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Monitoring of the hydrological, hydraulic and morphological characteristics of the Danube River and inventory of biodiversity components on the joint Croatian-Serbian sector of the Danube River

Final Monitoring Report

for Sub-Activities 2.2 and 2.3

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Abbreviations

EN	Ecological Network Natura 2000
MESD	Croatian Ministry od Economy and Sustainable Development (from May 2024 transformed into Croatian Ministry of Environmental protection and Green Transition)
MSTI	Croatian Ministry of the Sea, Transport and Infrastructure
MCTI	Serbian Ministry of Construction, Transport and Infrastructure
NHC	National Habitat Classification
NP	National Park
PA	Protected Area
HR	Republic of Croatia
RS	Republic of Serbia
WAMOS	Transnational Waterway Monitoring System
WFD	Water Framework Directive

1. INTRODUCTION

Monitoring on the Danube on the Croatian-Serbian sector of the river is an integral part of the international EU project "Preparation of FAIRway2 works on the Rhine-Danube corridor" (hereinafter abbreviated: EU project) which is conducted within the CEF 2014-2020 calls in the field of transport. The project partners in this EU project are the Austrian Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, the Serbian Ministry of Construction, Transport, and Infrastructure (MCTI) and the Croatian Ministry of the Sea, Transport and Infrastructure (MSTI). The EU project is coordinated by "viadonau" from Vienna.

This EU project plans to, among other tasks, through the implementation of monitoring of relevant waterway maintenance parameters and through inventory of the biological diversity components on the joint Croatian-Serbian sector of the Danube, provide the basis for a joint strategy of Croatia and Serbia for the purpose of maintaining the Danube as an important international waterway. Based on the monitoring data collected by the Croatian partner (MSTI), the project partner from Serbia (MCTI) will further redefine the critical priority sections on the common sector of the Danube and analyse their alternative solutions, and all results will be presented within a comprehensive study. This comprehensive study will be the basis for the future joint adaptive management of the Danube in the border zone between Croatia and Serbia, which will simultaneously enable continuous maintenance of the international waterway and ensure the protection of biodiversity and maintenance of natural flood ecosystem services on both sides of the river.

The contract number U-22/00119 (hereinafter: Contract) on procurement services for Monitoring of the hydrological, hydraulic and morphological characteristics of the Danube River and inventory of biodiversity components on the joint Croatian-Serbian sector of the Danube River (hereinafter abbreviated as: Monitoring on the Danube) was signed between The Ministry of the Sea, Transport and Infrastructure of the Republic of Croatia (hereinafter abbreviated as: Beneficiary or MSTI) and the Consortium Oikon Ltd. from Zagreb, Hidroing Ltd. from Osijek and Vodoprivredno-projektni biro JSC from Zagreb (hereinafter abbreviated as: Contractor) on 18 January, 2023, with an 18-month execution period.

The contract is implemented through realization of all monitoring and inventory activities, and through the creation of a GIS database, as shown in the project task, which is an integral part of the contract. Monitoring on the Danube is contracted in the following scope, and is divided within the Contractor's team in the following manner:

- Inventory of river regulation infrastructure (Hidroing, www.hidroing-os.hr)
- Riverbed hydrographic surveying (Vodoprivredno-projektni biro, www.vpb.hr and MMPI)
- Calculation and measurement of sediment velocity and flow (Hidroing, www.hidroing-os.hr)
- Piezometer installation (Hidroing, www.hidroing-os.hr)
- Fish inventory (Oikon, www.oikon.hr)
- Habitat inventory (Oikon, www.oikon.hr)
- River benthos type inventory (Oikon, www.oikon.hr)
- Bird inventory (Oikon with subcontractor Croatian Society for the Protection of Birds and Nature, www.ptice.hr)
- Establishment of a geoinformation system (Oikon, www.oikon.hr).

The research area is provided in **ANNEX 1** where 17 critical sections along the Danube River are marked (see Figure 1-1 below also).

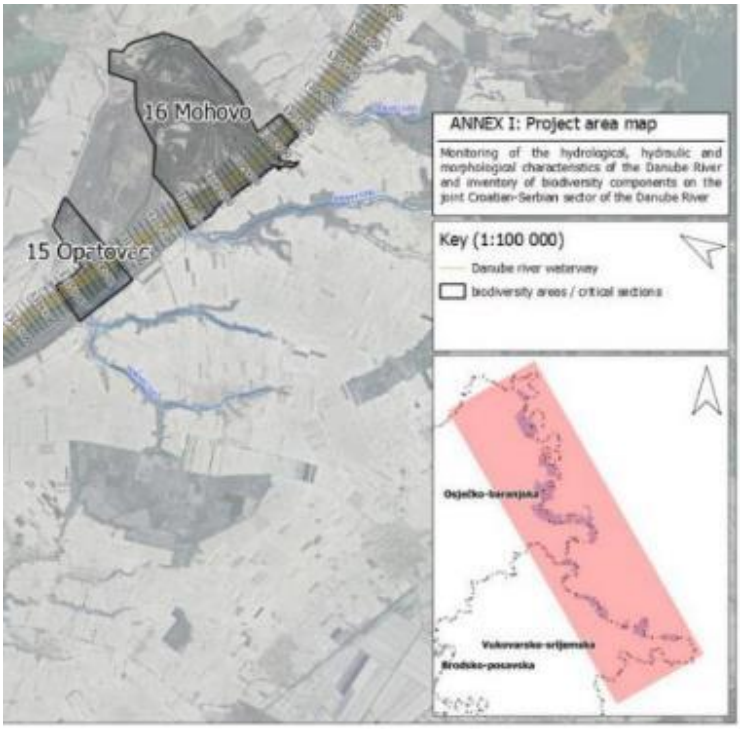


Figure 1-1: Segment of the project area map

It should be noted that the Croatian-Serbian sector of the Danube is one of the ecologically best preserved river sections along the entire Danube and is therefore of supra-regional importance in terms of nature conservation (Kerstin Bock & Arno Mohl, WWF AT). The section of the Danube affected by the infrastructure project largely form the core zone of the 5-country Biosphere Reserve. In this area nature conservation is of top priority. The Croatian-Serbian Danube hosts:

- 50% of the most natural river stretches on the first 2,000 km (ICPDR 2014/21)
- most natural floodplains on the first 2,000 kilometers (source to Iron Gate) → corresponds to 50% of all river stretches with intact floodplains on the Danube (ICPDR 2014/21)
- the largest floodplain forests on the entire Danube River
- 5 large protected areas totalling about 82,000 ha (2 nature parks, 2 nature reserves, Natura 2000 and Emerald sites → all included in the 5-country Biosphere Reserve)
- the highest breeding density of white-tailed eagles in continental Europe (over 100 breeding pairs)
- the most important fish spawning area (Kopacki Rit) next to the Danube Delta
- probably the last refuge for the almost extinct ship sturgeon (*Acipenser nudiventris*).

