14th Meeting on the Follow-up of the
Joint Statement on Guiding Principles on the Development of Inland Navigation and Environmental Protection in the Danube River Basin

Zagreb, 13-14/09/2023

River training and dredging works along the confluence of the Drina and Sava rivers

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Confluences of large rivers as significant navigational and ecological challenges

Belgrade - Confluence of the Sava and Danube Rivers

Aljmas - Confluence of the Drava and Danube Rivers

Passau - Confluence of the Ilz, Danube, and Inn Rivers

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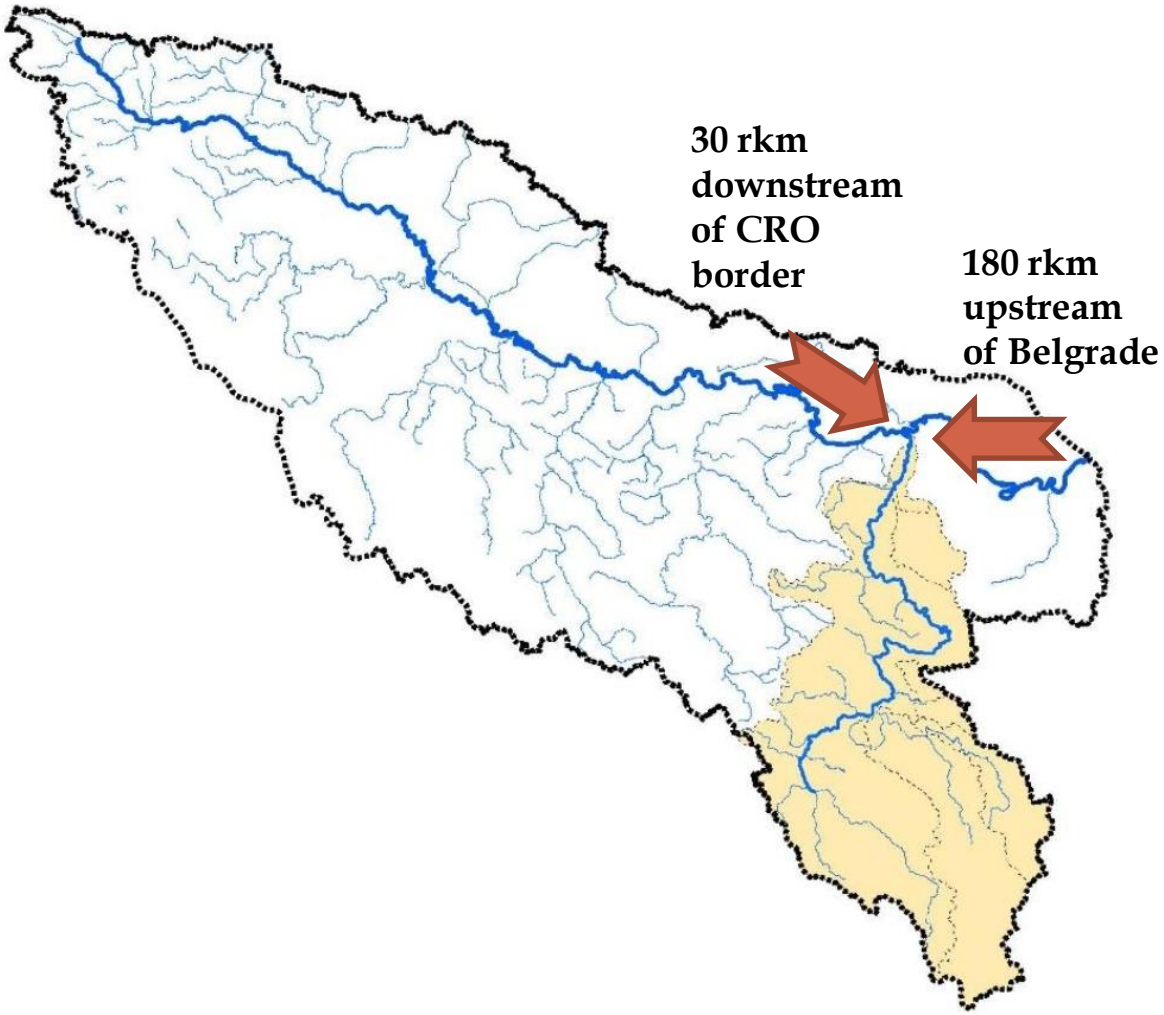
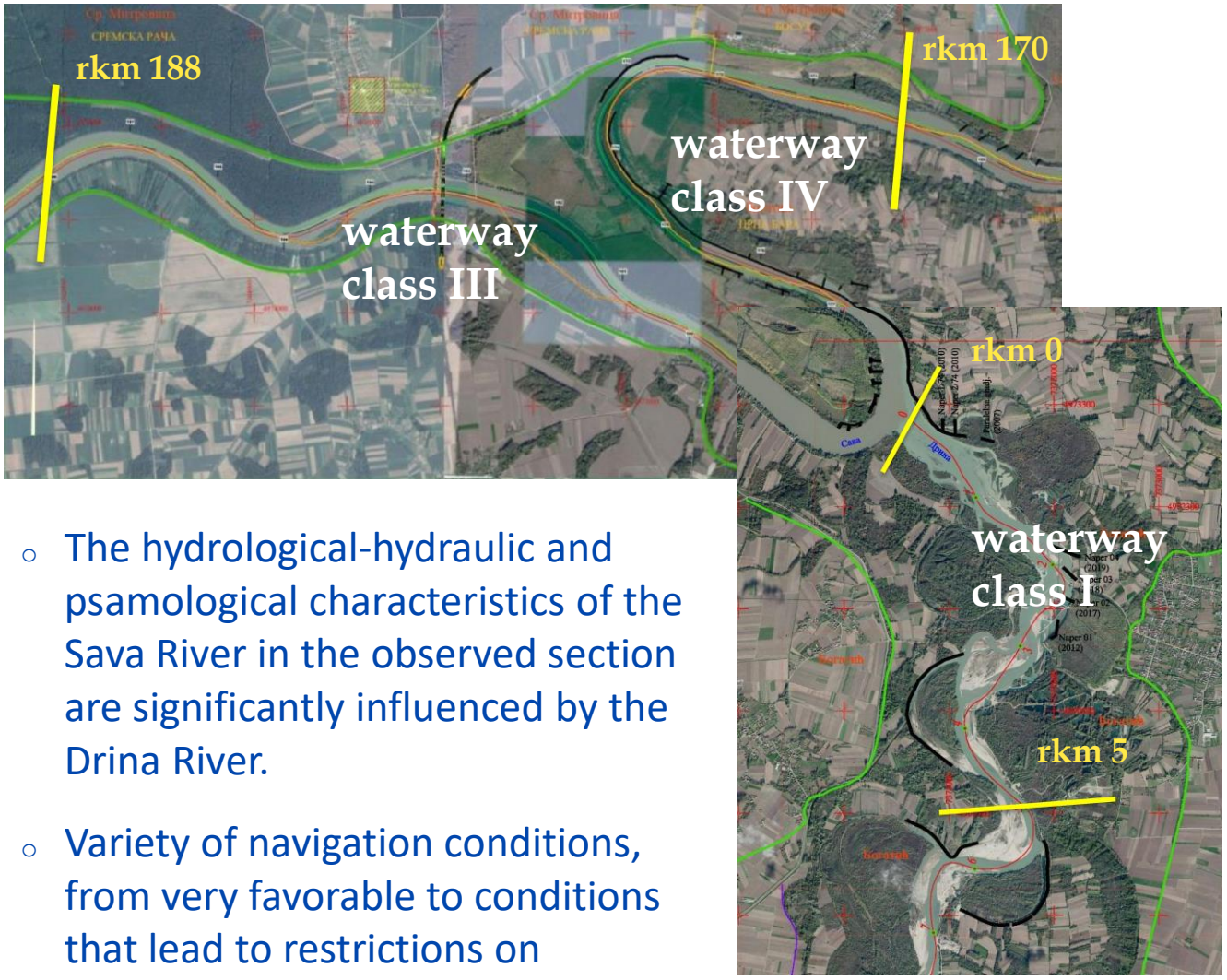
- Points with complex topographic, hydraulic, and ecological changes.
- Problems such as erosion, sedimentation and altered flow patterns.
- Navigation might provide difficulties and potential hazards
- Balancing the needs of navigation with the preservation of natural confluence ecosystems is a crucial challenge in managing these morphological issues

