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# Monitoring of hydrological, hydraulic and morphological characteristics of the Danube and inventory of biodiversity components of the Croatian- Serbian common section of the Danube

~Monitoring of parameters important for  
waterway maintenance~



27.09.2023. / Igor Tadić /Hidroing Ltd. Osijek; Slaven Marasović / VPB Ltd. Zagreb

# 1. MONITORING OF PARAMETERS IMPORTANT FOR WATERWAY MAINTENANCE

## 1. MONITORING OF PARAMETERS IMPORTANT FOR WATERWAY MAINTENANCE

1.1 Inventarization of river regulation infrastructure

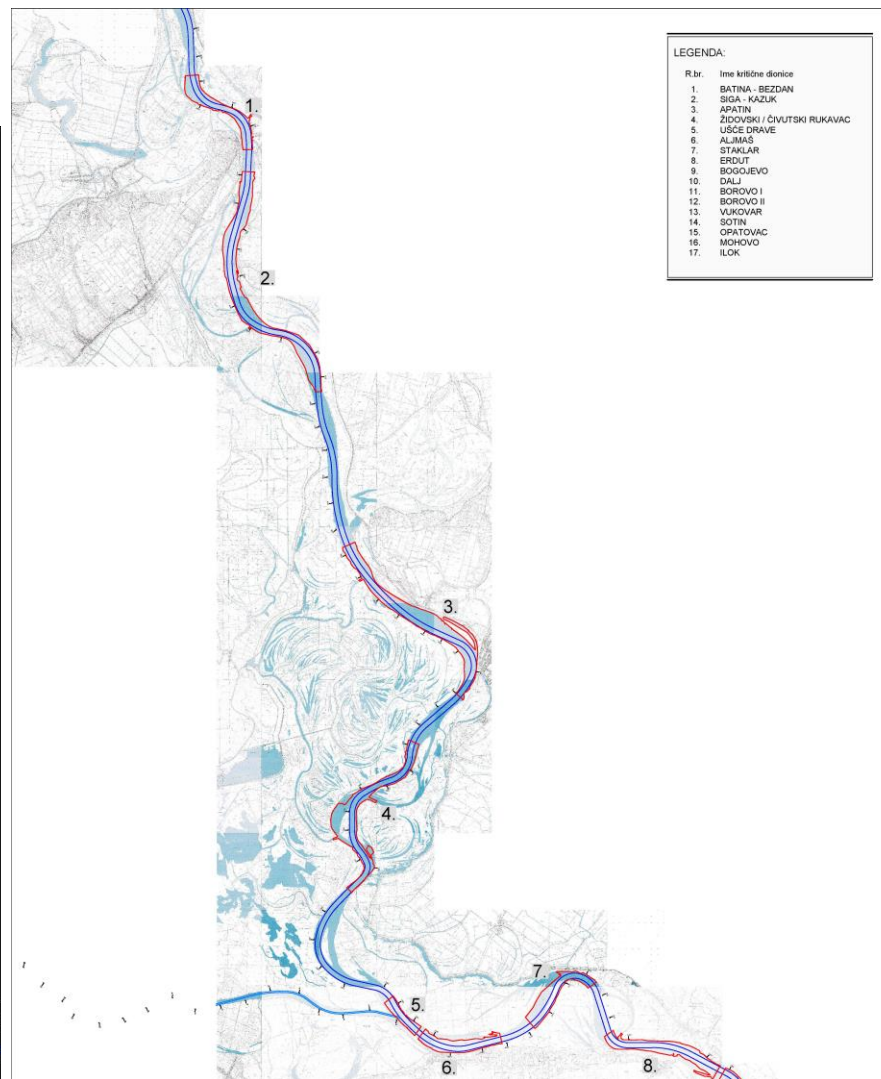
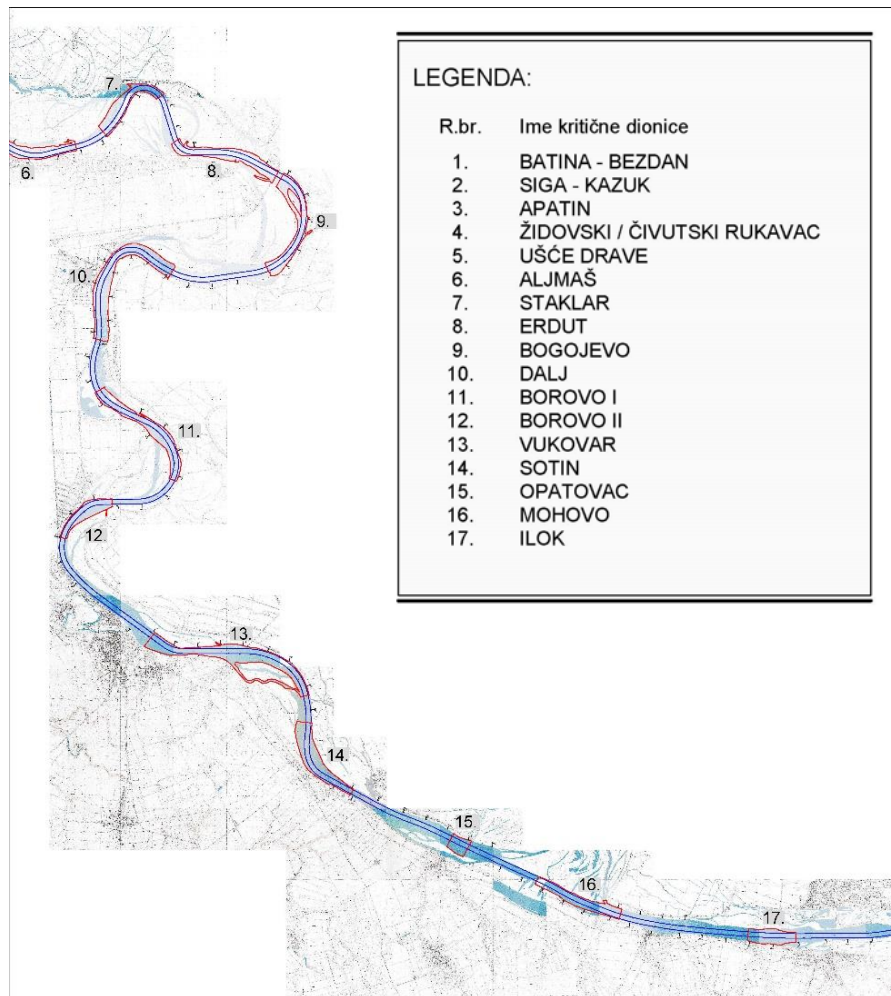
1.2 Riverbed measurement of cross-sections of Danube river