It should be noted also that:

- 89% of critical sections along the Croatian-Serbian sector of the Danube River are situated in the core zone of the 5-country Biosphere Reserve Mura-Drava-Danube
- 11% of this critical sections are situated in the buffer zone of the 5-country Biosphere Reserve Mura-Drava-Danube.

During project development, care was taken to harmonize the results with the previously conducted research methods and inventories on this sector of the Danube, as far as this was possible and justified, and priority was given to harmonizing with databases on monitoring biological diversity in NATURA 2000 areas according to the Habitats Directive (Directive 92/43/EEC of 21 May, 1992 on the conservation of natural habitats and wild fauna and flora) and the Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council of 30 November, 2009 on the protection of wild birds) and with databases on the monitoring of the hydrological, hydraulic and morphological characteristics and biological components of water conditions according to the Water Framework Directive (Directive 2000/60/EC of the European Parliament and the Council of 23 October, 2000).

All contracted field activities, data processing and analysis activities and the establishment of a geo-information system for monitoring on the Danube were carried out within the given deadlines, and below, within the framework of this Final Monitoring Report, an overview of all performed activities is given with an emphasis on the course and method of field data collection. In addition, a presentation of the difficulties during project implementation, a presentation of further activities related to use of the project results, and a concluding presentation of the achieved dynamics of Monitoring on the Danube are given.

Recommendations are also given in this Final monitoring report for the implementation of further activities related to monitoring of the joint Croatian-Serbian sector of the Danube River. The main objective is to use the obtained results in the best possible way to satisfy the needs of future adaptive management of the Danube in the border zone between Croatia and Serbia, i.e. for the purpose of continuous maintenance of the international waterway in synergy with protection and/or restoration measures of biodiversity and natural hydrological processes.

Below presented hydrographic survey of the Danube using the "single-beam depth gauge" (chapter 3.1.2.1) was supplemented by the presentation of the hydrographic survey using the "multi-beam depth gauge" (chapter 3.1.2.2), which was carried out separately and was not the scope of this contract, in order to gain insight into the preparation of all necesaary input data that will be used within this EU project for the preparation of the joint strategy of Croatia and Serbia for the purpose of maintaining the Danube as an important international waterway.

2. PERFORMED PROJECT ACTIVITIES

2.1. Monitoring of relevant waterway maintenance parameters

2.1.1. Inventory of all river regulation infrastructure

Overview

Preparation was conducted and a preparatory meeting was held with the Beneficiary (1 February, 2023), where the Beneficiary was presented with the approach to the inventory of regulation structures related to navigation, and open issues were discussed (photo documentation on the condition of regulation structures with recording shots locations, conditions on the possible use of a drone for filming certain regulation structures etc.).

All documents received from the Beneficiary were downloaded, reviewed, and analysed, especially documents "Cadastre - schematic form of buildings" and "Cadastre - tables".

All necessary permits for the implementation of field works in the border area have been collected - see Chapter 3, Table 3-1).

Digitalization of the downloaded cadastral forms and tables of all water structures related to navigation was carried out, and a preliminary map of the project area was created showing the locations of regulation structures on the joint Croatian-Serbian section of the Danube. The map is divided into several overview maps, which were presented in a separate document: *Current Status Analysis* (mark: I-2206/23; Hidroing Ltd. Osijek, April 2023). These overview maps of regulation structures by section were used as a basis for field work.

All equipment has been prepared and team members have been appointed to carry out the field work.

Based on the Terms of Reference and the agreement from the preparatory meeting, the methodology of the inventory implementation was elaborated. The methodology is as follows:

Text box 2-1 Methodology for inventory of regulation structures

Methodology for inventory of regulation structures

In accordance with the available documents "Cadastre - schematic form of buildings" and "Cadastre - tables", which are an integral part of the Project Terms of Reference and the contract, it is necessary to determine the condition of all regulation structures on the entire joint Croatian-Serbian part of the Danube.

In order to prepare for the inventory and determination of the condition of the structures, existing cadastral tables will be digitized and a preliminary map of the project area will be created showing the locations of all buildings included in the inventory. The preliminary map will be created according to the cadastre, and with the help of satellite images of the joint Croatian-Serbian section of the Danube, will be used as a basis for field work.

For the purposes of the actual inventory of all regulation structures related to navigation, all structures shall be:

• geodetically surveyed (i.e. spatial and elevation recording of the structure crown), namely:
- revetments (beginning and end of the structure, visible damage if necessary)
- groynes and parallel structures (beginning and end of the structure, base in the bank)

• photographed and documented at water levels that allow a visual inspection:
- photos must contain location data (GPS coordinates) so that they can be displayed within the interactive map of the project area (photographs to be taken at least once from the upstream side and once from the downstream side)
- structures should be photographed from several sides for the purpose of a detailed visual impression
- photographs can be taken from the land or from the river, but also from the air (drone recording) if there are no obstructions from vegetation.

After the field work, the structures shall be analysed and processed in several textual and graphic forms:

• textual (table):

- structure designation,
- name and type of structure,
- location of the structure,
- length and elevation of the crown of the structure,
- condition of the structure

• graphically:

- the layout plan of all regulation structures with a display of the structure designation: the content shall encompass all regulation structures surveyed during field work, aligned with data from cadastre
- structures will be marked according to the following description:

Figure 2-1: View of the regulation structure (example)

Designation guide:

- 1431 – river kilometer of the structure
- D1 - right bank first object (L = left bank)
- 1431+070 – exact river kilometer of the structure

An example of a table view is given below:

Table 2-1: Example of a tabular overview

Right bank						
No	**Structure designation**	**Name and type of structure**	**Location of the structure (rkm or rkm range)**	**Length of the structure [m]**	**Crown elevation of the structure [m a.s.l.]**	**Status of the structure**
1	1431-D1	T-groyne	1431	206	82,95	Good

Field work activities have been monitored to ensure high(er)visibility of the structures and have been conducted during October 2023. 78 existing objects on the right bank have been identified; 89 objects on the left bank.