Sava river basin with Drina river sub-basin



- The confluence is located at the transition from the middle to the lower part of the Sava's stream.
- Drina's basin makes up one fifth of the Sava basin.
- The Drina basin is characterized by a large amount of water, so that even a third of the Sava's water comes from the Drina river.

Project area (Sava, rkm 188-170 and Drina, rkm 5-0)



- The hydrological-hydraulic and psamological characteristics of the Sava River in the observed section are significantly influenced by the Drina River.
- Variety of navigation conditions, from very favorable to conditions that lead to restrictions on navigation at low river water levels.
- The left bank of the Sava River in the Project area, as well as the right bank of the Drina and the right bank of the Sava downstream from the confluence of the Drina are located on the territory of the Republic of Serbia
- The waterway on the Sava is categorized in the AGN agreement as an inland waterway of international importance as is the Drina river from rkm 15-0

Project information

- **Project goal**: To enhance navigation conditions on the critical sector of the Sava River near the Drina River mouth
- **Phases:**
  - Field investigations
  - Prefeasibility study and General design (2021). *It addressed the Sava River from km 170 to km 188 and the Drina River from km 0 to km 5*
  - Feasibility study and Preliminary design (2022) for the training works from km 178.2 to km 183.2
  - Environmental impact assessment study (2023)
  - Construction permit design (ongoing)
  - Elaborates for dredging (ongoing)
- A special agreement is set for works on the common RS – BH section upstream of the Drina River
- A notice according to ESPO sent to Croatia.

Field investigations, analyses and modeling

Field investigations

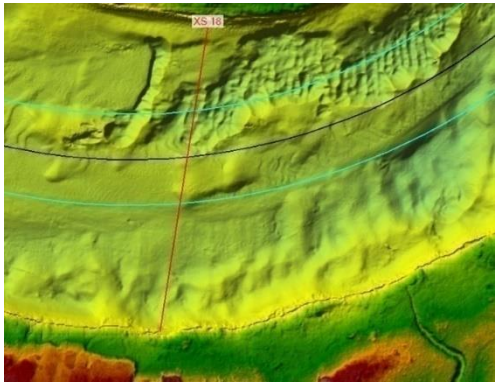
- Bathymetry (2020, 2021, 2022, 2023)
- Hydraulic (HD) and sediment measurements (2 campaigns)
- Investigation drilling and sediment sampling

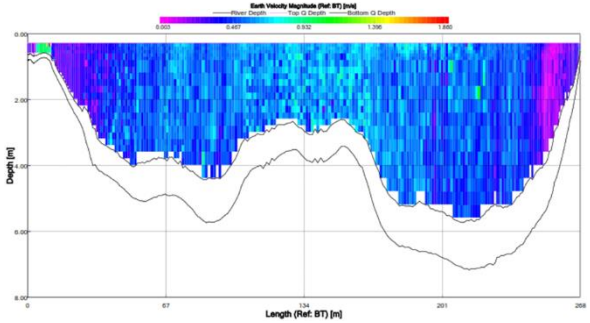
Hydrology

- Average, low and high flows (1929-2018 and 1989-2018)