1.3 Monitoring and analysis of flow, velocity and sediment transport

1.4 Piezometer installation

# Assessment of critical sections (1)

## ▶ Critical sectors (17)



# Assessment of critical sections (2)



Determining criteria for analysis	Sources and rationale
<b>Waterway depth and width:</b> <ul style="list-style-type: none"> <li>Nominal requirement: 2,5 m of depth for a 200 m width of the fairway at LNWL (94%, 343 d/a)</li> <li>Additional: analysis for a range of depths (2,5/2,8/3,0 m) and widths (80-200 m).</li> <li>Criticality: depending on the dredging quantities required (exceed/do not exceed 10.000 m<sup>3</sup>).</li> </ul>	<ul style="list-style-type: none"> <li><b>AGN agreement</b></li> <li><b>DC:</b> Fairway Rehabilitation and Maintenance Master Plan – Danube and its navigable tributaries, Version 13 November 2014</li> <li><b>CRO:</b> Ordinance on classification and opening of fairways on inland waters</li> <li>Methodology for prioritization of critical sectors (Plovput&amp;MSTI)</li> <li><i>Dredging threshold od 10.000 m<sup>3</sup> and additional ranges taken from the Methodology</i></li> </ul>
<b>Waterway radiuses (curvature):</b> <ul style="list-style-type: none"> <li>1000 m radius (800 exceptionally)</li> </ul>	
<b>Width and height of bridge passes:</b> <ul style="list-style-type: none"> <li>50 m of minimal width</li> <li>9,10 m of minimal height, measured from high-water level (1% occurrence (4 days/a) of a 25RP) to lowest bridge construction</li> </ul>	
<b>Critical sections due to bank side-erosion:</b> <ul style="list-style-type: none"> <li>Qualitative factor taking into account the vicinity of the bank</li> </ul>	<p>Added criteria to account for registered landslides in the near vicinity of the fairway</p>