Data gathered:

- Geometry data and Geodetic survey (length of the structure, geodetic points, structure profile, location in rkm)
- Foto-documentation (geo-located)
- Assessment of the current state/functionality
- Identification of extent of damages (where applicable)

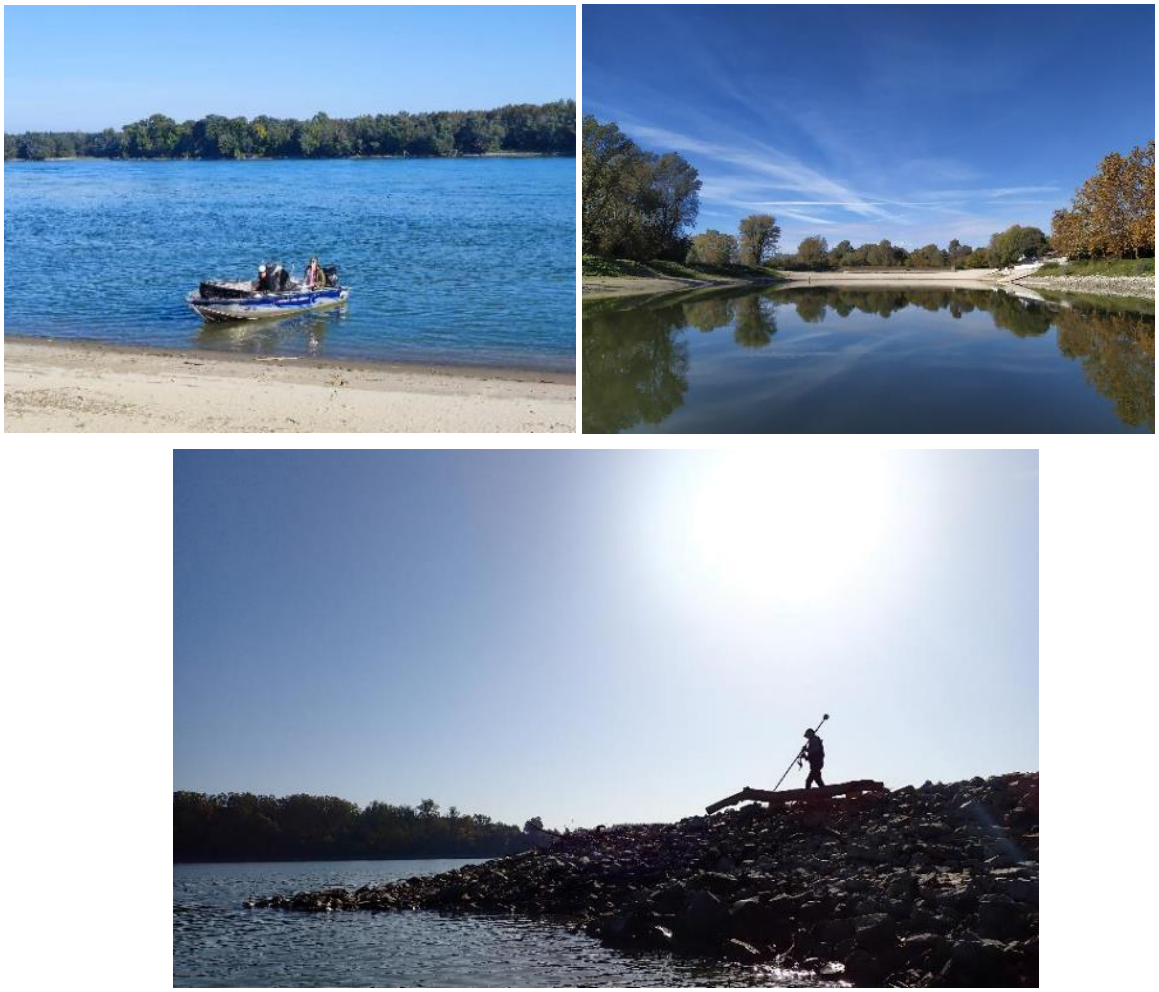


Figure 2-2 Inventory activities (October 2023)

Results

Upon completion of all field works, the obtained data were processed within the Elaborate "Inventory of river regulation infrastructure related to navigation" (see: **ANNEX 7**) and the following textual and graphic representations were given in the Elaborate (see example below, Figure 2-3):

- Serial number of the structure on the left or right bank
- River regulation structure name (e.g., 1423 – river kilometre of the infrastructure, D5 - right bank, fifth object (L = left bank))
- Structure type: revetment, groyne, T-groyne, parallel structure, imported fills or barrier
- Chainage of the river regulation structure – exact river kilometre of the structure, for groynes and barriers in river kilometres, and for revetment, parallel structures and imported fills, the range from river kilometre to river kilometre
- Length of the river regulation structure in meters (for groynes length parallel with the fairway).
- Crown or toe elevation of river regulation structure in meters above sea level (m a.s.l.)
- Mark and page number in the "Cadastral Register"
- Location of the structure on an orthophoto image
- Pictures of the structure
- Analysis of the condition of the structure (functionality, state and additional notes)

Functionality of the structure is described according to the function it performs in river regulation:

Structure type	**Possible functionalities of the structure**

Barrier	Barrier on backwater flow blocks the flow of the backwater at low water levels/Performed the function of partitioning the flow/Not in the function of blocking the flow of the backwater at low water level.
Revetment	In function/Not in function to protect the bank from erosion at low/medium/high water levels.
Groyne	Effect of material deposition ongoing/non-functional/finished (upstream, downstream). Performed the function/In function/Not in function of moving the bank into the riverbed by backfilling upstream and downstream of the structure.
Parallel structure	Performed the function/In function of moving the bank in the riverbed by backfilling upstream and downstream of the building.
Imported fill	In function of preventing further coastal erosion.

The condition of structures was evaluated in four categories:

- Bad condition
- Satisfactory condition
- Good condition
- Excellent condition

Below is an example of the analysis of a regulation structure.