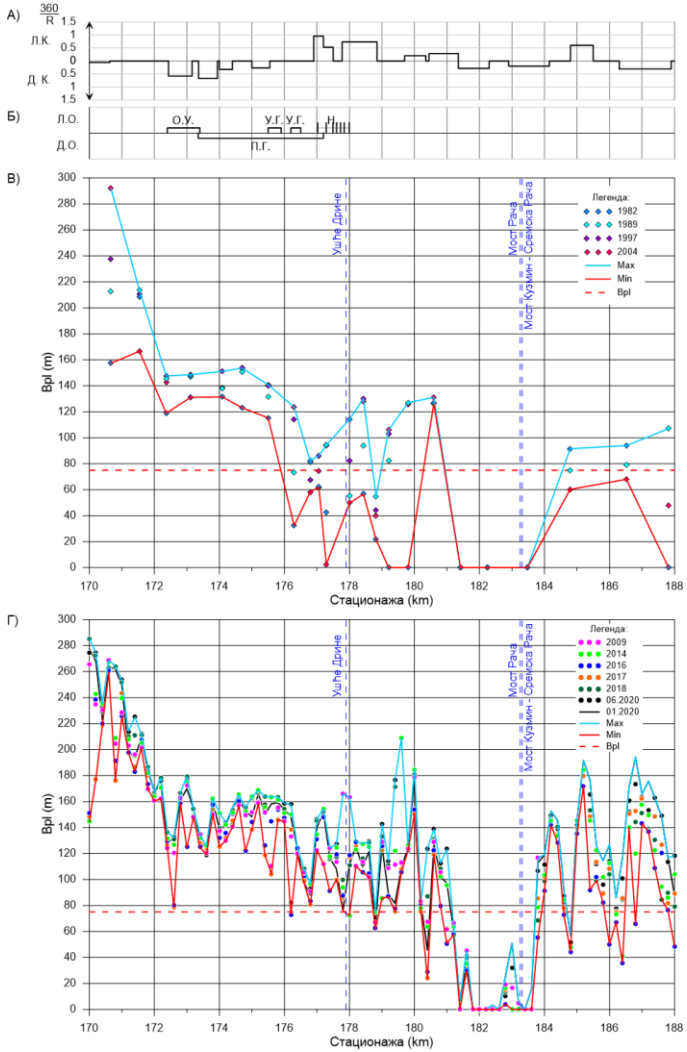
Hydraulic and sediment modeling

- 1D HEC RAS
- 2D HEC RAS



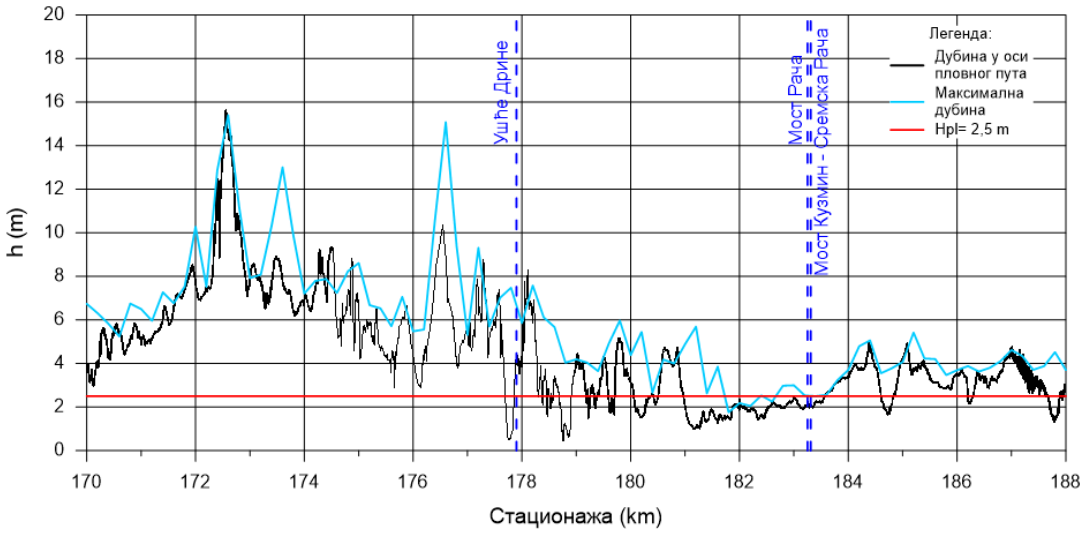


Prefeasibility study and General design, km 170 – km 188



Identified problems at Rača critical sector for navigation on the Sava River:

- Sharp river bend
- Insufficient navigation width and depth upstream of the Drina mouth (km 178)



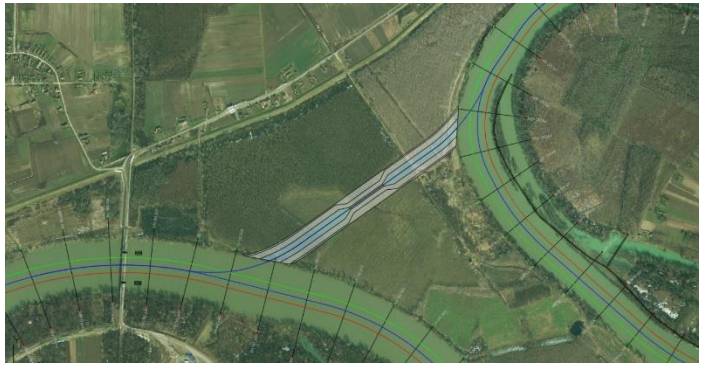
Prefeasibility study and General design, km 170 – km 188