# Assessment of critical sections (3)



Criteria fulfilled	
Criteria not fulfilled	

No	Name of critical section	from rkm	to rkm	Depth of fairway	Width of fairway					Radius of fairway	Width and height of bridge passes	Critical sections due to erosion	TOTAL
					200 m	150 m	120 m	100 m	80 m				
1	Batina / Bezdan	1429,00	1425,00										
2	Siga-Kazuk	1424,20	1414,40										
3	Apatin	1408,20	1400,00										
4	Židovski/Čivutski rukavac	1397,20	1389,00										
5	Ušće Drave	1383,40	1381,60										
6	Aljmaš	1381,40	1378,20										
7	Staklar	1376,80	1373,40										
8	Erdut	1371,40	1366,40										
9	Bogojevo	1366,20	1361,40										
10	Dalj	1357,00	1351,00										
11	Borovo I	1348,40	1343,60										
12	Borovo II	1340,60	1338,00										
13	Vukovar	1332,00	1325,00										
14	Sotin	1324,00	1320,00										
15	Opatovac	1315,40	1314,60										
16	Mohovo	1311,40	1307,60										
17	Ilok	1302,00	1300,00										

- 10 critical sectors determined (out of 17), predominantly due to insufficient fairway depth/width and erosion potential
- Currently, no ongoing/long-term traffic disturbances in critical sections – short distances with small occurrence of two-way traffic
- Critical sections – to be further analyzed, potentially to implement mitigation measures

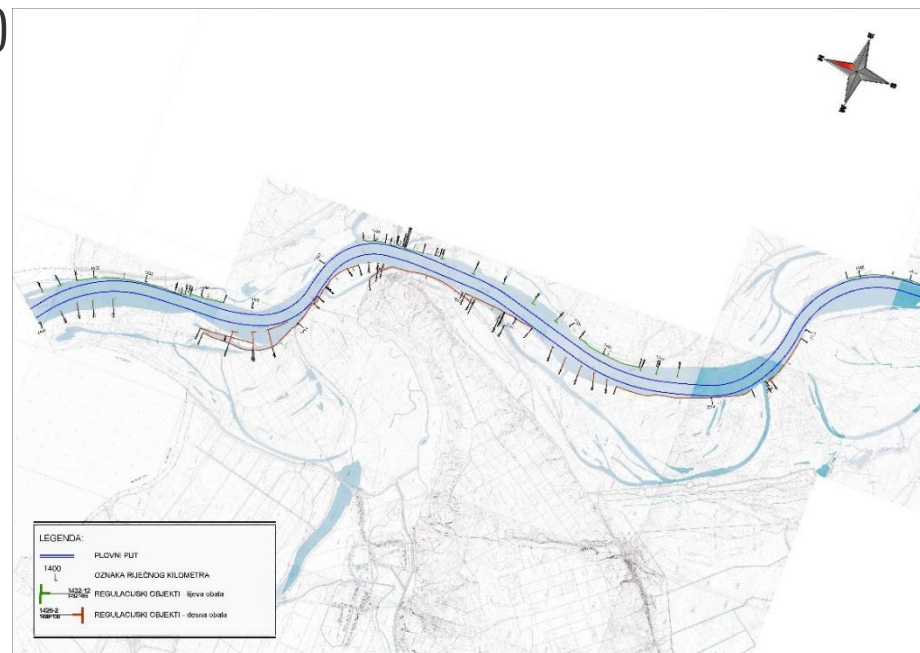
# Inventorisation of river regulation infrastructure

## ► *Inventorisation of river regulation infrastructure*

- Field work of inventorisation and assessment of existing river regulation infrastructure on both sides of the Danube
- Estimate of around 85 existing objects on the right bank; 90 objects on the left bank
- Assessment of the current state and identification of extent of damages (where applicable)

## ► *Current status (09/2023):*

- Inventorisation to commence in Q4 of 2023 (to allow lower water levels and more visibility of the structures)





