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Effects of newly built hydrotechnical infrastructure on the Danube in Serbia

Republic of Serbia
Ministry of Construction, Transport and Infrastructure
Directorate for Inland Waterways

Co-financed by the Connecting Europe Facility of the European Union

River Training and Dredging Works on Selected Sectors along the Danube River

6th STAKEHOLDERS' FORUM

- The Project was financed 100% by the European Union, within the "IPA 2010" program. The value of the project is 2.2 million Euro, and the end users are the Ministry of Transport and the Directorate for Inland Waterways.
- The main goal of the Project is the preparation of Technical documentation for River Training and Dredging Works on the Danube River, which would enable conditions for safe navigation in periods of Low Navigation Levels and remove critical sectors for navigation.

Delegation of the European Union to the Republic of Serbia

EuropeAid/129691/C/SER/RS
Tender number: 10SER01/14/11

Preparation of Documentation for River Training and Dredging Works on Selected Sectors along the Danube River

Witteveen Bos

DHI

ENERGOPROJEKT

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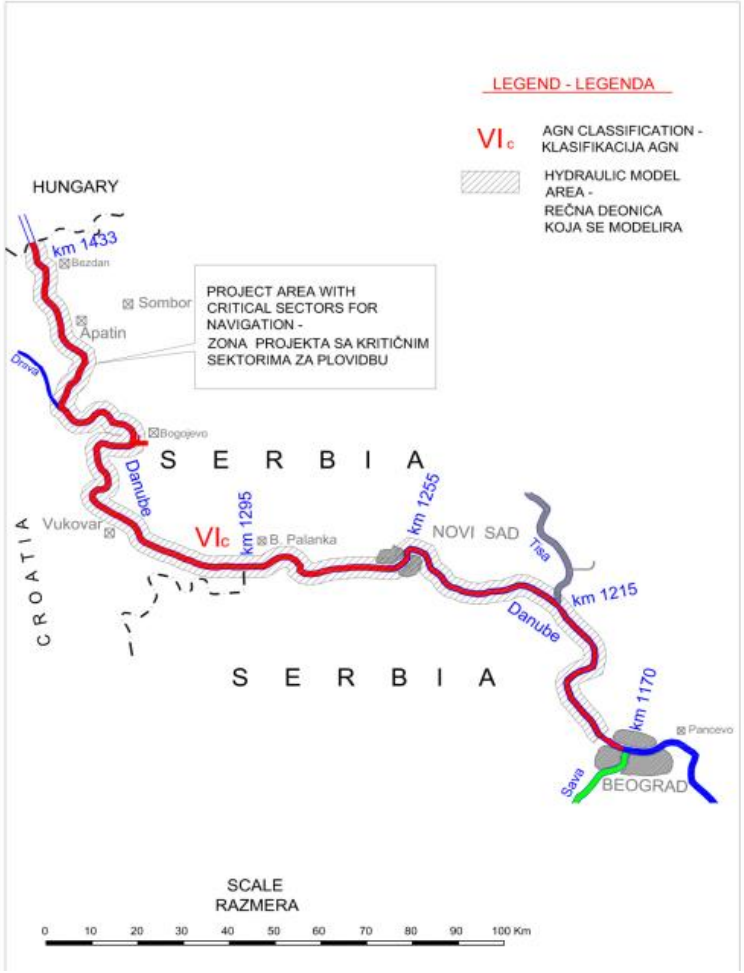
Preparation of Project

- The overall objective of this project is "to contribute to restoration and creation of safe and swift navigation on the Danube River in full accordance with the Danube Commission requirements, EU standards and legislation of Republic of Serbia."

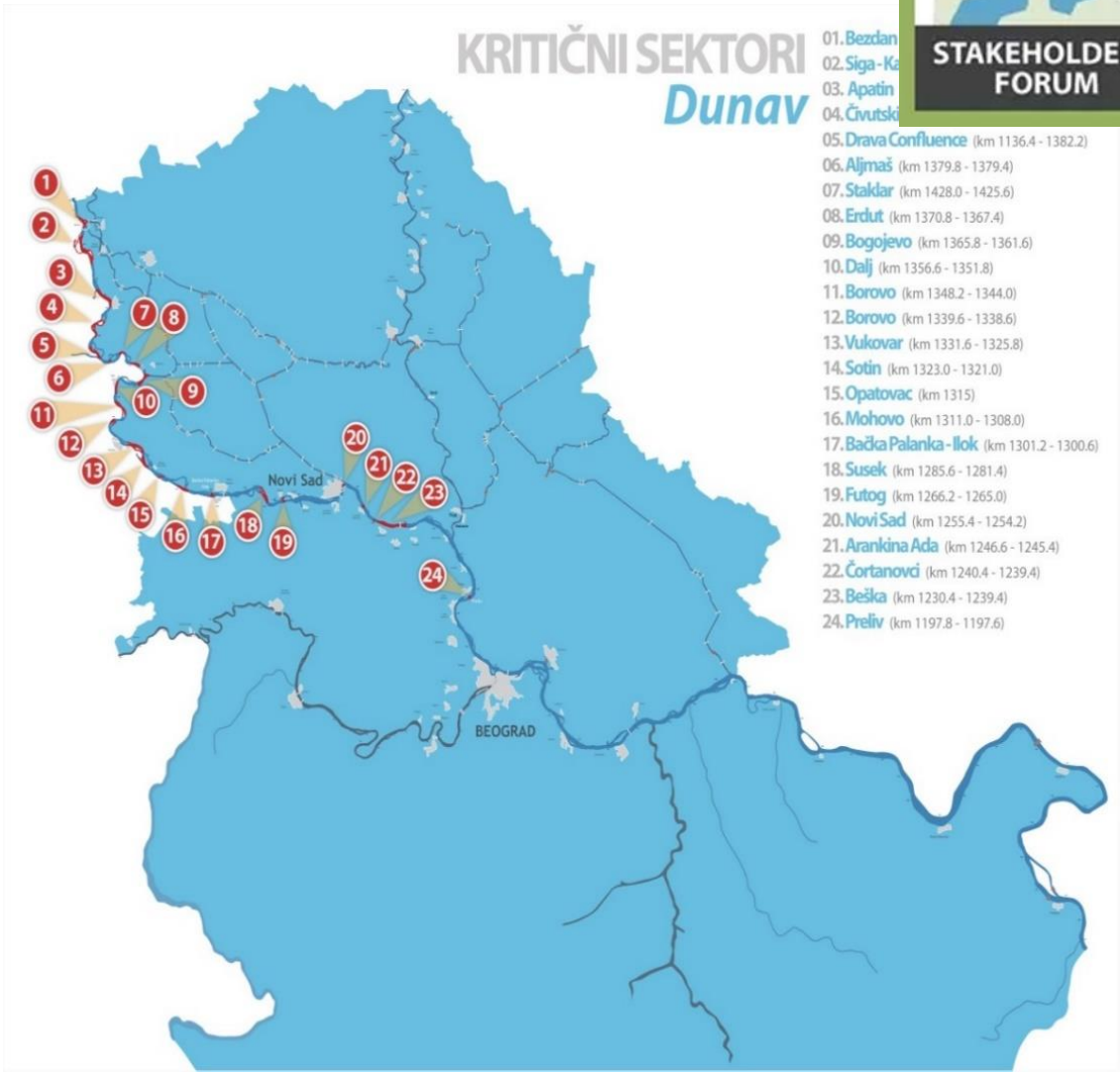
- The project is planned in three phases:
  - Phase 1 - Prefeasibility Study with the General Design
  - Phase 2 - Feasibility Study with the Preliminary Design
  - Phase 3 - Main Design with Tender documentation



Preparation of Project

- **Within the Phase 1, the new Low Navigation Levels (LNL; EN) were calculated, according to the recommendations of the Danube Commission, and based on hydrological data for the period 1981-2010.**
- **Within the Phase 2, a 2D hydraulic model was prepared. For the needs of a more detailed analysis of the effects of the proposed, a morphological model was also prepared.**

A total of 24 critical sectors have been identified in the Project area having limitations to navigation.



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Multi-criteria analysis (MCA) on critical sector

- Prior to the execution of the 2D modelling, options for all critical sectors were identified.