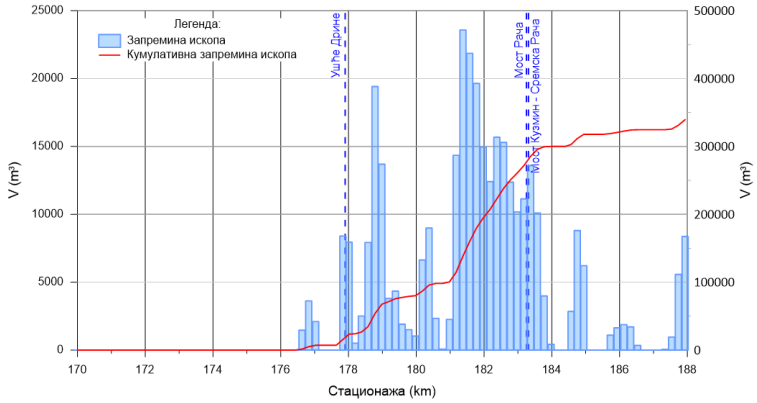
3 options for hydro-technical works were considered:

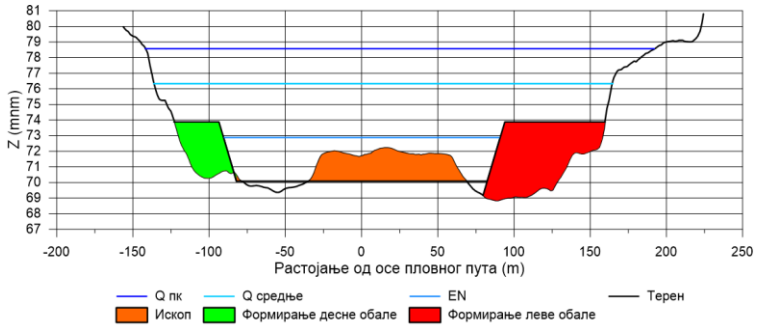
(1) new navigation channel and lock to avoid all obstacles to navigation (42 Mio €)

(2) capital and yearly maintenance dredging (26 Mio € for 30 years)

(3) river training from km 178+200 to km 183+200 incl. dredging of sandbars and T groins (6,8 Mio €)