# Monitoring of the Croatian/ Serbian Danube common section (river-km 1433,1 - 1295,5)

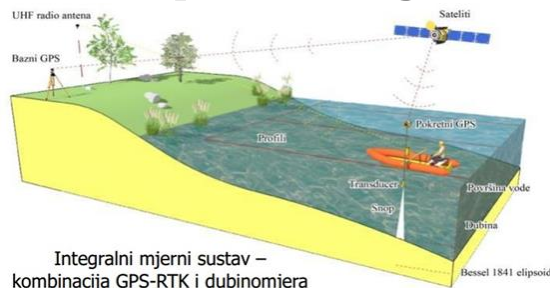


## ▶ *Riverbed measurement of cross-sections of Danube river*

- Field work of hydrographic riverbed measurements of cross-sections
- Overall length of ~ 140 rkm; 1374 control profiles (equidistance of 100 m); 2 sets of measurements (yearly)

## ▶ *Current status (09/2023):*

- First set of measurements conducted in 05-07/2023
- Data processing



# Monitoring of the Croatian/ Serbian Danube common section (river-km 1433,1 - 1295,5)

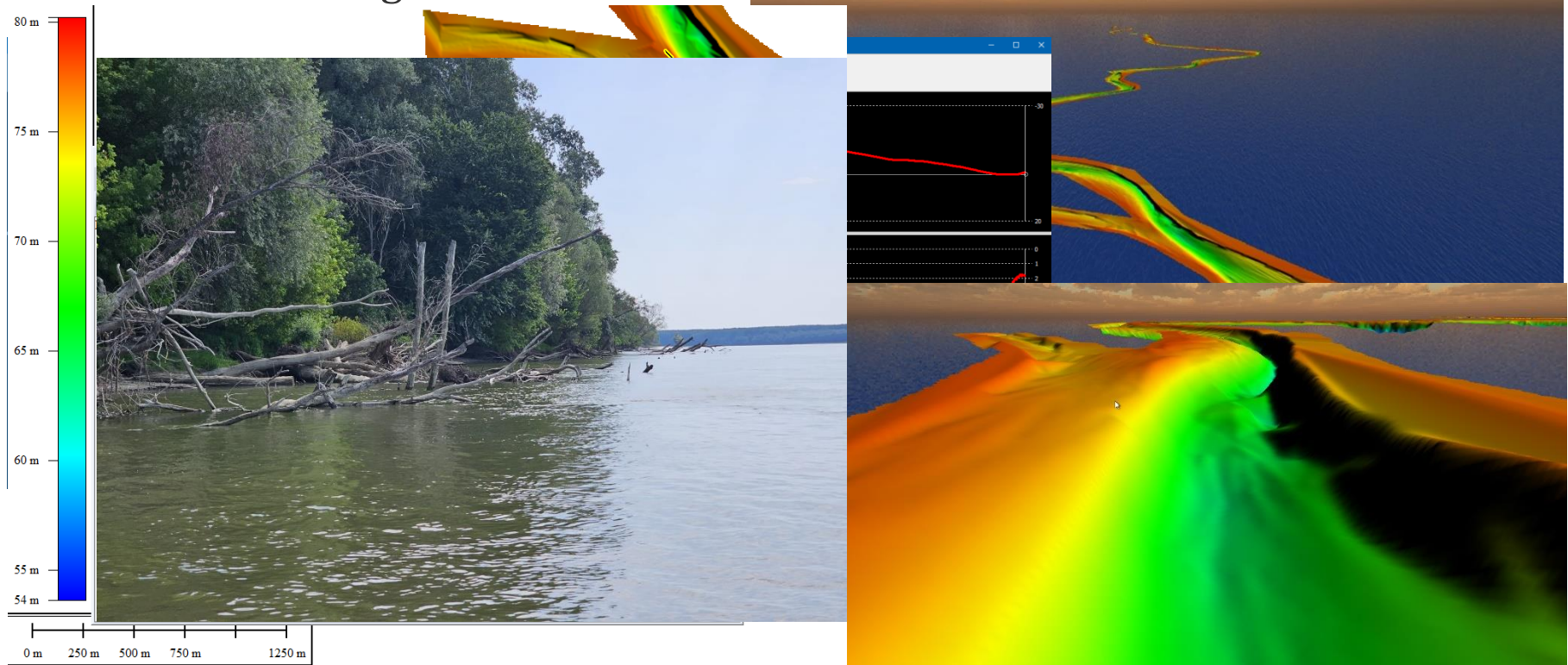


## ▶ *Cross-section data processing*

- Cleaning data