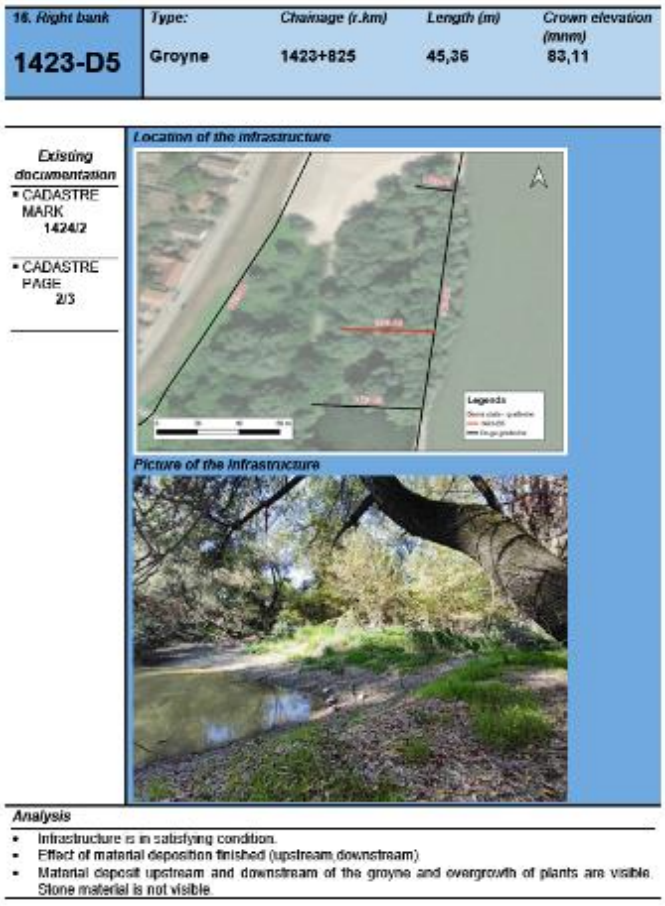


Figure 2-3: Example of graphical and textual description of a river regulation infrastructure

The Elaborate, in addition to the tabular/graphical analysis described above, also contains the layouts of regulation structures with a display of the building designation, i.e. structure characteristics recorded during the field visits which are aligned with records from the cadastre of buildings. After processing, the results of inventory of regulation structures were included in the MMPI's GIS database.

2.1.2. Riverbed hydrographic surveying

2.1.2.1. Single-beam hydrographic surveys

Overview

Preparation was carried out and a preparatory meeting was held with the Beneficiary (1 February, 2023), at which the Beneficiary was presented with methodology for hydrographic measurement, and some open questions were discussed (the influence of hydrology on the dynamics of the survey, preparation, and analysis of results on earlier surveys).

All materials received from the Beneficiary were taken over, examined, and analysed, which include the following:

- Previous geodetic and hydrographic measurements of the relevant section of the Danube River from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary),
- Characteristic navigable water levels of the Danube (NPV, VPV),
- Danube waterway from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary),
- Transport technology bases (data on ship movement (logs of navigation), traffic elements, traffic data, cargo structure, passenger ship traffic, etc.),
- Water level/flow measurement data at the Batina, Aljmaš, Vukovar and Ilok hydrological stations.

All necessary permits for the implementation of field works in the border area have been collected (see Chapter 3, Table 3-1).

Based on the project assignment and the agreement from the preparatory meeting, and on the basis of the downloaded materials, the surveying methodology was developed.

According to this methodology, surveying should be carried out with a single-beam depth gauge on 1376 control profiles (profile density is 100 meters, from coast to coast), as well as recording with a single-beam depth gauge on 8 control profiles on the Drava River [from 0+000 to 0+800, profile density is 100 meters, from coast to coast]. When surveying, an integrated measurement system is applied as a combination of GPS-RTK and depth gauge (Figure 2-4).

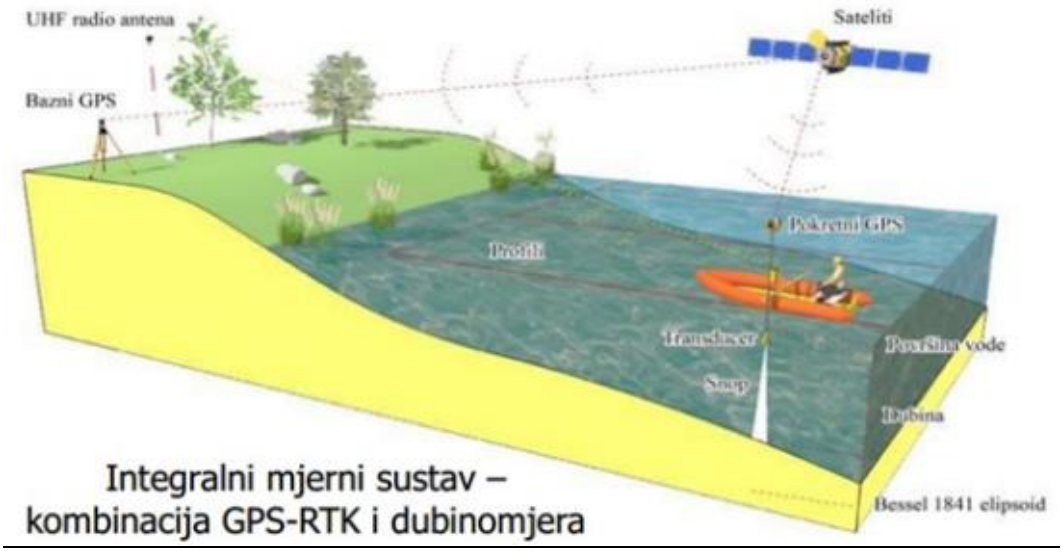


Figure 2-4: Schematic representation of the integrated measurement system

All the equipment and the vessel have been prepared (Figure 2-5) and the team members have been appointed to carry out the field work, and in cooperation with the Beneficiary, the positions of the cross-section profiles of the Danube have been set and verified by the Beneficiary.

Figure 2-5: Vessel used for hydrographic surveys

Text box 2-2 Methodology for hydrographic surveying

Methodology for hydrographic surveying

System preparation and data collection

Before any project, the system needs to be adjusted in order for the stored data to comply with project requirements.