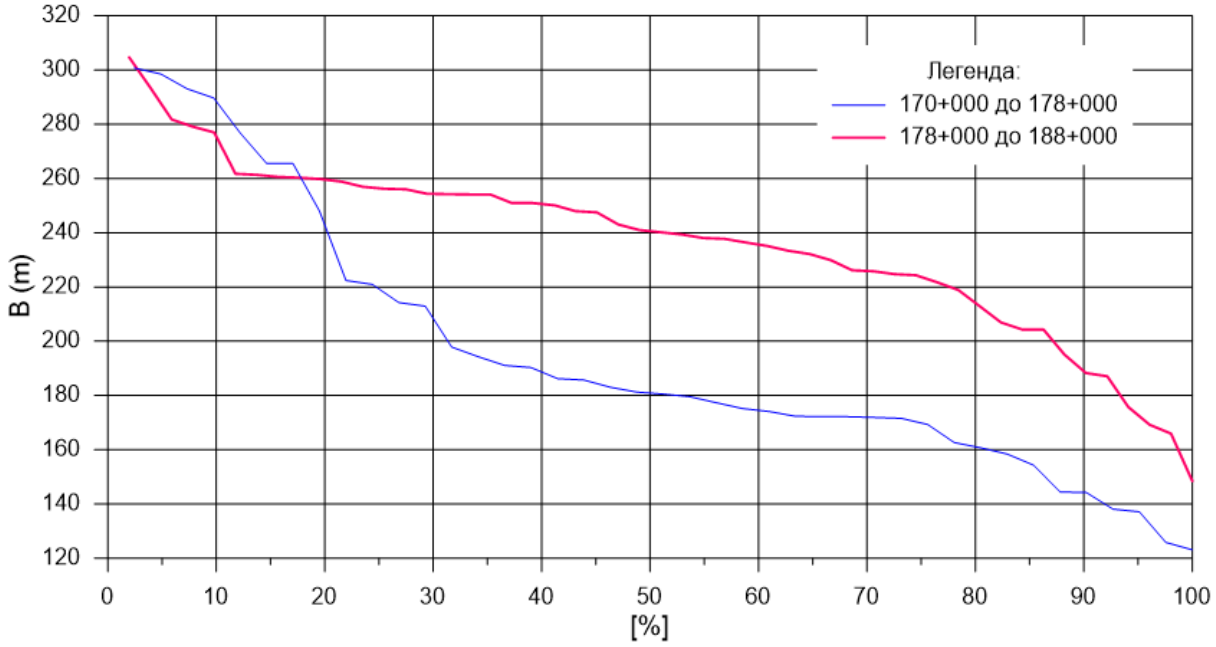


Prefeasibility study and General design, km 170 – km 188

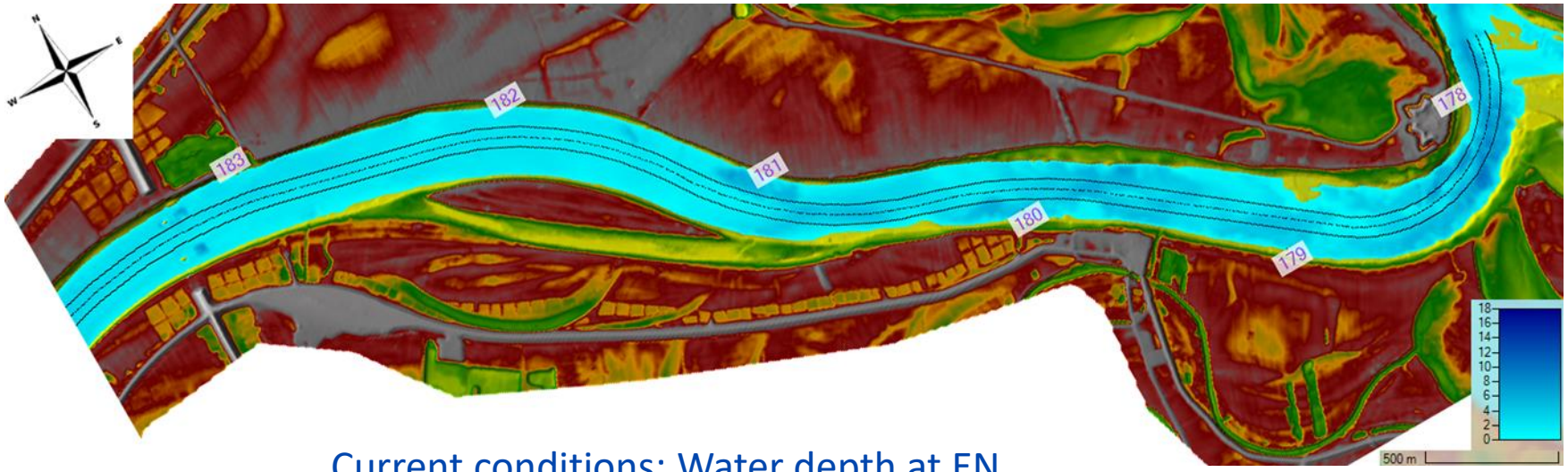
Problem: Sava riverbed is wider in the section upstream from the confluence of the Drina than in the section downstream from the confluence. Sediment coming from the upstream sectors of the Sava is retained there and forms sandbars in the middle of river channel that obstruct free navigation.

Dredging the sandbars that hinder navigation is not a long-term sustainable solution, because the same process can be expected in the future.

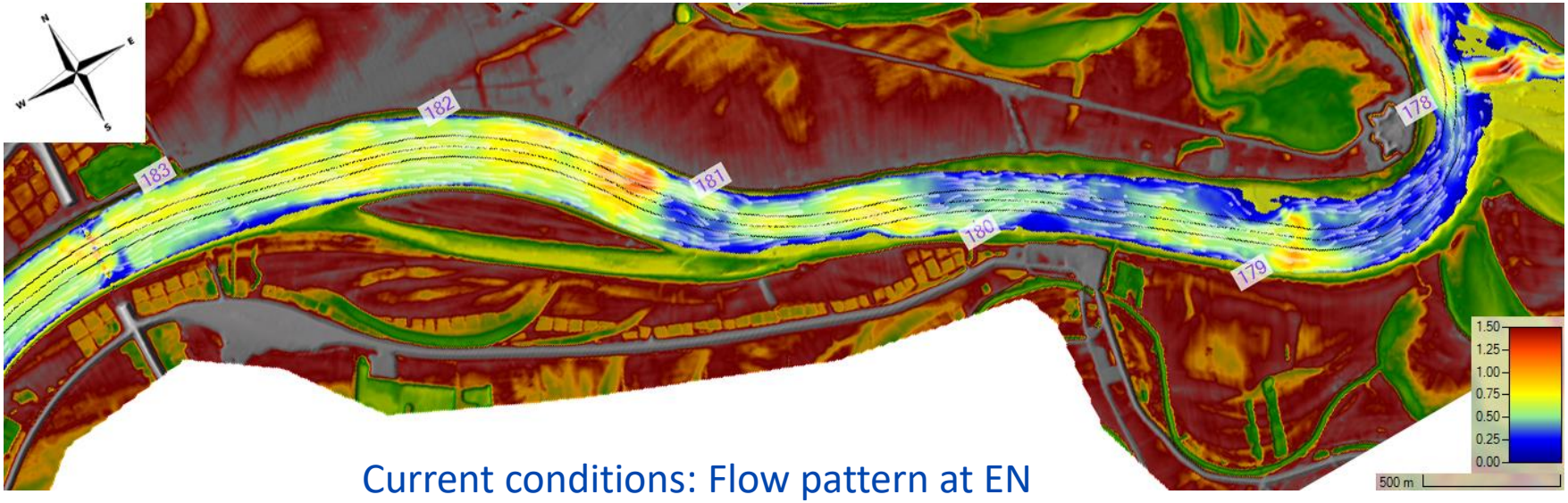
River training solution: To dredge the sandbars in the waterway to the designed level, and to build hydrotechnical structures along both banks of this straight section to improve the conditions for the transport of sediment and thereby ensure the long-term sustainability of the navigation conditions.



Preliminary design, km 178.2 to km 183.2



Current conditions: Water depth at EN



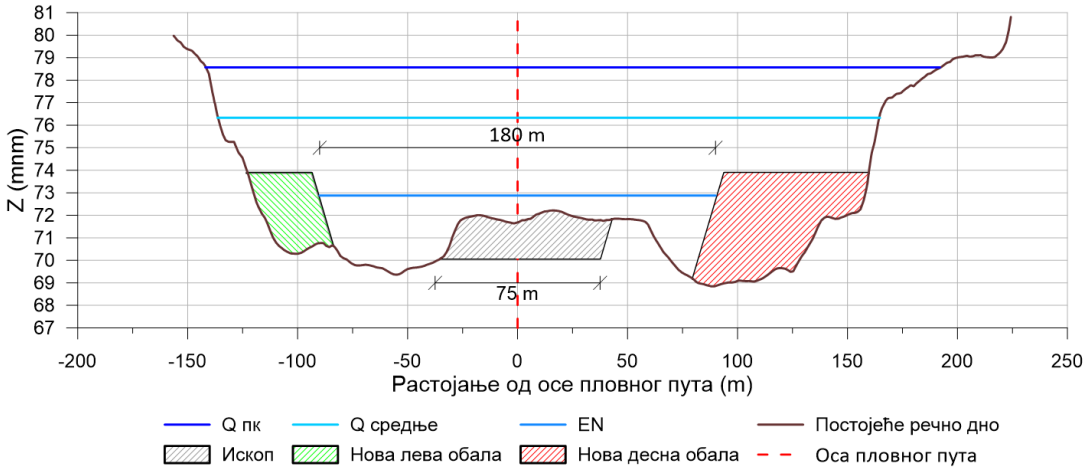
Current conditions: Flow pattern at EN

Preliminary design, km 178.2 to km 183.2

The proposed technical solution includes:

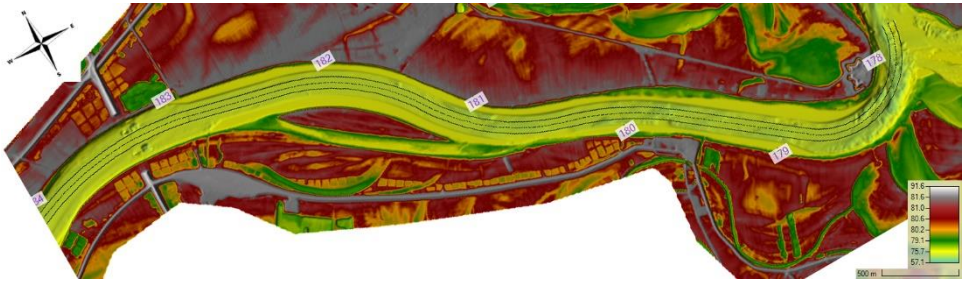
- Construction of hydro-technical structures (mostly groins) along the left and right bank of the Sava. The crown level is at EN+1 m.
- Dredging of shoals in the waterway with a width of 75 m and a depth of 2.8 m below the lowest navigation level (EN).
- Dredged material is placed in groin fields. Depth of sediment deposit is 0,5 m bellow the average groin height.

Expected effect: After the construction of hydro-technical structures and filling of groin fields the low-water channel will be narrow, and sediment transport conditions in the middle of the river will be improved.



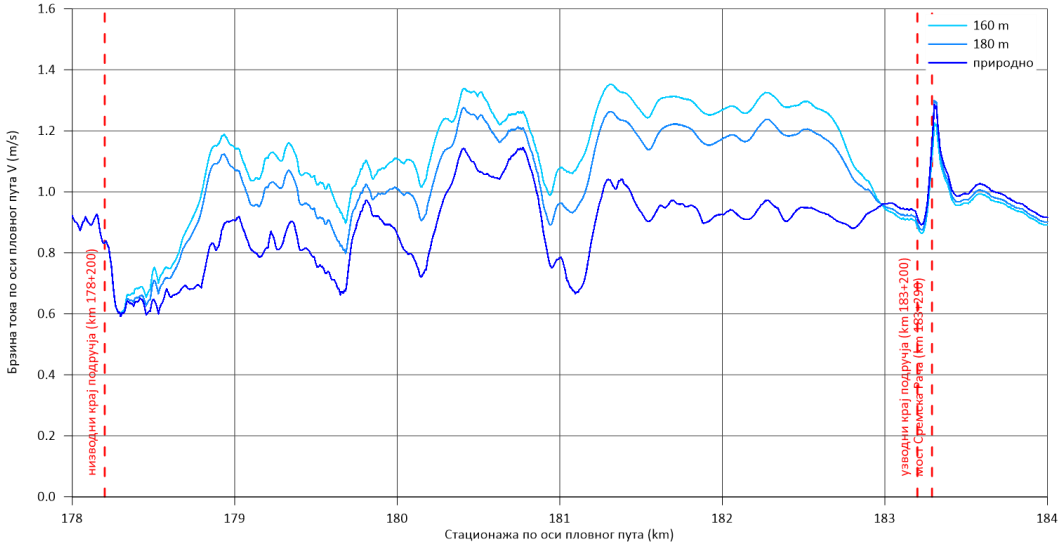
Preliminary design, km 178.2 to km 183.2

Step 1: Analysis of the low water channel width (B)



Options:
B = 180 m (50% downstream from the mouth of the Drina)
B = 160 m (80% downstream from the mouth of the Drina)

Flow velocities in the axis of the Sava fairway (results of 2D model)



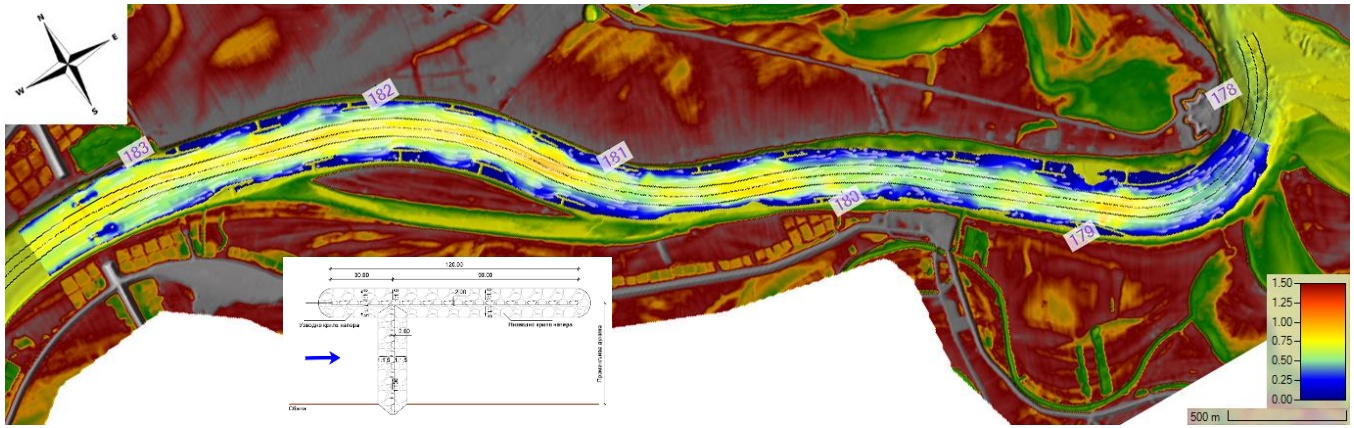
Adopted low water channel width B=180 m, due to lower flow velocities in the fairway axis