- Projecting data on cross-section lines
- Creating 3d model

## ▶ *To do*

- Data processing
- Second set of measurements  
12/2023-04/2024





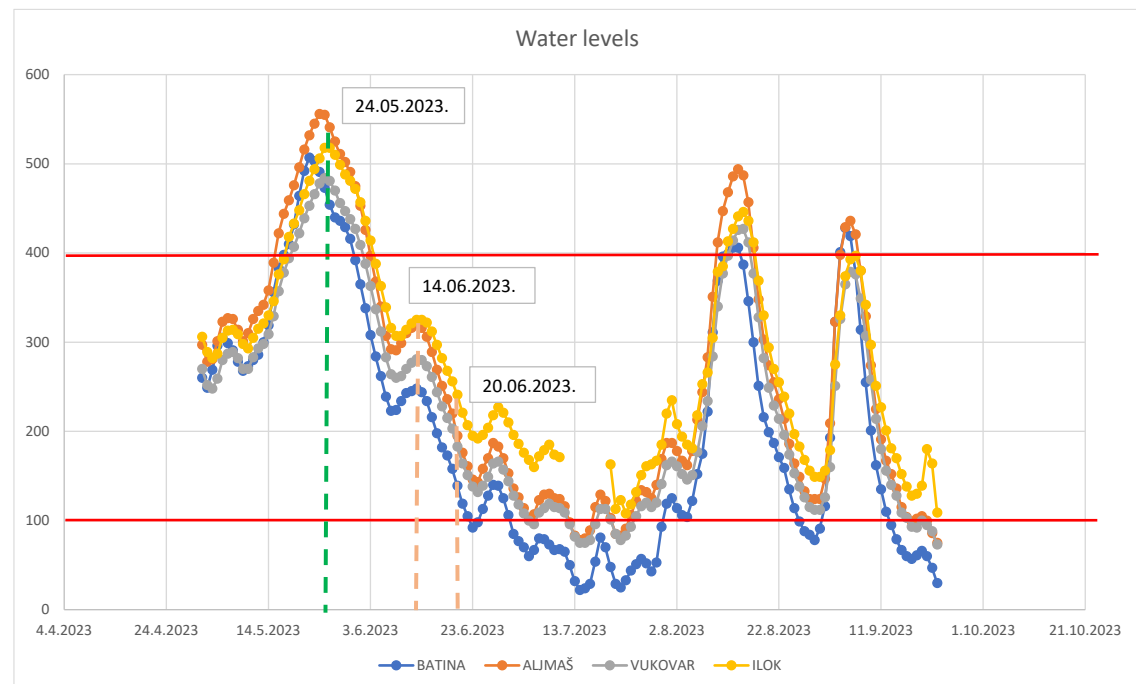
# Monitoring and analysis of flow, velocity and sediment transport

## ► Monitoring and analysis of flow, velocity and sediment transport

- 3 sets of measurement campaign (lower, medium and higher water levels) on 3 locations
- Locations: Batina/Vukovar/Ilok for flow and velocity measurements; Batina/Drava confluence/Ilok for sediment transport

## ► Current status (09/2023):

- Measurement campaign for higher and medium water levels conducted
- Measurement campaign for lower WL in Q4 2023