The GNSS instrument was adjusted using GPS Configurator software where the types of record and record transfer parameters are selected. The records from the GNSS instrument associated to Hypack 2016a and HydroBox 2.45 were the following:

- GGA - 3D location and accuracy data
- GST - GPS Pseudorange Noise Statistics
- GSV - Satellite data
- VTG - Vector track and Speed (of navigation)
- ZDA - Date and time (possibility to harmonize the software with the GNSS instrument) (URL1)

Identical parameters have to be adjusted in all software and instruments in order for the communication to be valid.

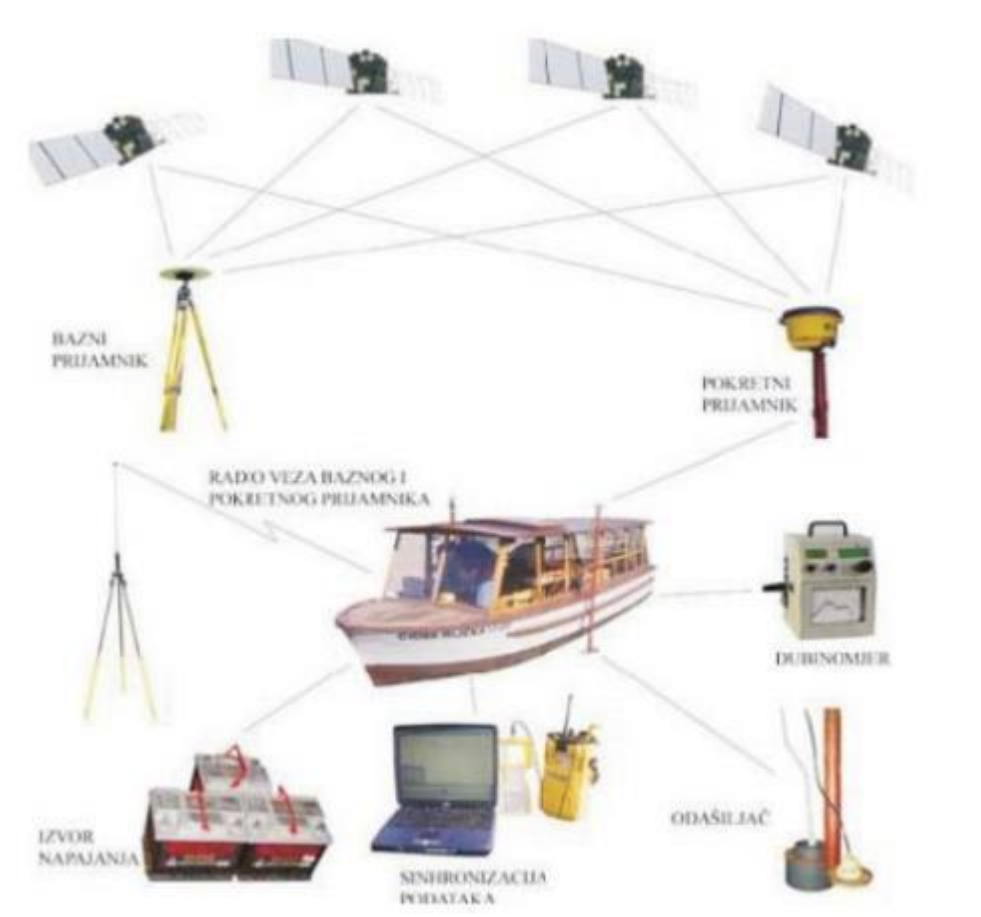


Figure 2-6: Overview of operation of the system for underwater survey of riverbeds, lakes or sea (UNEP/PAP/MAP/RAC 1997)

The parameters (ellipsoid, projection, parameters for transformation, geoid model) for the project area had to be associated to Hypack2016a. Identical parameters also had to be adjusted in the controller (TSC2) of the GNSS instrument which simultaneously transmits data to the said instruments. The Hypack 2016a for parameter adjustment is presented on Figure 2-7.