- In order to determine which options would be subject to 2D modeling options were evaluated and screened based on three criteria:
  1. EFFECTIVENESS
  2. ENVIRONMENTAL IMPACT
  3. COST

Table 2.1. Example of the screening of options

Option	Effectiveness	Environment	Cost
1	+	-	+
2	+	0	0
3	0	0	-
4	+	0	-
5	+	0/-	0

Options are compared to each other per sector, as follows:

- negative
0 neutral
+ positive

Multi-criteria analysis (MCA) on critical sector

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Selected modelling options (X= dredging, X = structures)

Sector	Location	Option						Totals		
		1	2	3	4	5	6	SER-CRO	SER	
1	Bezdan		X	X		X		3		
2	Siga-Kazuk		X	X				2		
3	Apatin			X	X			2		
4	Čivutski Rukavac		X					1		
5	Drava confluence				X	X		2		
6	Aljmaš		X					1		
7	Staklar	X		X				2		
8	Erdut	X						1		
9	Bogojevo	X			X			2		
10	Dalj	X	X	X				3		
11	Borovo (1)		X	X	X	X		4		
12	Borovo (2)	X		X				2		
13	Vukovar				X	X		2		
14	Sotin			X		X	X	3		
15	Opatovac							0		
16	Mohovo							0		
17	Bačka Palanka				X	X		2		
	Total							32		

Selected modelling options (X= dredging, X = structures)

Sector	Location	Option						Totals		
		1	2	3	4	5	6	SER-CRO	SER	
18	Susek			X	X			2	2	
19	Futog	X		X				2	2	
20	Novi Sad								0	
21	Arankina Ada	X		X				2	2	
22	Čortanovci	X	X		X			3	3	
23	Beška		X	X	X	X		4	4	
24	Preliv		X	X	X			3	3	
	Total								16	48

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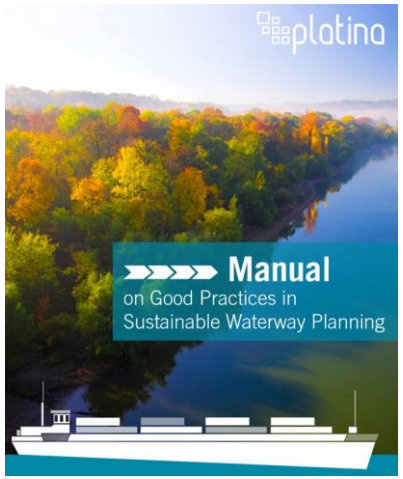
Project Implementation

- **Within the Phase 3 the Main Projects and Tender documentation for 6 critical sectors located downstream of Bačka Palanka were completed**
- **Hydrotechnical structures have been built in three of the six critical navigation sectors to improve navigation conditions**
- **Chevrons were built on two critical sectors (Futog and Preliv) - the first hydrotechnical structures of this type on the Danube**
- **All hydrotechnical structures were built in accordance with the "Handbook of Good Practice in Sustainable Waterway Planning"**



Chevrons - newly built hydrotechnical structures on the Danube River in Serbia

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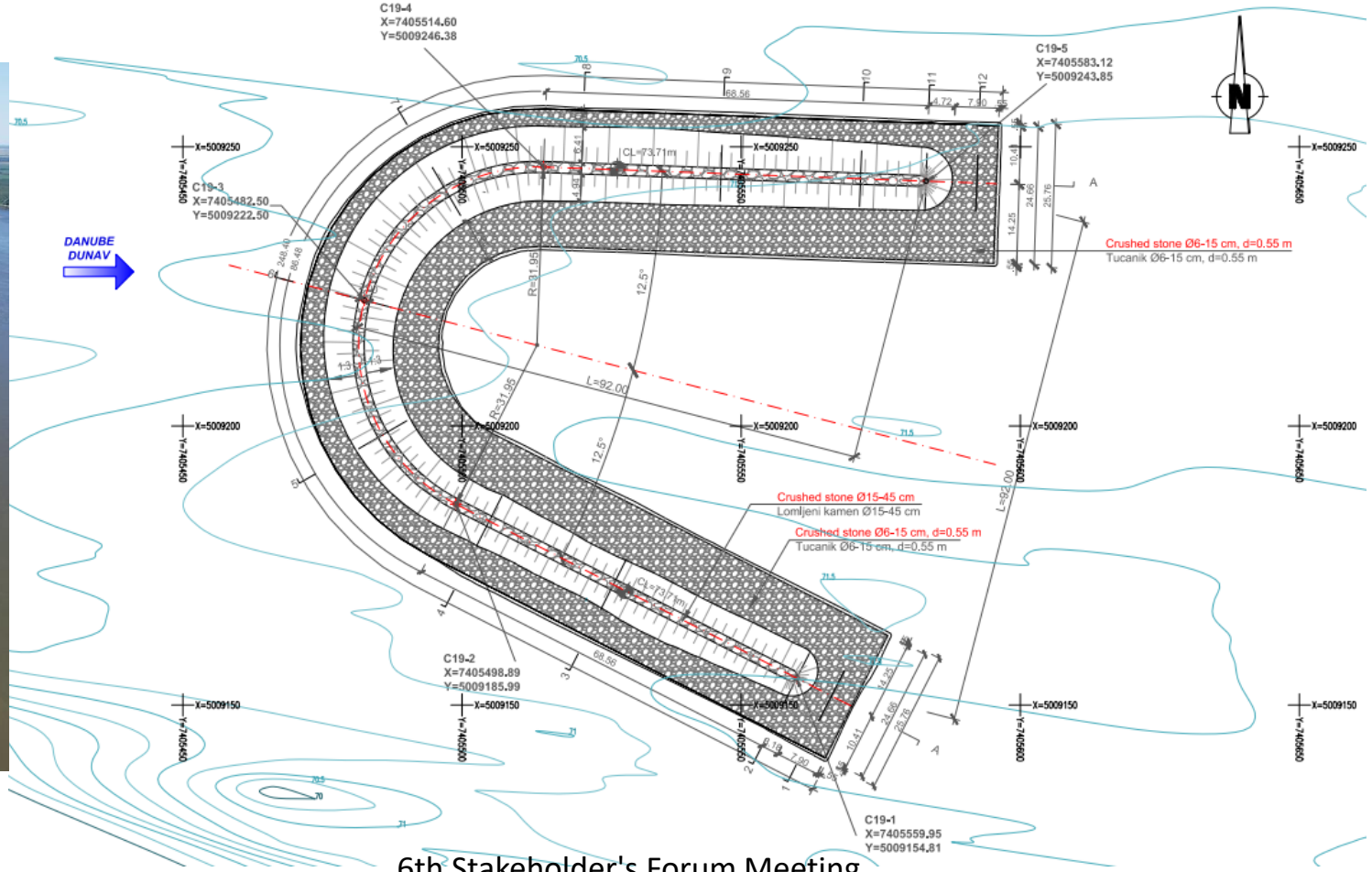

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Expected effects of newly built hydrotechnical infrastructure

The effects of groins and chevrons can vary depending on their design, placement, and local environmental conditions.

Groins:

- Reduced sediment transport along the river.
- Stabilization of the river bank and reduced erosion on one side.
- Potential narrowing of the river channel.
- Altered water flow patterns.

Chevrons:

- Formation of sediment deposits in a V-shaped pattern.
- Natural habitat creation in the river.
- Altered flow dynamics and currents.
- Possible obstruction to navigation in some cases.