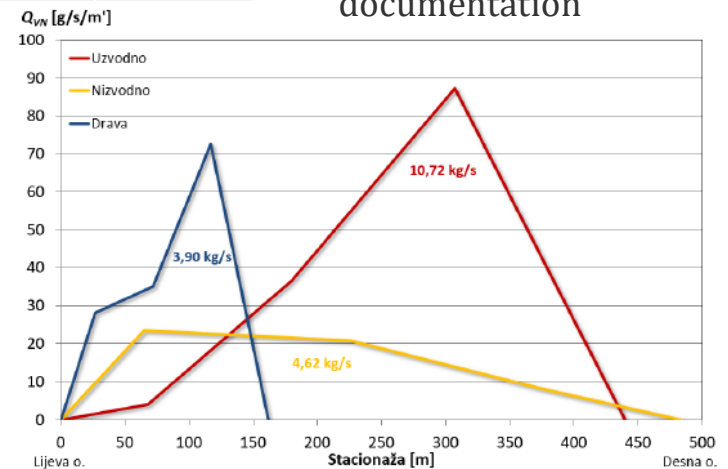
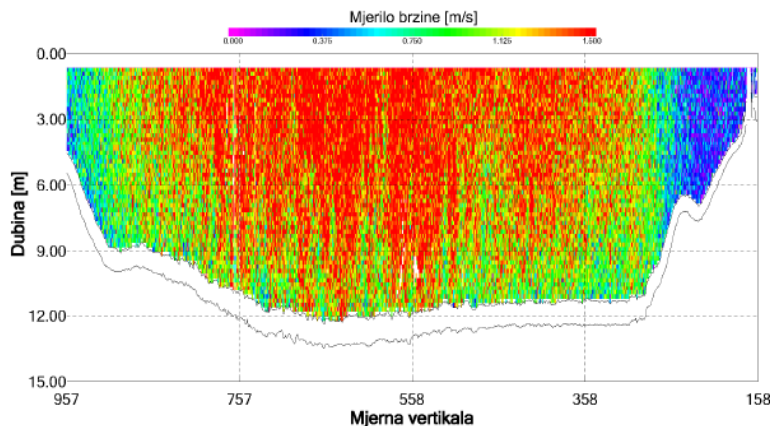


# Monitoring and analysis of flow, velocity and sediment transport

## ► Intermediate results (High water-level campaign) • Flow and velocity data distribution fairly consistent, bearing in mind cross section geometry (~ 1 m/s of integrated velocity, >1,5 m/s in main current)

Location	rkm	Q [m³/s]	V <sub>avg</sub> [m/s]	H <sub>max</sub> [m]	H <sub>avg</sub> [m]	Q <sub>bs</sub> [kg/s]	Q <sub>ss</sub> [kg/s]
Batina/Bezdan	1429,0	3862	0,91	10,86	8,34	6,01	128
	1425,0	3916	1,02	13,03	9,93	9,21	130
Drava confluence	1383,0	4009	0,96	18,30	9,62	10,72	135
	0,5	1336	0,78	8,71	6,07	3,90	47
	1381,6	5373	1,07	13,48	11,06	4,62	190
Vukovar	1332,0	5439	0,99	11,07	7,61	11,09	190
	1325,0	5082	1,18	13,78	10,26	8,11	183
Ilok / Backa Palanka	1302,0	5389	1,17	10,01	8,76	10,19	198
	1300,0	5301	1,05	12,07	8,08	13,43	184

- Bedload sediment 5-7% of total sediment
- Preliminary/intermediate results a product of direct method of analysis (measurement campaign), indirect method interpretation to ensue (correlation) within final documentation



# *Piezometer installation*

## *Piezometer installation*

- Piezometer installation adjacent to Danube (<100 m), 15m of depth for continuous monitoring of water levels and temperature
- Locations: Batina, Aljmas and Ilok

## *Current status (09/2023):*

- Installed piezometers

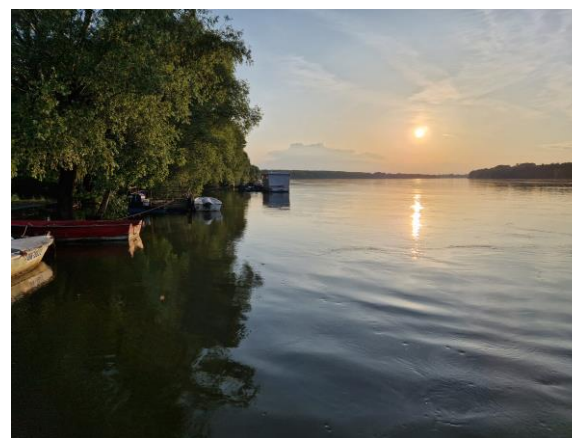




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# Thank you for your attention !



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