Preliminary design, km 178.2 to km 183.2

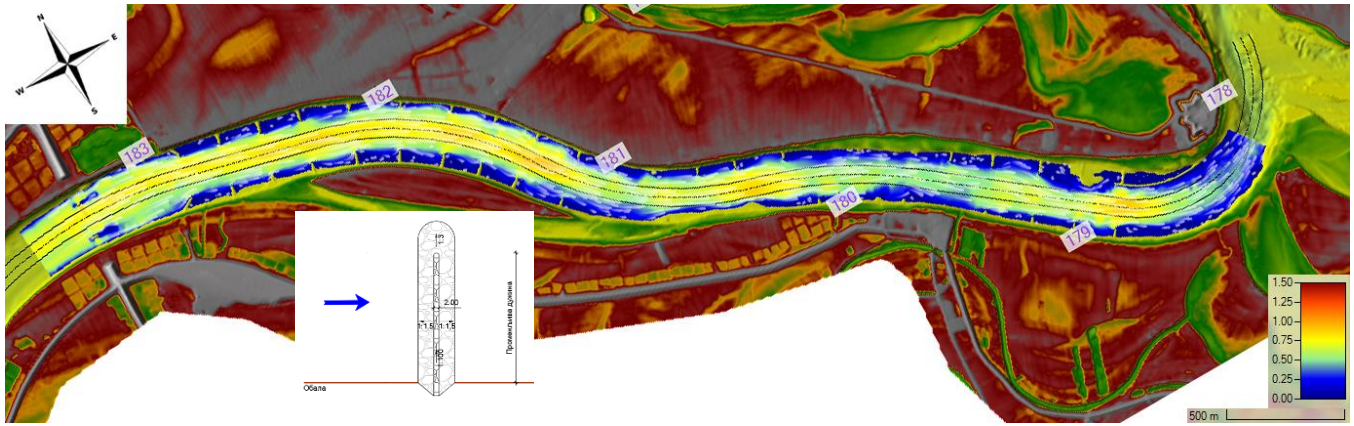
Step 2: Type and distance between groins

Options investigated using 2D model:

1. T groins, L=2B
2. Straight groins attached to the riverbank, L=B
3. Straight groins detached from the riverbank, L=B



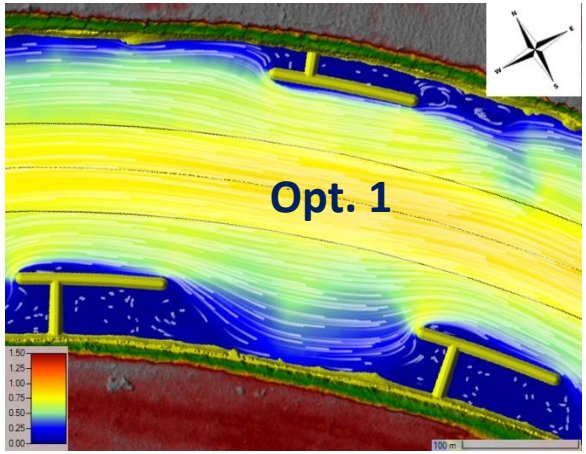
Option 1 (T groins), flow conditions at EN

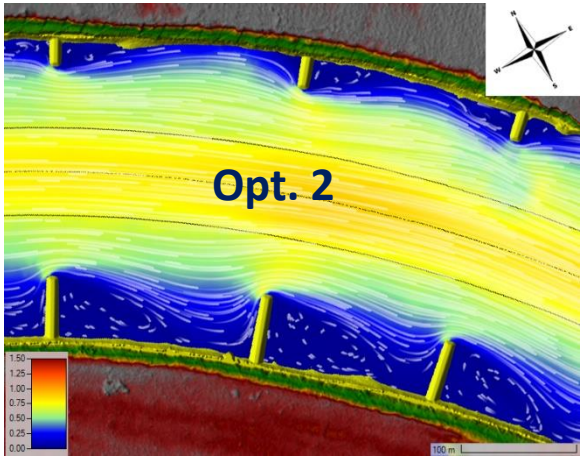


Option 2 (attached straight groins), flow conditions at EN

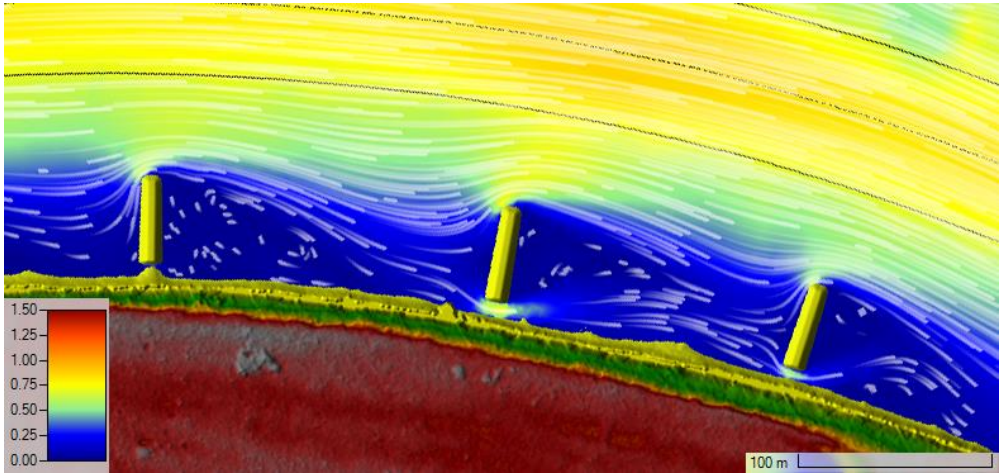
Preliminary design, km 178.2 to km 183.2