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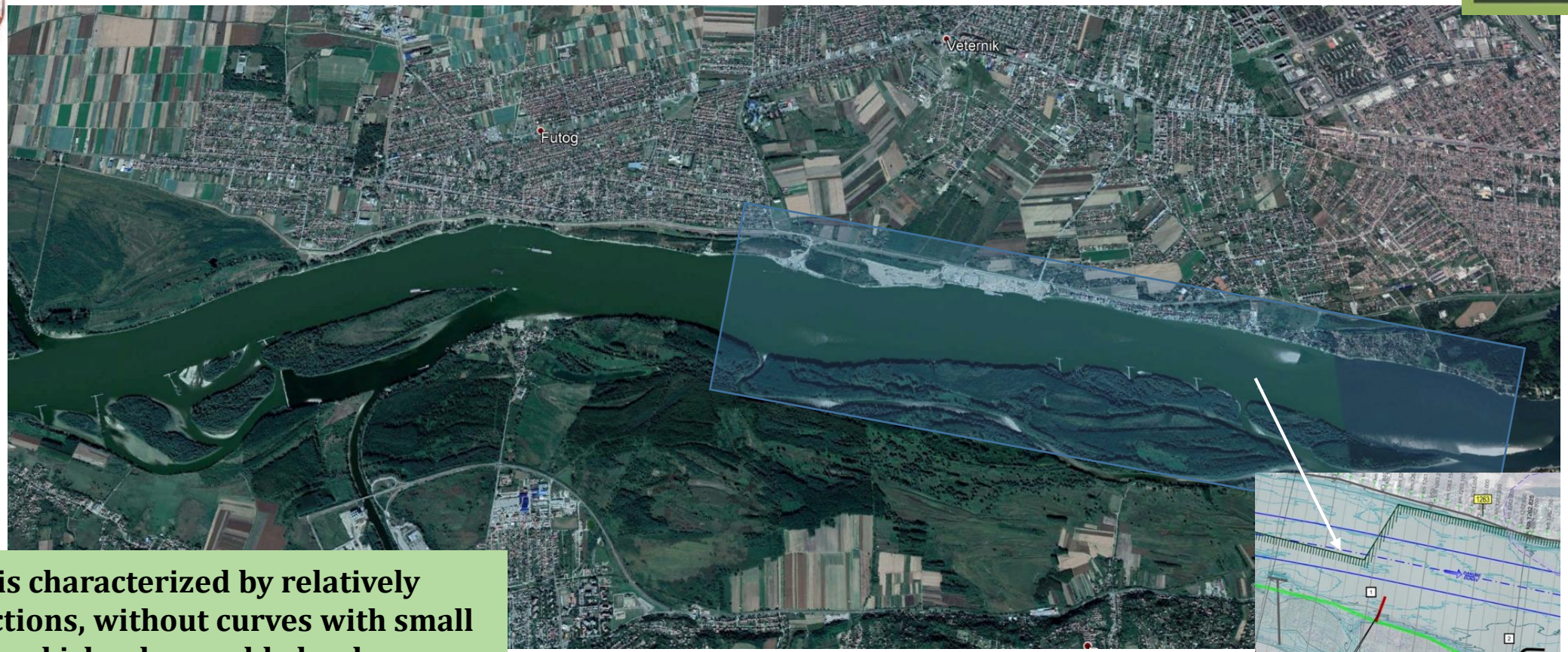
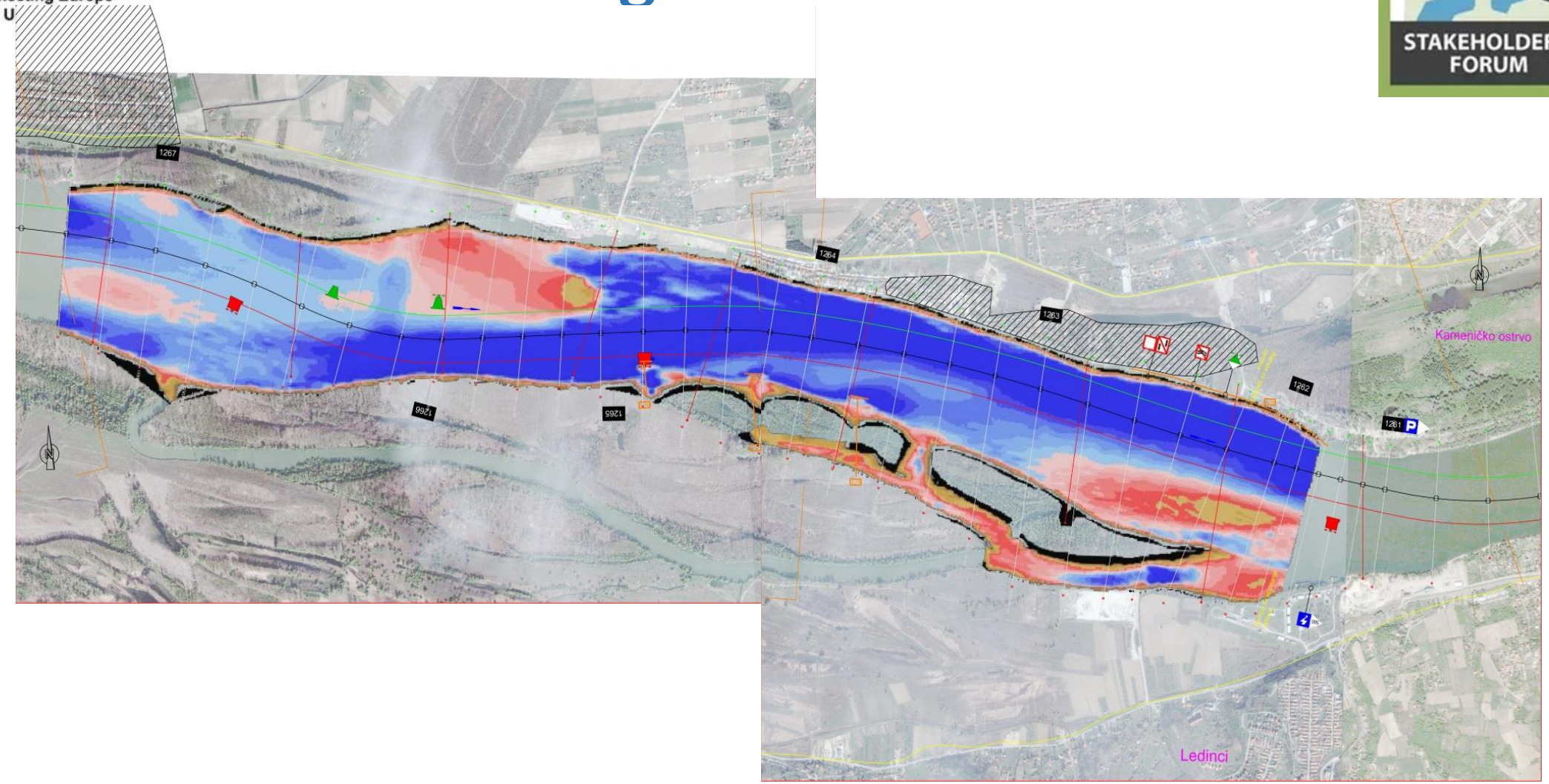
Critical sector „Futog“
(km 1267+400 – km 1261+600)

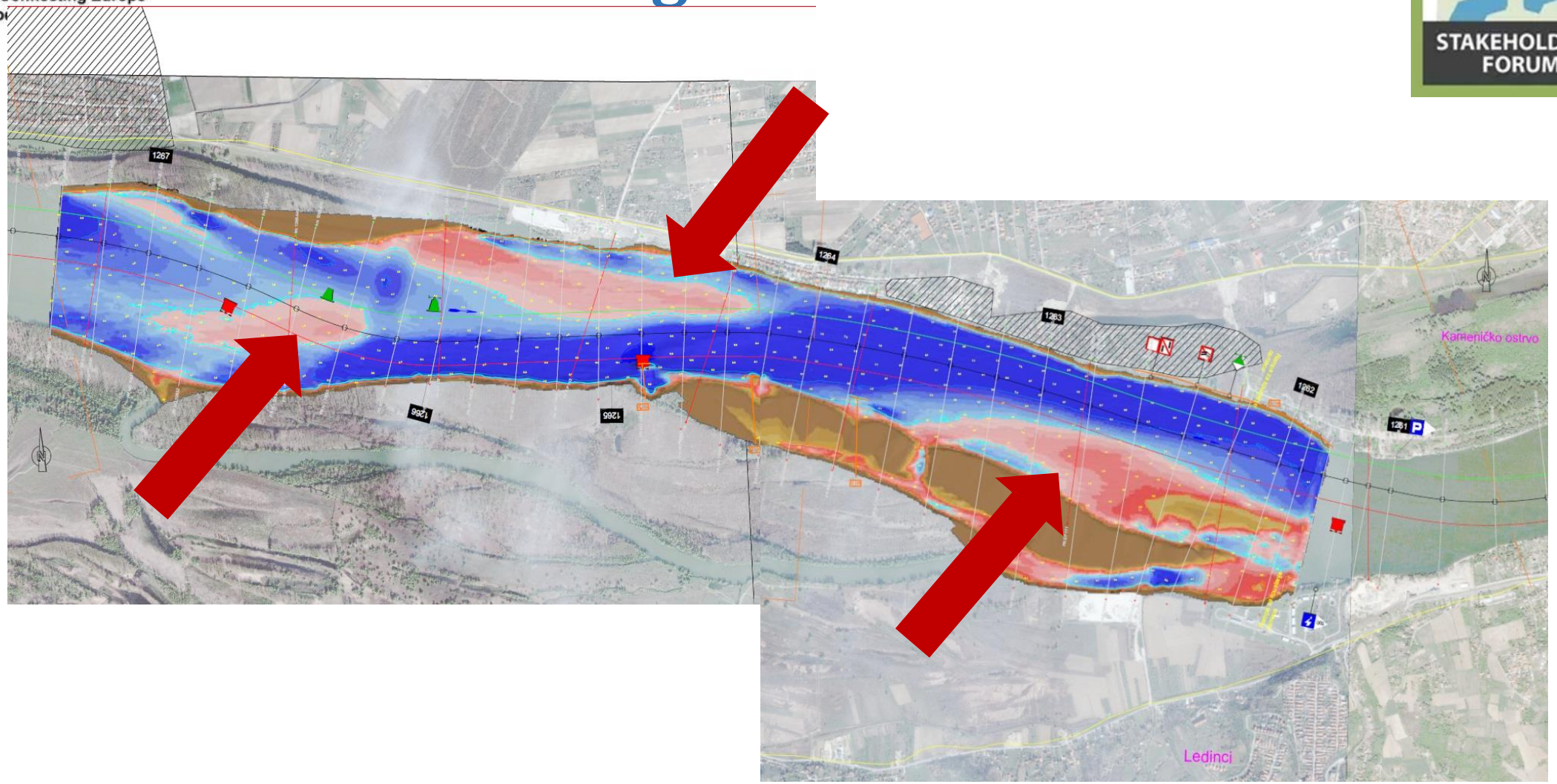


The sector is characterized by relatively straight sections, without curves with small radius, formed island, movable banks, hydrotecnical structures built in the past and the relocation of the main river axis from one bank to the other.

