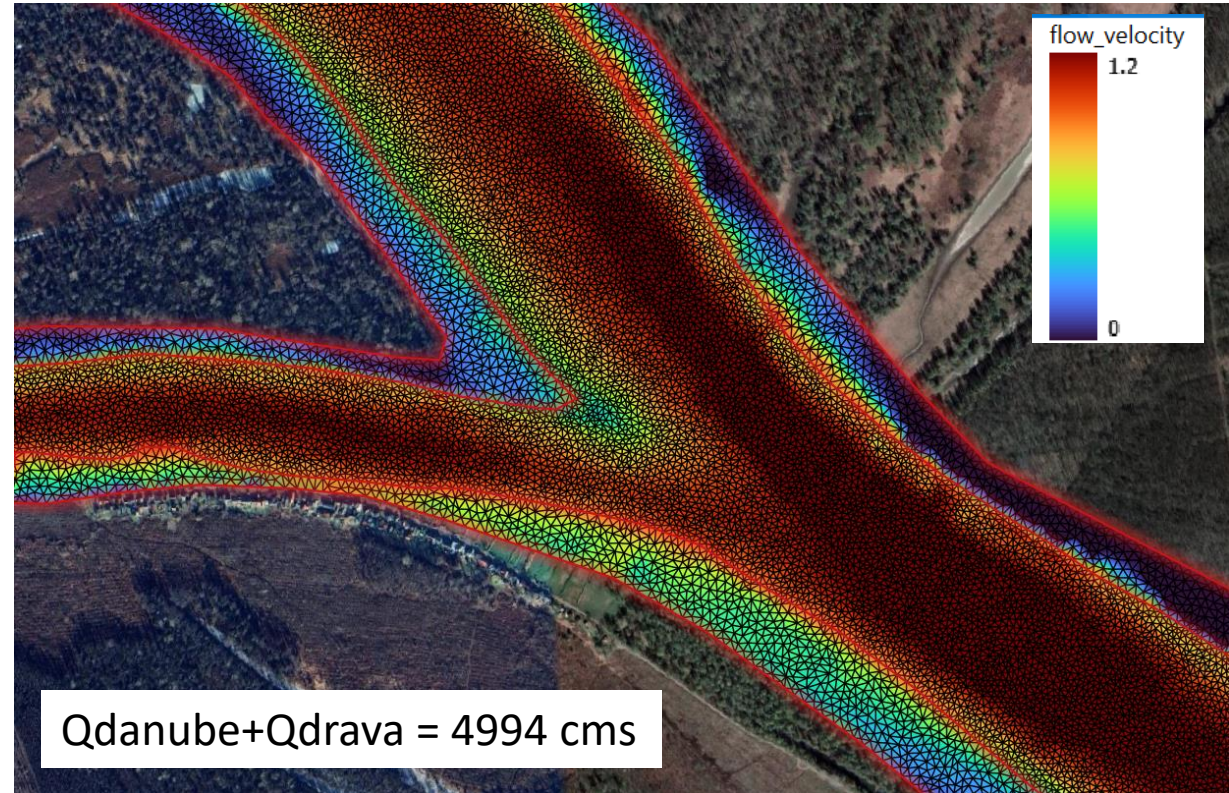
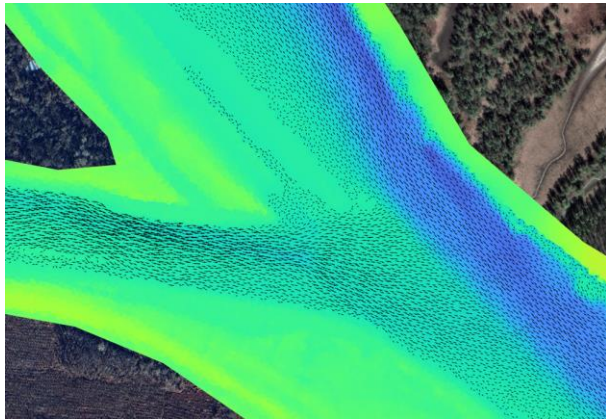
Measures under consideration (Drava confluence - Aljmaš – Staklar)

- "New" ideas
- Sediment balance (Lower erosion along Aljmaš sector -> lower depositon along Staklar sector)