Step 2: Type and distance between groins





Opt. 2 is cheaper (building of wings of T groins in deep water requires large quantities of material) and has better hydraulic effects



Opt. 3 accepted as environmentaly better option than opt. 2

Preliminary design, km 178.2 to km 183.2

Final system of river engineering structures consists of:

- 2 inclined (attracting) groins the upstream end of the section
- 14 straight attached groins along the left bank and 12 along the right bank, length 18 – 54 m
- 1 guide bank at the downstream end
- 30 short bank revetments

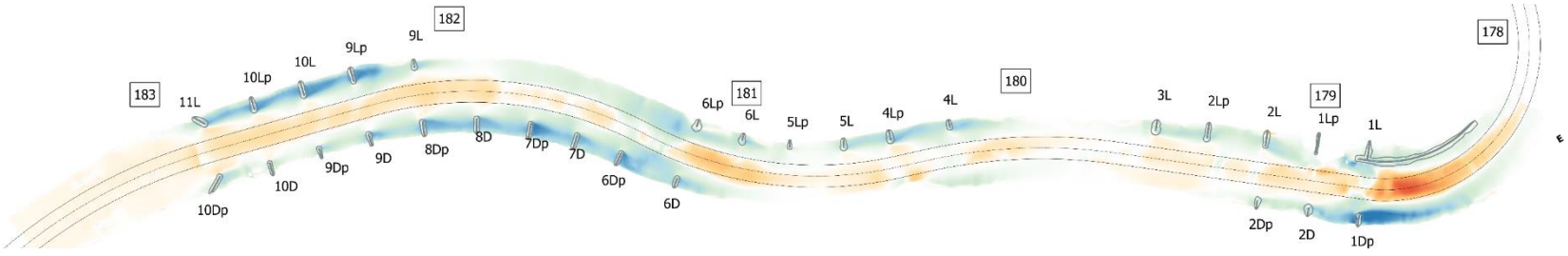
Crown levels:

- Groins and guide bank: EN+1
- Revetments: EN+2

Works shall be done from the river, using floating construction machinery

Effects:

- Flow concentration in a low water channel
- Low velocities in groin fields – sedimentation
- Sediment budget is not disturbed, only lateral redistribution. No impact on downstream section
- Dettached structures – free movement of biota under all hydrological conditions
- Bank revetments cover only lower part of the river bank (6-7m high)



Current vs. designed conditions: Flow velocities at EN

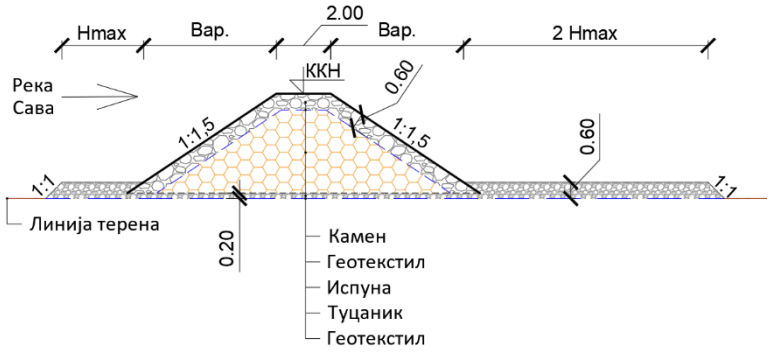
Preliminary design, km 178.2 to km 183.2

Step 3: Selection of material for construction

A. Stone

B. Geotubes filled with dredged sediment + stone cover

C. Geobags filled with dredged sediment + stone cover



- Assesment of Pros and Cons for all options: Options A and C are better than B
- Priced bill of quantities: Cost of option A is 6% higher than C

Preferred option A:

- All structures will be made of stone (Ø15-45 cm) on a layer of breakstone (Ø6-15 cm) on top of geotextile
- Easy construction
- Durable

Preliminary design, km 178.2 to km 183.2

Period	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Fish spawning												
Bird nesting												
Unfaurable hydromet conditions												
Construction period												

Construction period: 4 months per year

Construction sequence: River engineering structures should be built from the upstream to the downstream end, grouped in 5 sub-systems (3 on the left bank and 2 on the right bank). Total material quantities: Stone 28500 m^3, Breakstone 13000 m^3

Dredging from the waterway begins immediately after the completion of the construction (228.000 m^3)
Dredged sediment is deposited in the formed groin fields: on the left side 124615 m^3, on the right side 68631 m^3



Environmental impact assessment study

Impact on	Construction	Exploitation
Air quality	☹	X
Water quality	☹/X/X	☹☺/X/X
Land quality	X	X
Noise and vibration	☹	X
Heat and harmful radiation	X	X
Health of population	X	X
Meteorological parameters and climate	X	X
Ecosystem	X/☹	X/☹☺
Population, population concentration and migration	X/☹	X/☺
Land use	X	X
Infrastructure	X	☺
Natural assets of special value, historical monuments	☹	☺/X
Landscape	☹☺	☹☺

Conclusions

The technical solutions to enhance navigation conditions on the Sava River upstream of the Drina River confluence are designed to:

- Meet the required dimensions of the international Sava River waterway by Improving navigation conditions in the critical sector
- Provide a more long-term solution than periodic dredging, by building river engineering structures that will form a new low-water riverbed (narrow the existing one) and increase sediment transport in the waterway
- Use the natural potential of the river flow to carry out erosion or sediment deposition
- Meet the needs of the environment by building detached river engineering structures, with a channel between the structure and the river bank where the migration of aquatic organisms in low-water periods is ensured
- Fit into the environment, using natural material (stone) for their construction.
- Enable the creation of new habitats for wildlife in the partially filled groin fields and contribute to the development of recreational fishing in the project area.

ICPDR IKSD
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

INTERNATIONAL SAVA RIVER BASIN COMMISSION

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Thank you for your kind attention

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