Futog - 2012


1267
1266
1265
1264
1263
1262
1261
Kameničko ostrvo
Ledinci

Futog - 2013


1267
1264
1263
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1261
1266
1265
Kameničko ostrvo
Ledinci

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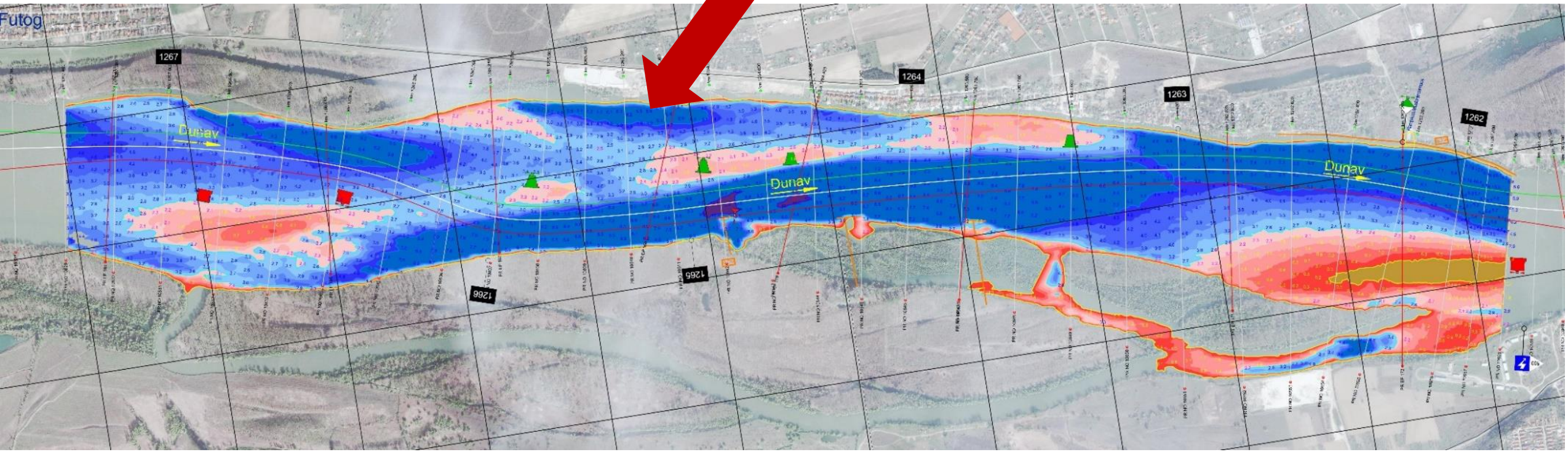
Futog - 2016



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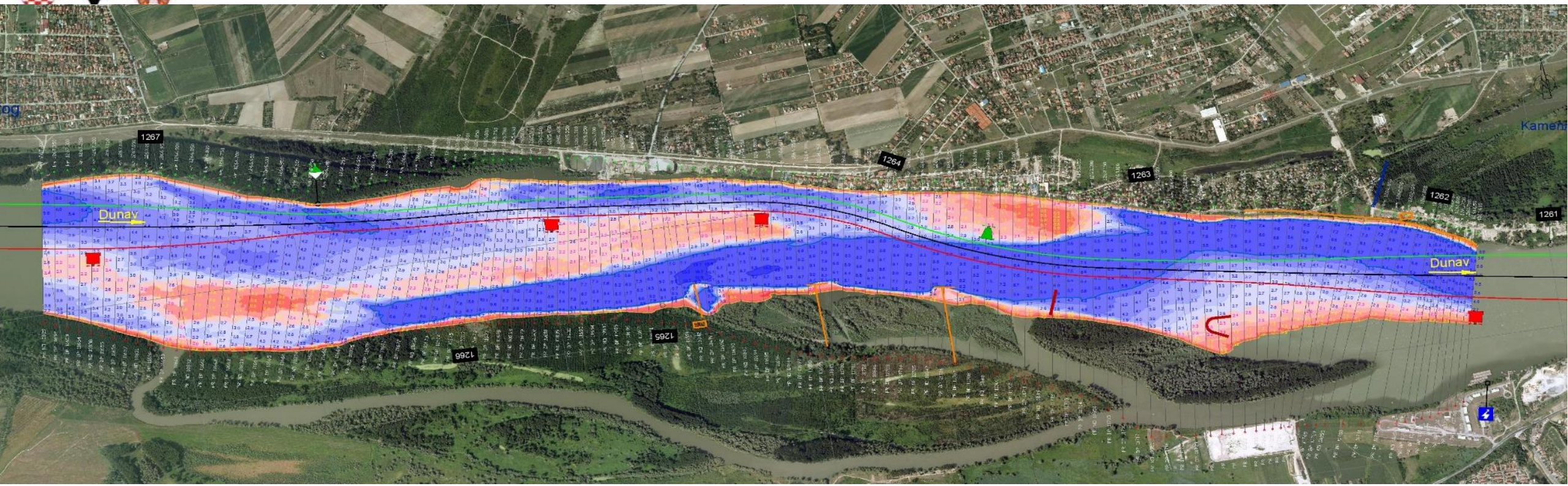
Futog - 2017



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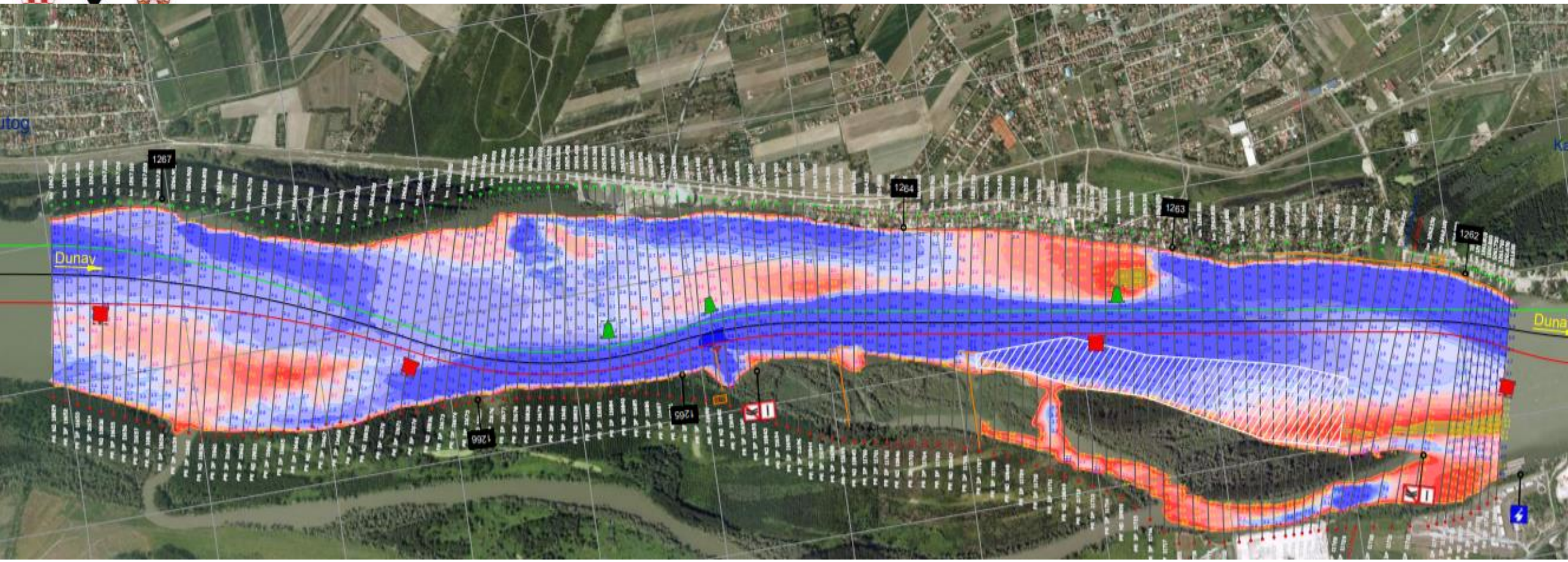
Futog - 2018



Futog - Modelling options

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- **Option 1: Bank protection at left bank, chevrons, sills, groynes at right bank**
- **Option 2: Dredging**
- **Option 3: Detached groyne and chevron at right bank**

Table 22.2. Critical sector #19 - Screening of the options

Option	Effectiveness	Environment	Cost
1	0	-	-
2	-	0	0
3	0	0	0

Based on the ranking and the sensitivity analysis, Option 3 is optimal regarding the required criteria for navigation improvement, environmental impact and cost