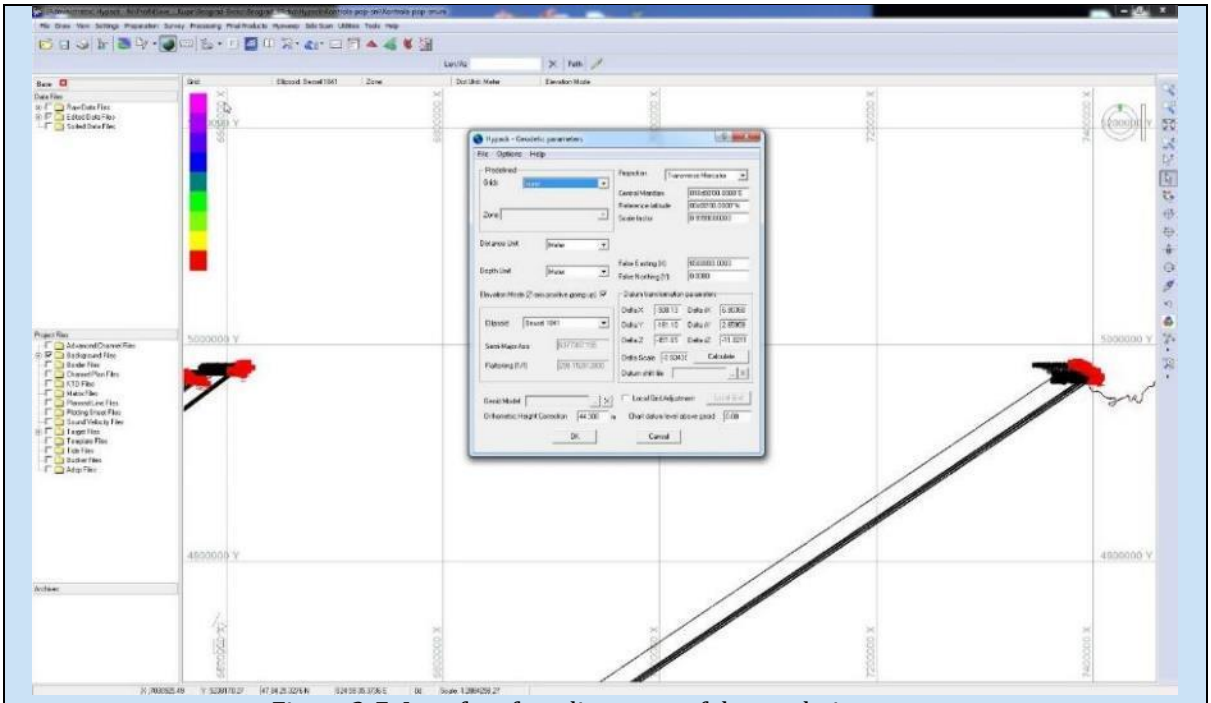


Figure 2-7: Interface for adjustment of the geodetic system

The planned positions of cross sections are also entered into Hypack 2016a in one (*.dxf) of the foreseen formats and into the controller (TSC2) in order to make real-time precise positioning in relation to the planned positions of cross sections. In this way, two people have insight into the position of the boat and direction of navigation, by means of which the precision of navigation per cross section improves, which contributes to data more suitable for the development of a 3D model and improves the safety of navigation.

Hypack 2016a has an option to store data on WGS84 ellipsoid, local date and an ellipsoid of local date. The data that the system can record and derive from the application are presented on Figure 2-8. This simplifies the data processing possibility and the results themselves are better "cleansed" from different negative impacts on the quality of surveying.

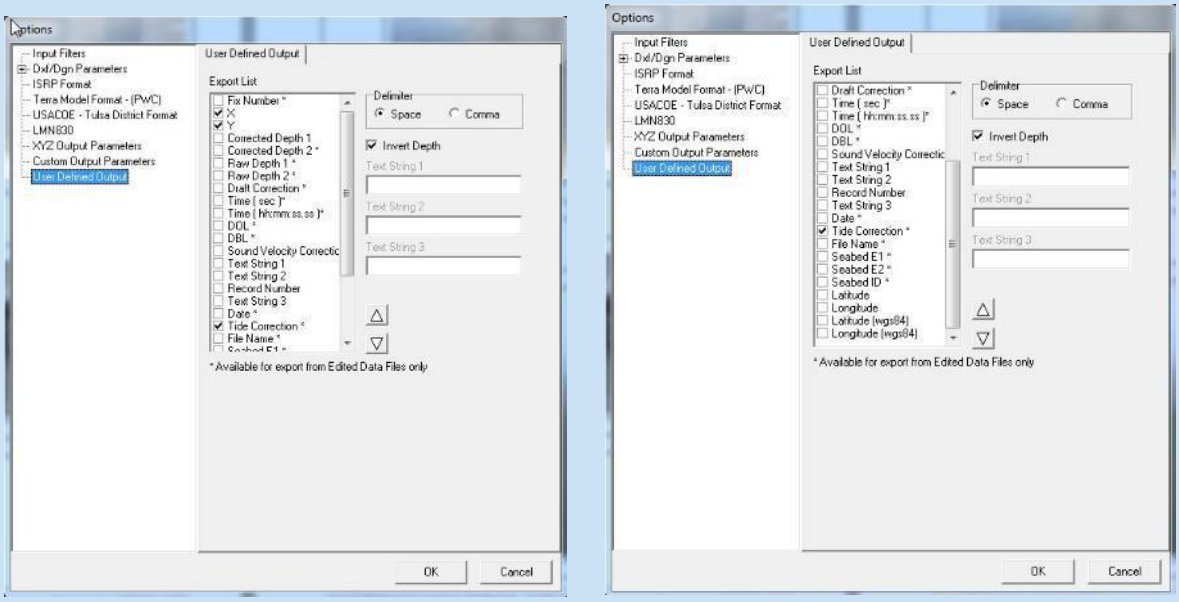


Figure 2-8: Options for data storage and output from

When observing, it was important to pay attention to the latency test, because considering the speed of the boat, the acoustic signal can return incorrect information about the position of the current depth.

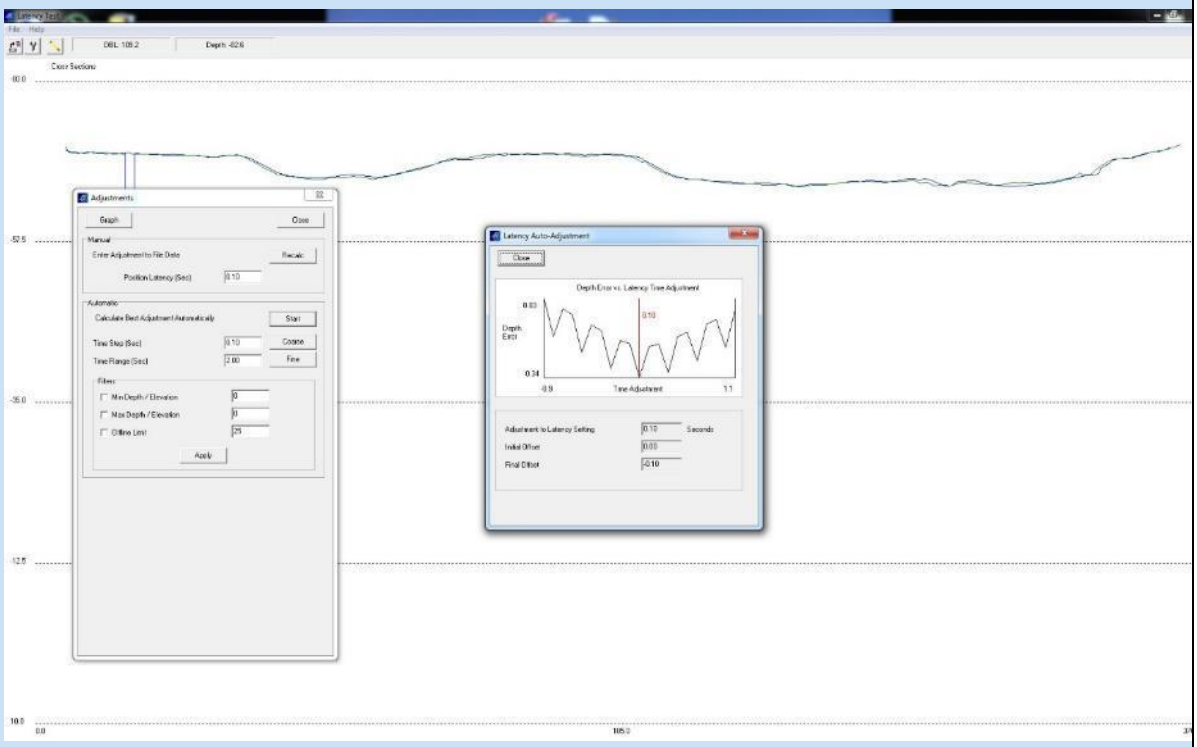


Figure 2-9: Latency test

Every day before the start of the survey, water temperature was checked as an indicator for the speed of sound in the water. The obtained data was checked with at least one control measurement of data obtained from the echo sounder and direct readings from the staff gauge.