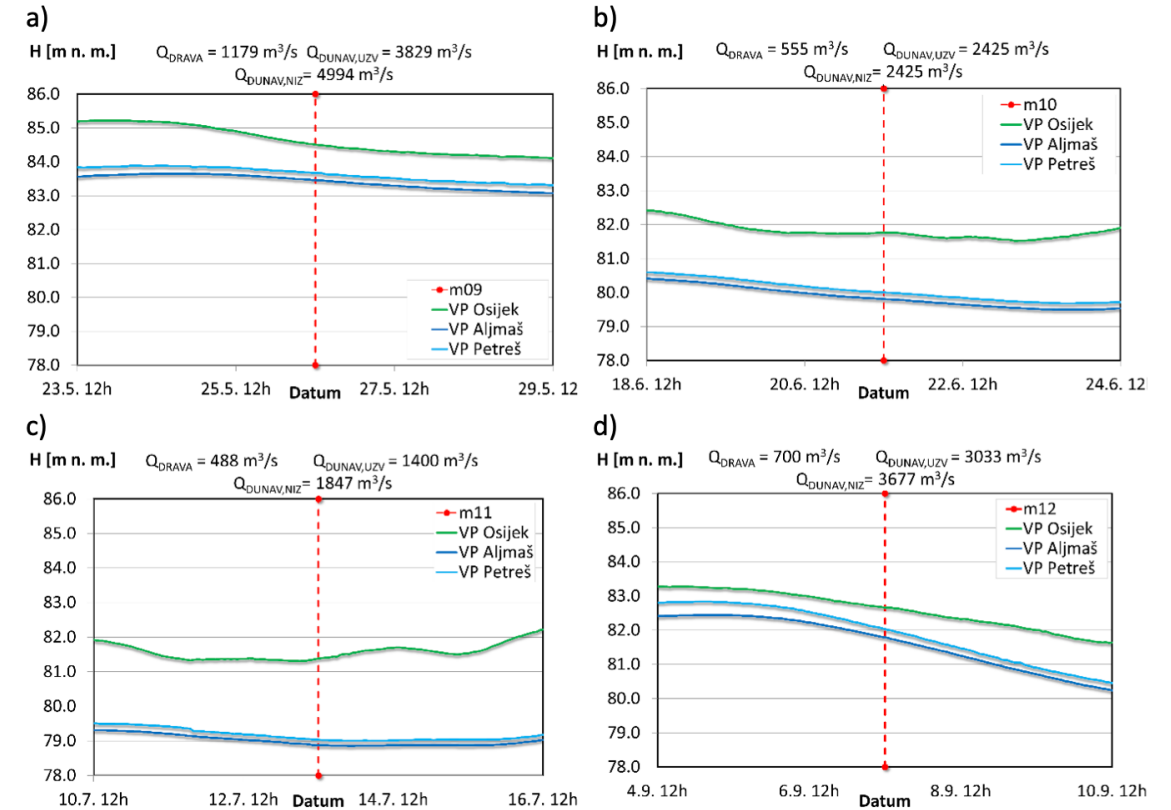
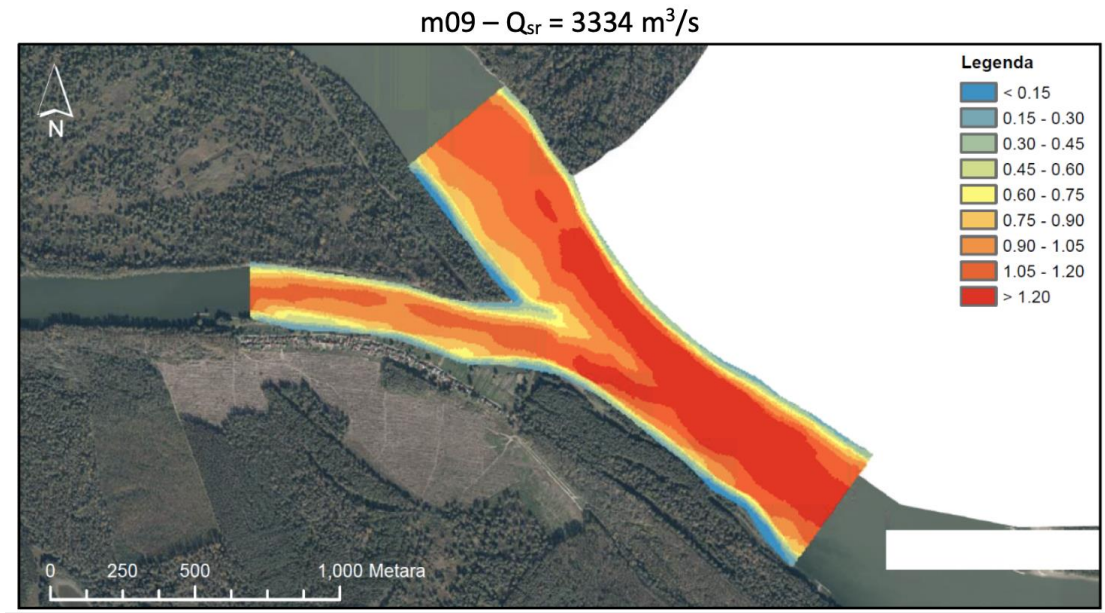
Model setup

- Sectors from Apatin to Staklar
- Basement V4 model tested
- 421033 cells
- HPC version allows massive GPU parallelization
- Hybrid riverbed model
- New data for calibration obtained



Calibration

- New data provided by Hidroing
- Velocity data for Drava confluence
- 4 surveys
- Good agreements for m9 survey (m10 and m12 have not been analyzed yet)



Slika 4.1. Nivogrami s vodomjernih postaja u blizini dionice ušća Drave, za mjerenje m09 (a), mjerenje m10 (b), mjerenje m11 (c) i mjerenje m12 (d)

Following steps

- Finalization of MCA definition activity
- Scenarios definition (initial setup)
- Sediment model calibration
- Numerical simulation (2D Sediment transport)
- Scenarios assessment (MCA)

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Thank you for your kind attention

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