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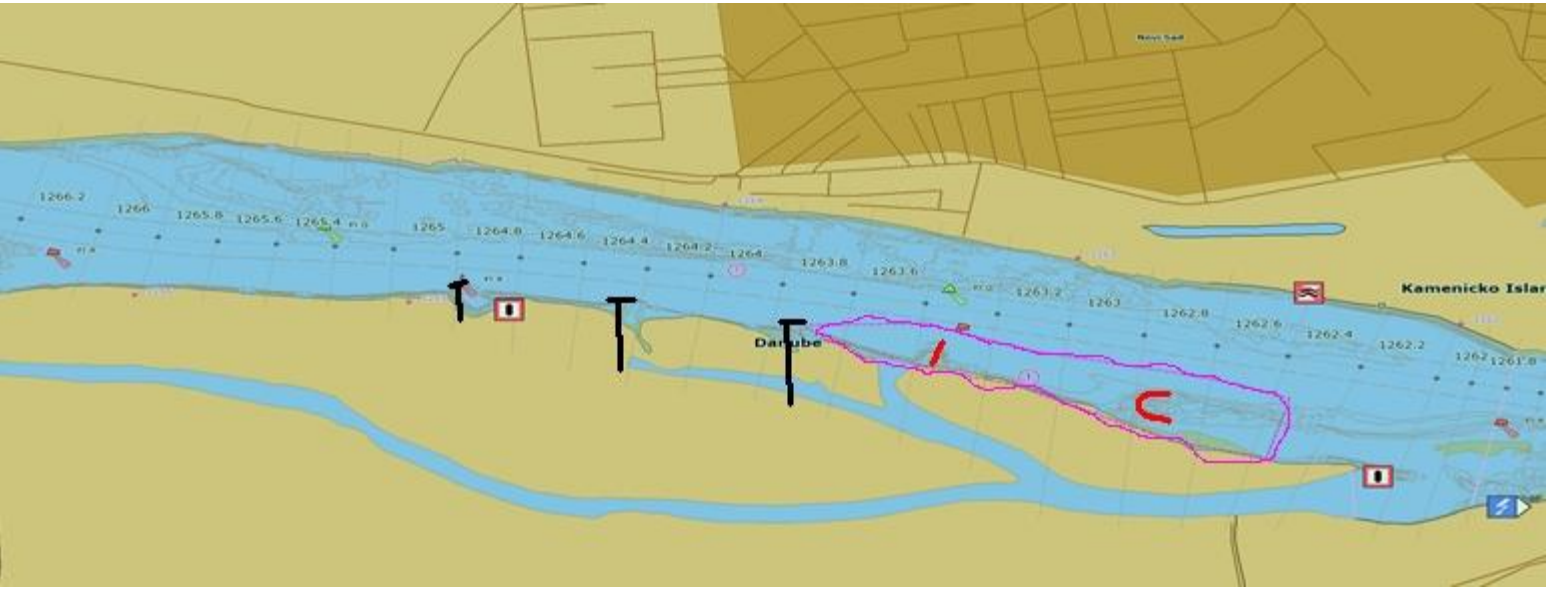
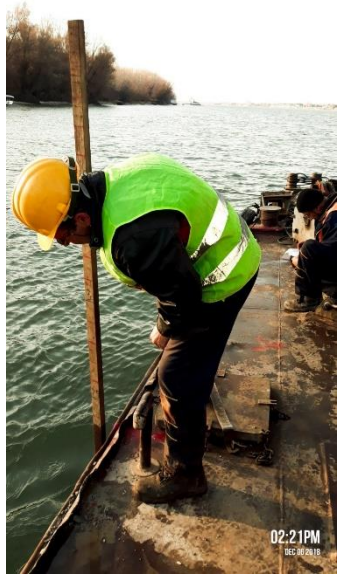
Futog - Effects of newly built hydrotechnical infrastructure

- Start of Works: August, 2018.
- Detached groyne is built at right bank (km 1263+350)
- Chevron is built at right bank (km 1262+800 – km 1262+700)
- All River Training Works on critical sector Futog have been completed on May, 2019.





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Futog - Effects of newly built hydrotechnical infrastructure

- The morphological analysis of the effects of newly built hydrotechnical infrastructure was done for the downstream section of the critical sector Futog (km 1263+400 – km 1261+600)
- Cross sections areas (related to Low Navigation Levels) were used for the morphological analysis
- Deformation of the riverbed was analyzed through cross sections area changes for the period from 2018. to 2023.
- Based on surface differences, percentage of deposition and erosion was calculated for the profiles located downstream from the built hydrotechnical structures (at a distance of 50 m each), as well as the volume of eroded and deposited river sediment

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Futog - Effects of newly built hydrotechnical infrastructure

FUTOG (km 1263+400 – km 1261+600) – 37 cross sections at a distance of 50m				
Time period	Percentage of		Volume of sediment ($x10^3$ m^3)	
	Erosion	Deposition	Eroded	Deposited
2018-2019	73	27	287.9	131.7
2019-2020	92	8	438.3	2.2
2020-2021	35	65	52.3	144.4
2021-2022	58	42	88.6	125.8
2022-2023	40	60	1.3	1.3

Futog - Effects of newly built hydrotechnical infrastructure

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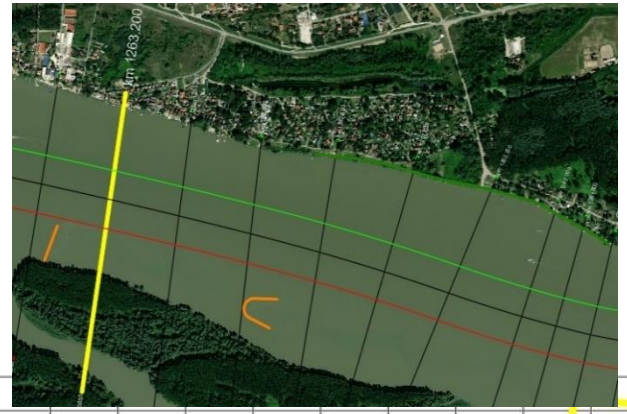
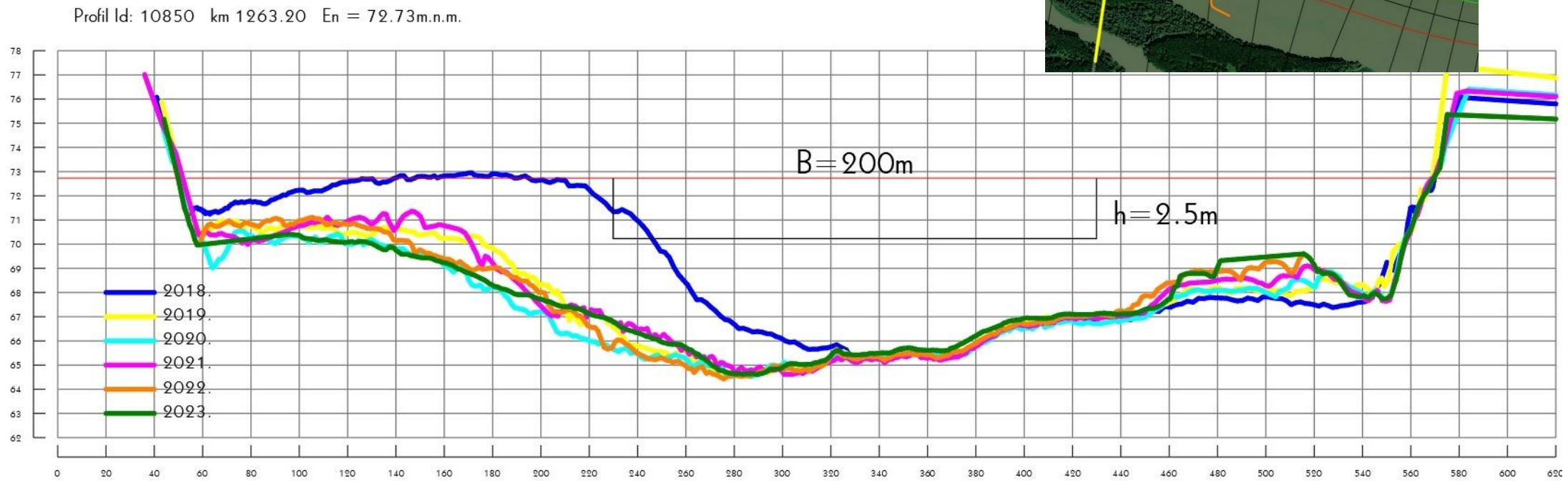
Cross section downstream of the detached groyne (km 1263+200)





Futog - Effects of newly built hydrotechnical infrastructure

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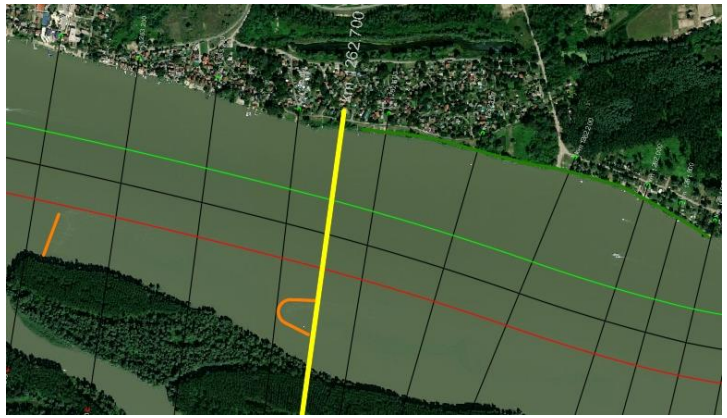
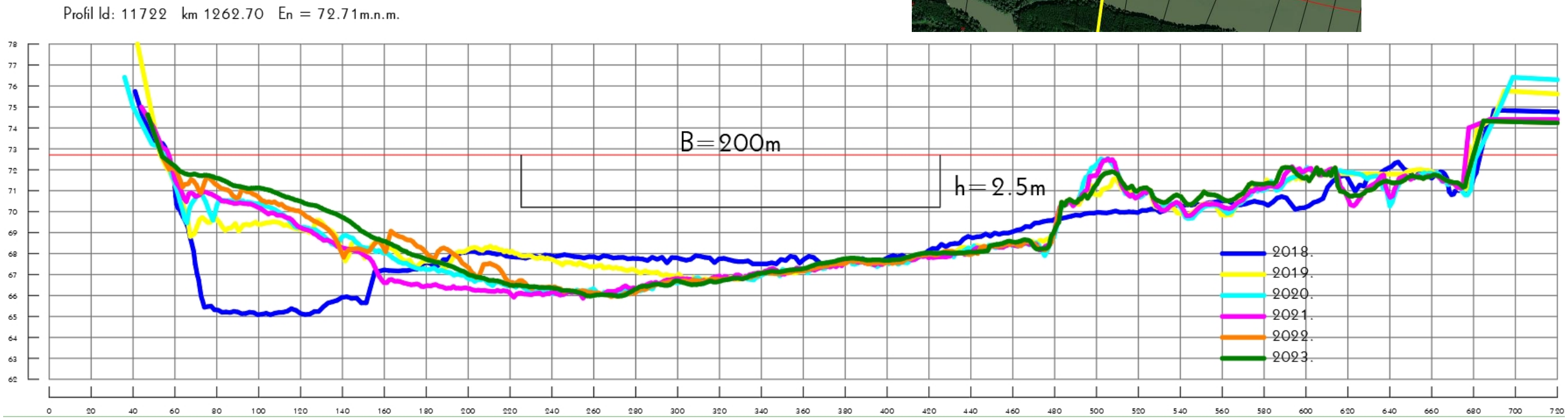
Cross section downstream of the chevron (km 1262+700)