It is important to note that certain areas have a weak or non-existent mobile connection, which resulted in the fact that it was not possible to access the CROPOS data. This was mostly noticed in the areas of Kopački rit and the village of Dalj as presented in Figure 2-10.

Figure 2-10: Locations of weak or no-mobile signal

Data processing

After field work, profiles must be processed. As a first step, data should be cleaned. A profiles cleaning process was applied due to noises related to waves, mud, obstacles, branches, fallen trees, fishes, river traffic, water swirls, etc. On Figure 2-11 and Figure 2-12, fallen trees on the river present a situation in the field when is difficult or even impossible to approach the coast for security reasons. In such cases, the whole profile could not be recorded, but it was finished in point of safe return to the river.

Figure 2-11: Branches, fallen trees

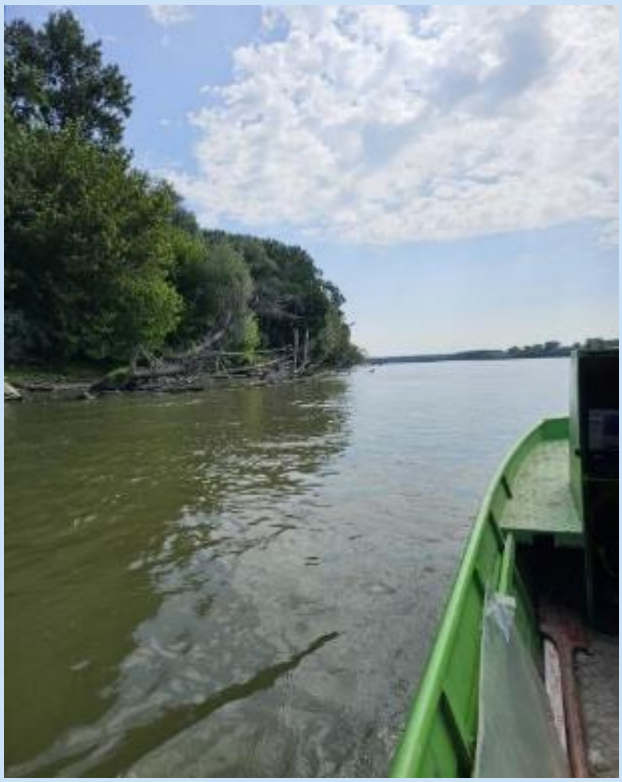


Figure 2-12: Branches, fallen trees

This was done with Hypack 2016a software and the Single Beam Editor tool. In this tool it is possible to identify different noises in the data and thento be cleaned and pre-processed. Recorded cross-section in noise cleaning tool is presented on Figure 2-13.

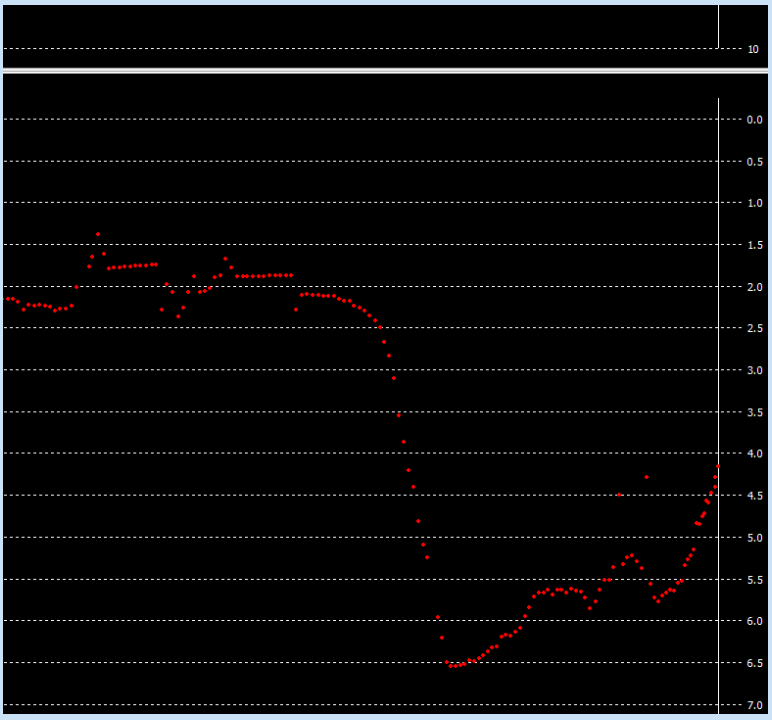


Figure 2-13: Noise cleaning

After cleaning the data, it is necessary to align points on cross-profile line as preparation for the 3d model build process. Therefore, considering it is impossible to drive ideally along the designed lines, it was necessary to place the recorded points on the defined lines. While points are on line, the created models better represent the terrain itself. In any case, data after cleaning noises and before alignment on cross-section lines are delivered to MSTI as well. On Figure 2-14 are presented recorded paths of surveying (grey dots) and cross-section lines (red lines). Sometimes, when water is too shallow, the surveying path departs more significantly from the cross-section line. It was done in order to collect more data and using them with the surveyed position represents useful data for various purposes.