Futog - Effects of newly built hydrotechnical infrastructure

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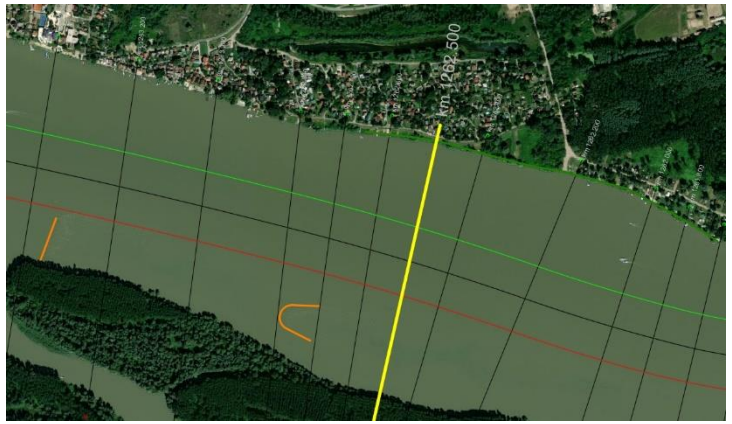
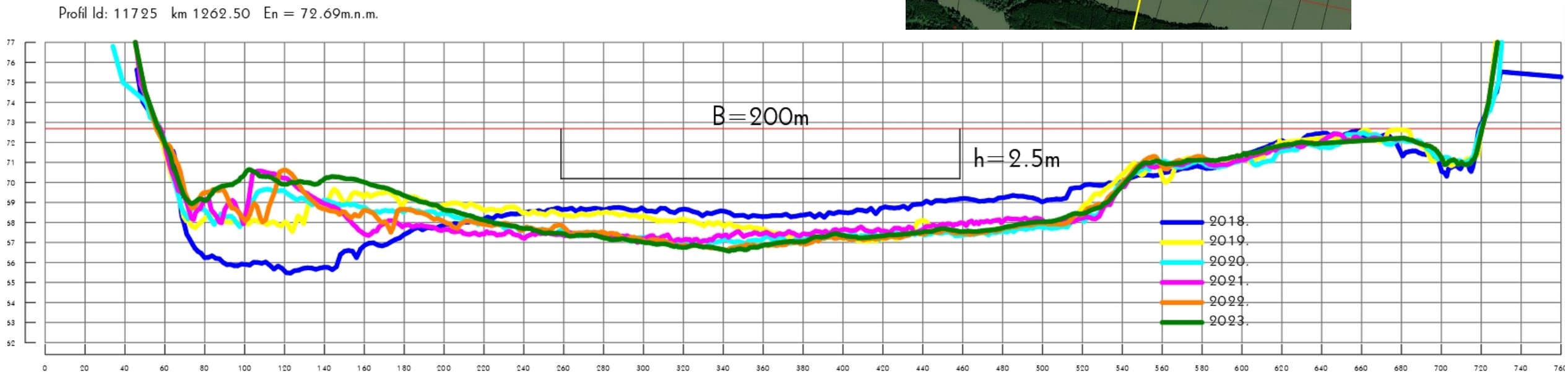
Cross section downstream of the chevron (km 1262+500)





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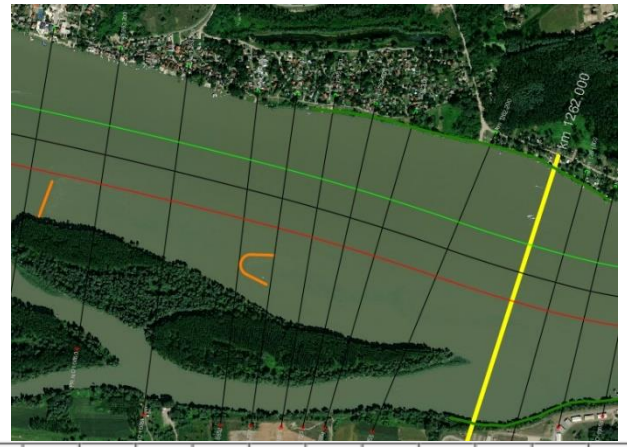
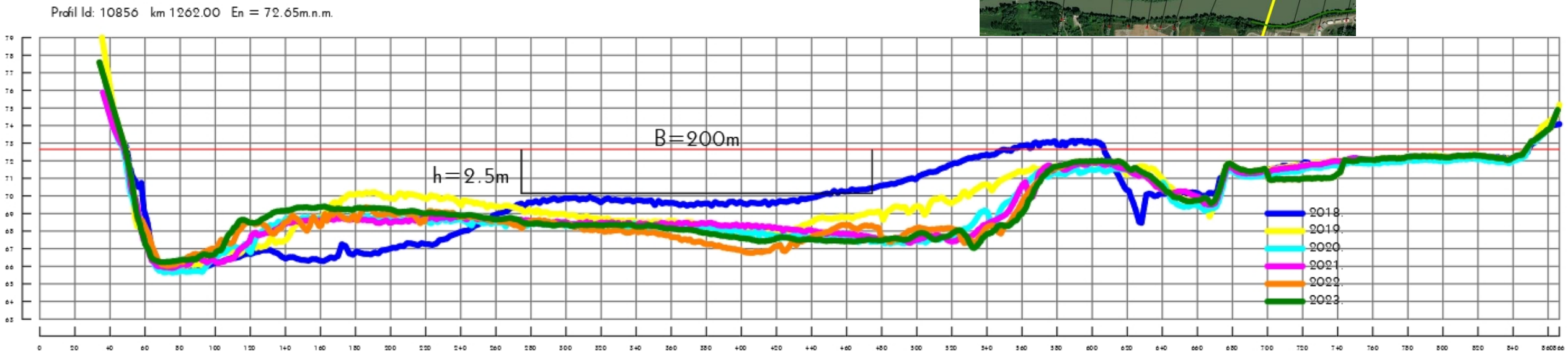
Futog - Effects of newly built hydrotechnical infrastructure

Cross section downstream of the chevron (km 1262+000)





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Futog - Effects of newly built hydrotechnical infrastructure

Conclusions:

- Morphological analysis of the downstream part of the critical Futog sector from km 1263+400 to km 1261+600 showed that the once problematic section of the waterway has become safe and meets the required dimensions of the waterway.
- Favorable morphological development of the riverbed was achieved by the construction of an detached groyn (km 1263+350) and a chevron (km 1262+800 – km 1262+700).
- In order to achieve the continuity of favorable navigation conditions in the critical sector of Futog, it is necessary to carry out regular hydrographic measurement of this sector, and in accordance with the current morphological conditions in the sector, dredging of river sediment in the waterway.

Critical sector „Preliv“ (km 1207+000 – km 1195+000)

- The river widens at the sector Preliv.
- An island with unprotected banks diverts the flow into the main channel and a side channel.
- The main channel is located along the left bank and the side channel is located along the right bank.
- The side channel is wider and shallower than the main channel.
- Due to the presence relocation of the main river axis from one bank to the other, vessels have experienced major navigation limitations in the past.

Critical sector „Preliv“ (km 1207+000 – km 1195+000)

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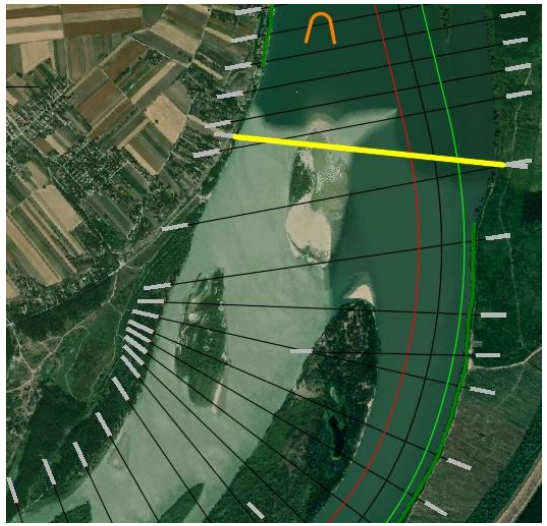
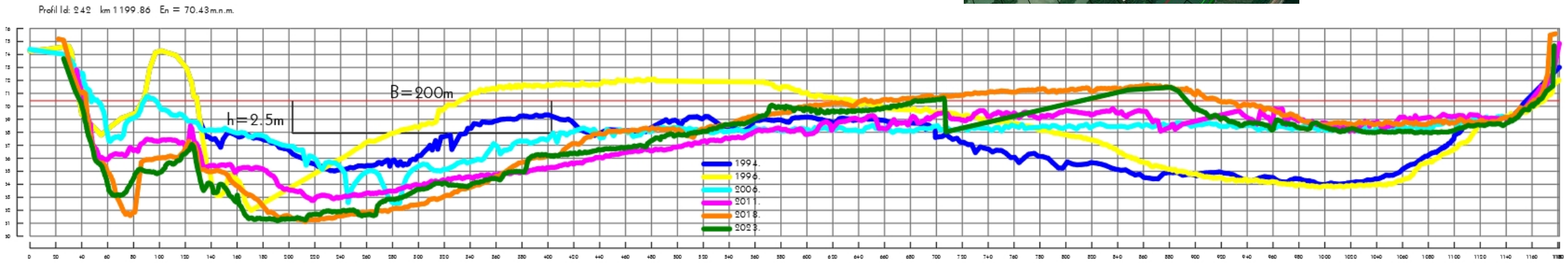
The river bed upstream of the side channel is highly morphological dynamic and the side channel was dominant in the past over the left - main channel.

Morphological changes of main and side channel from 1994. to 2023. (cross section km 1199+860)





Critical sector „Preliv“ (km 1207+000 – km 1195+000)

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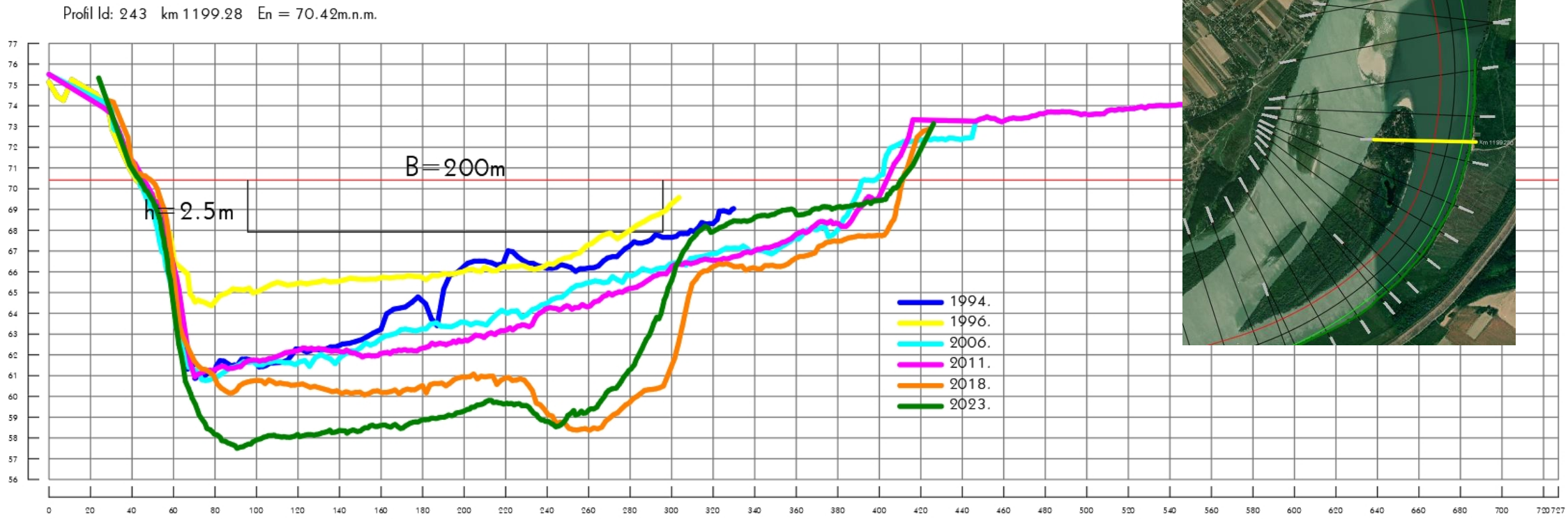
Morphological changes of main channel from 1994. to 2023. (km 1199+280)



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Preliv - Modelling options

- Option 1: Closure bund
- Option 2: Dredging
- Option 3: Chevrons
- Option 4: Chevrons and guiding bund

Table 27.2. Screening of the options

Option	Effectiveness	Environment	Cost
1	+	-	-
2	0	+	+
3	+	+	-
4	+	+	-

Based on the ranking and the sensitivity analysis, Option 3 is optimal regarding the required criteria for navigation improvement and environmental impact

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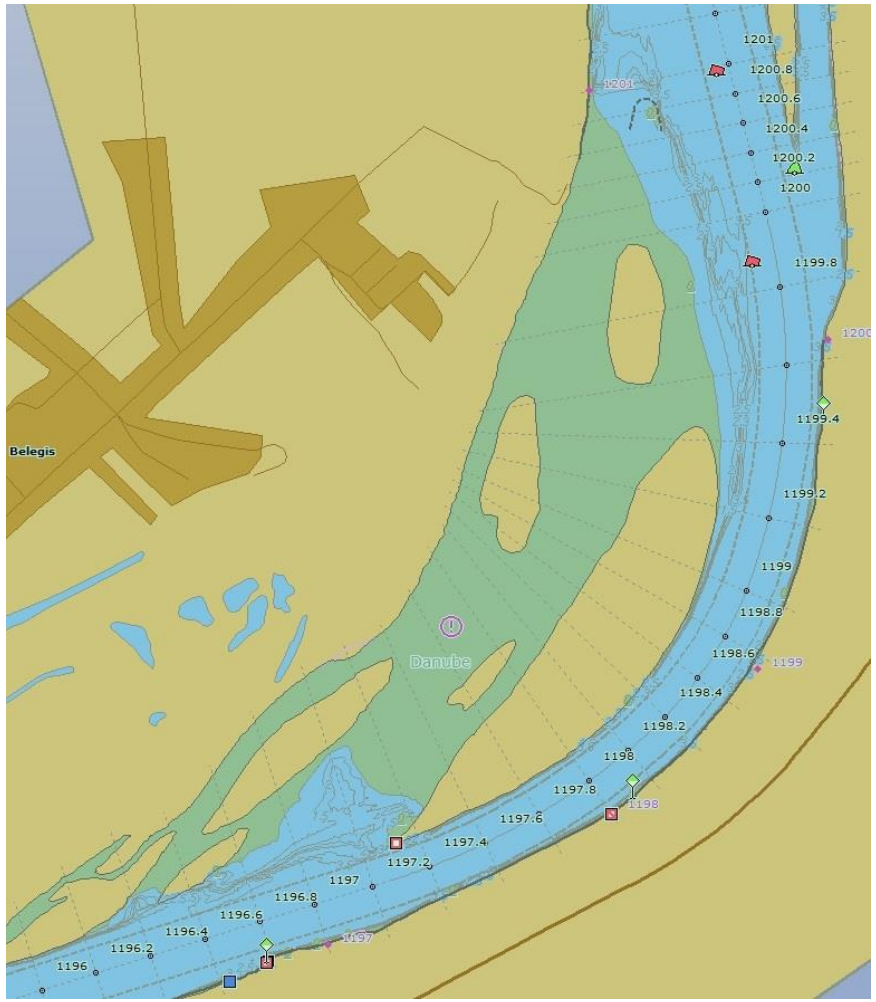
Preliv - Effects of newly built hydrotechnical infrastructure



- **Start of Works: 2018.**
- **Chevron is built at right bank (km 1200+900 – km 1200+700)**
- **All River Training Works on critical sector Preliv have been completed in 2019.**

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Preliv - Effects of newly built hydrotechnical infrastructure

- The morphological analysis of the effects of newly built hydrotechnical infrastructure was done for the downstream section of the critical sector (km 1201+000 – km 1195+000)
- Cross sections areas (related to Low Navigation Levels) were used for the morphological analysis
- Deformation of the riverbed was analyzed through cross sections area changes for the period from 2018. to 2023.
- Based on surface differences, percentage of deposition and erosion was calculated for the profiles located downstream from the built hydrotechnical structures (at a distance of 200 m each), as well as the volume of eroded and deposited river sediment for main and side channel.

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Preliv - Effects of newly built hydrotechnical infrastructure

PRELIV – main channel (km 1201+000 - km 1195+000) – 31 cross sections at a distance of 200m				
Time period	Percentage of (%)		Volume of sediment ($x10^3$ m^3)	
	Erosion	Deposition	Eroded	Deposited
2018-2019	32	68	110.9	335.0
2019-2020	90	10	974.1	1.2
2020-2021	23	77	73.1	263.4
2021-2022	19	81	22.0	355.6
2022-2023	77	19	368.1	42.0

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Preliv - Effects of newly built hydrotechnical infrastructure

6th STAKEHOLDERS' FORUM

PRELIV – side channel (km 1201+000 - km 1196+600) – 23 at a distance of 200m					
Time period	Percentage of (%)			Volume of sediment ($x10^3$ m^3)	
	Erosion	Deposition	no changes	Eroded	Deposited
2018-2019	39	52	31	70.9	212.2
2019-2020	83	13	4	374.9	90.6
2020-2021	61	35	4	87.9	69.6
2021-2022	22	26	52	12.7	118.3
2022-2023	43	52	4	138.1	136.4

Preliv - Effects of newly built hydrotechnical infrastructure

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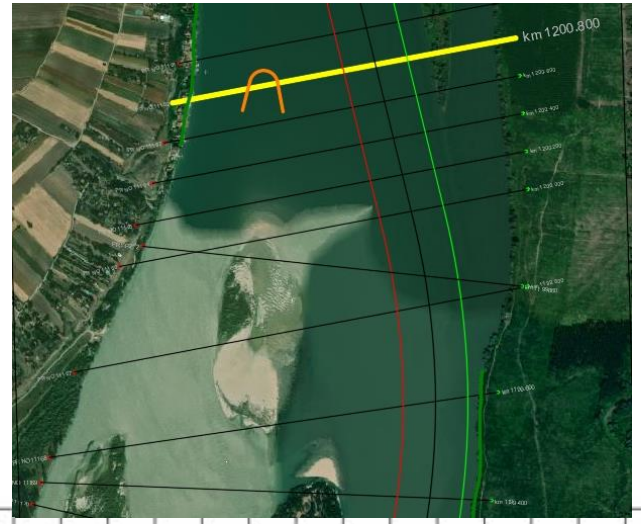
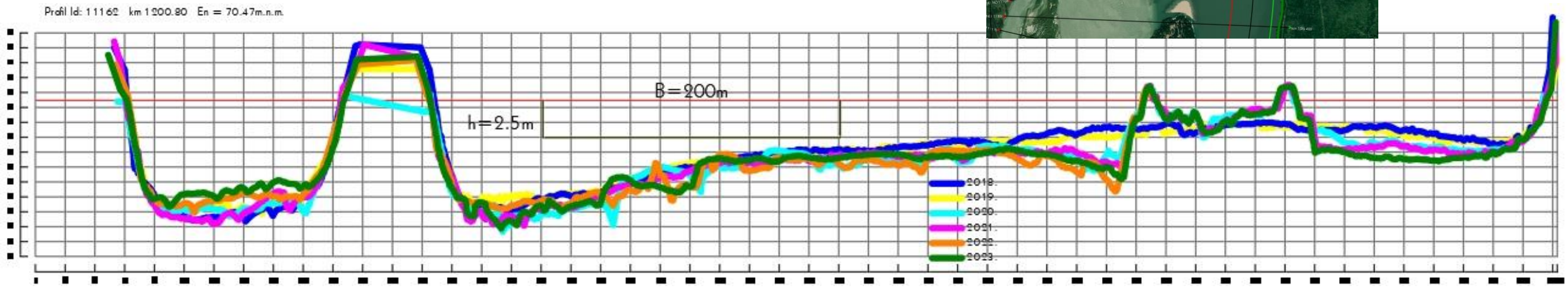
Cross section in the chevron zone (km 1200+800)





Preliv - Effects of newly built hydrotechnical infrastructure

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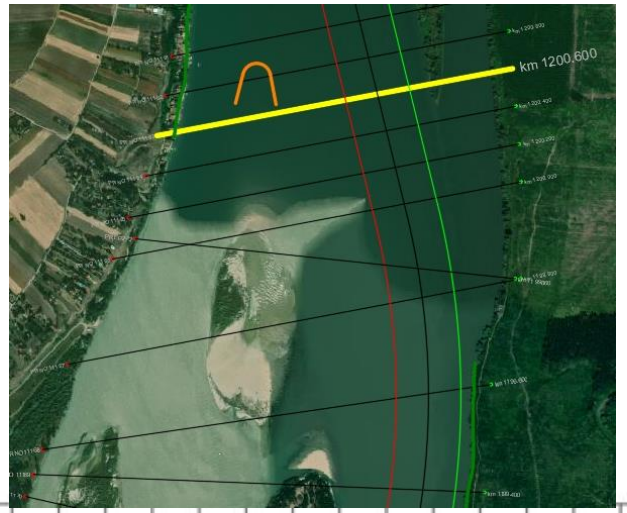
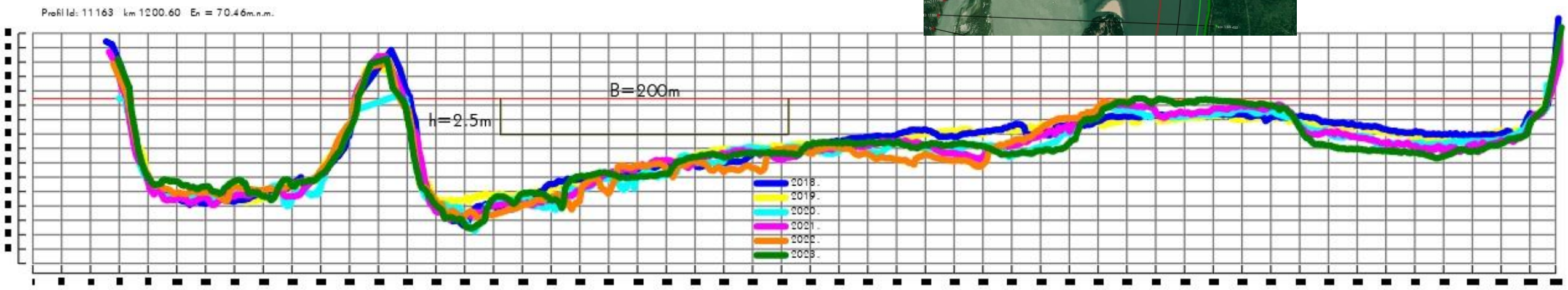
Cross section downstream of the chevron (km 1200+600)





Preliv - Effects of newly built hydrotechnical infrastructure

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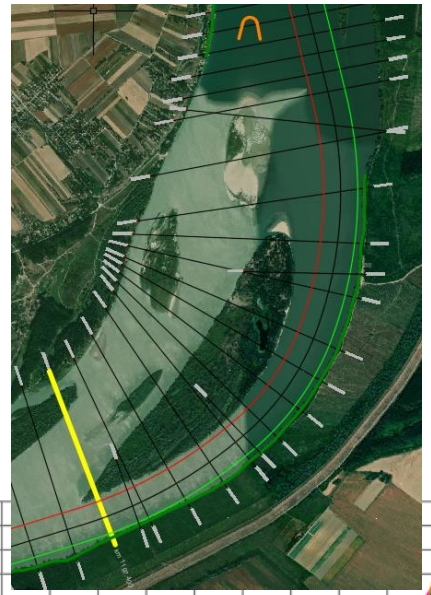
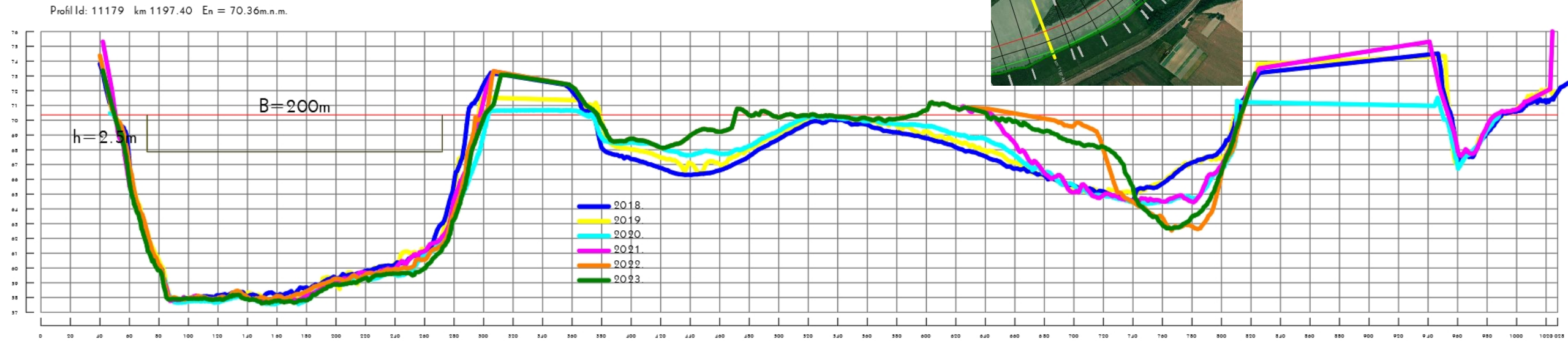
Cross section downstream of the chevron (km 1197+400)





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Preliv - Effects of newly built hydrotechnical infrastructure

Conclusions:

- The morphological analysis of the downstream part of the critical sector Preliv from km 1201+000 to km 1195+000 showed that a favorable morphological development of the bed was achieved by the construction of the chevron (km 1200+900 – km 1200+700).
- Built chevron is effective regarding the required criteria for navigation improvement

Environmental monitoring

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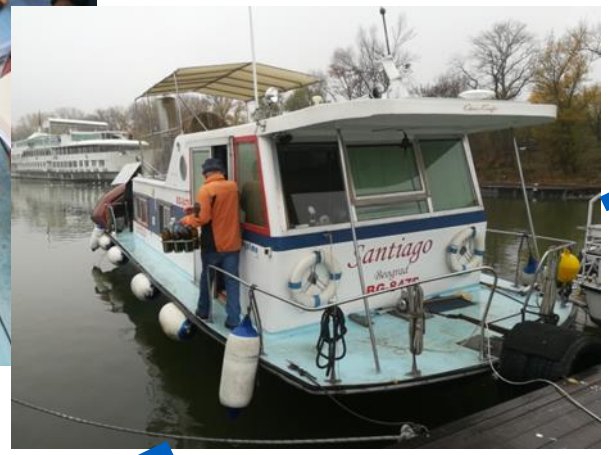
Water quality and sediment monitoring



Biological monitoring

Environmental monitoring

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Report on environmental monitoring **before** the works

Several Reports on environmental monitoring **during** hydrotechnical works

More Reports on environmental monitoring **after** hydrotechnical works

Final report on environmental monitoring

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Thank you for your kind attention

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