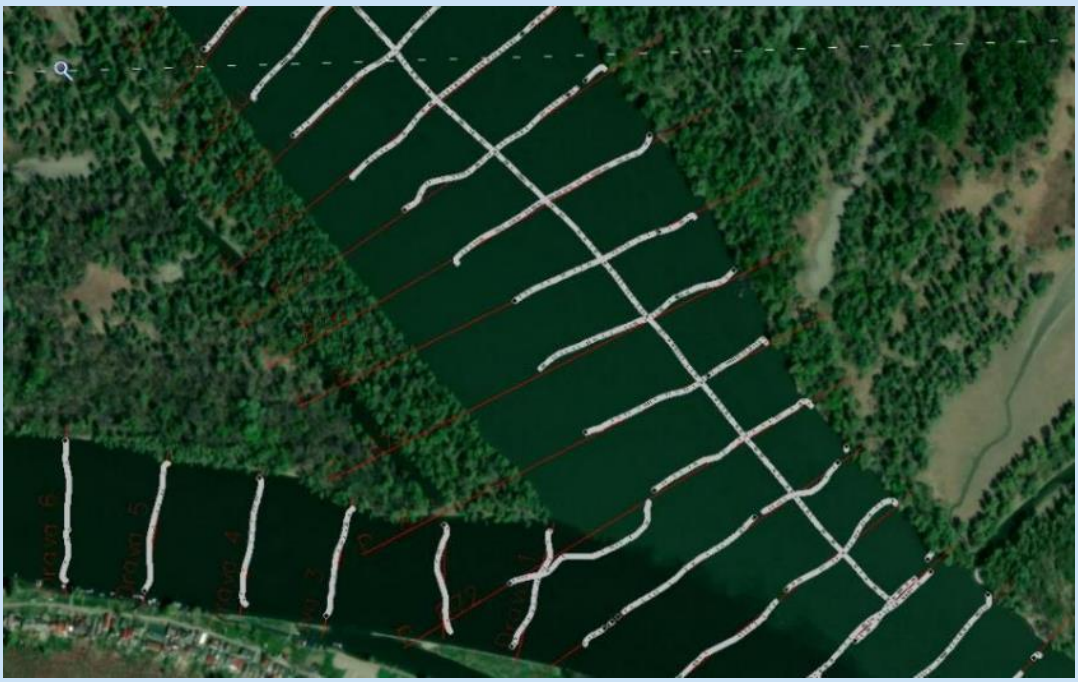


Figure 2-14: Driving according to profiles

Figure 2-15 represents position of surveyed, cleaned and aligned data on cross-section profiles.

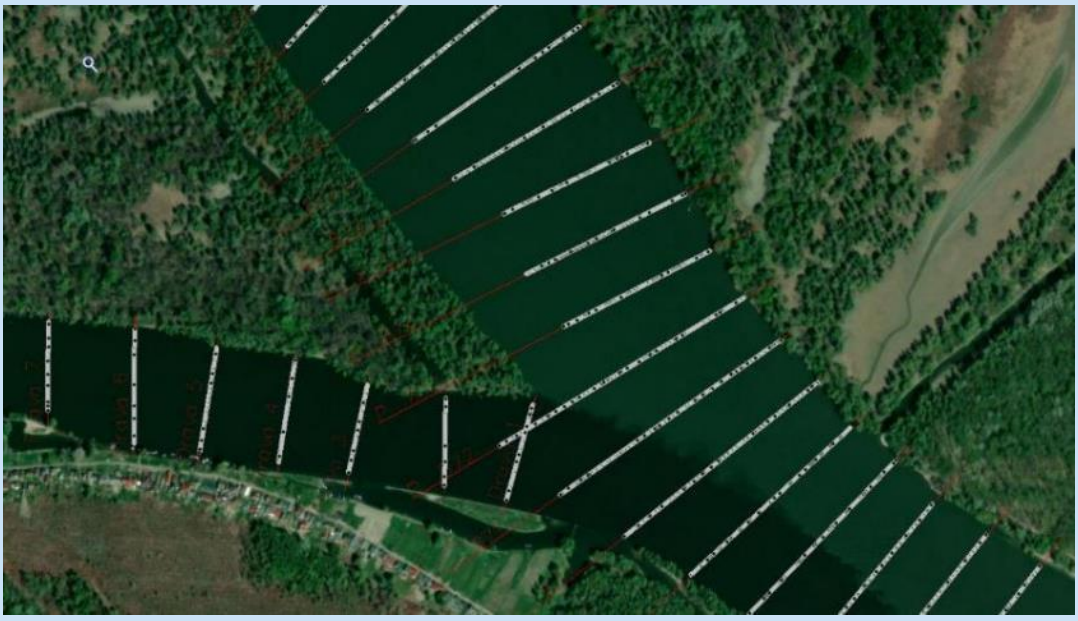


Figure 2-15: Placement of points by profiles

Data results

After aligning the profiles to the defined lines, a 3D model of the riverbed was created. 3d model was created based on aligned data. Figure 2-16 is an example of a 3D model in Drava river inlet in Danube River where warmer colours represent higher riverbed, while colder represent lower riverbed. Perspective on same area is presented in Figure 2-17.

Figure 2-16: 3D model overlaid with digital ortho-photo

From such a 3D model, various three-dimensional views are possible:

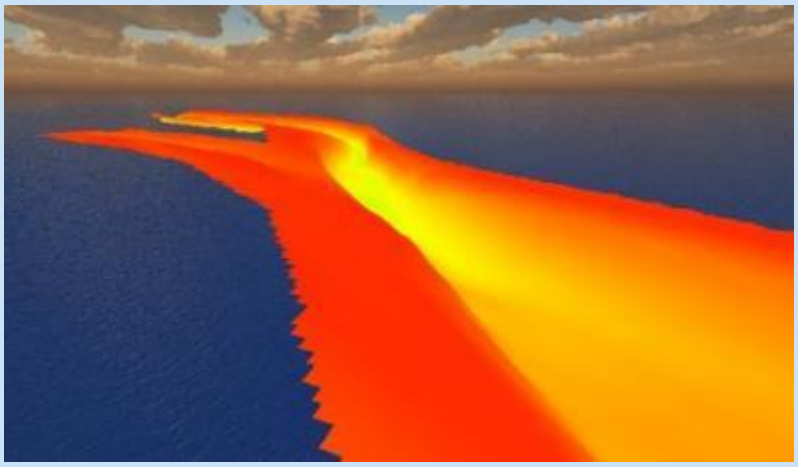


Figure 2-17: 3D model of the confluence of the Danube and the Drava River

Also, it is possible to add water level animation in the 3d model as presented in Figure 2-18 at 73.30 m *(HVRS71)*

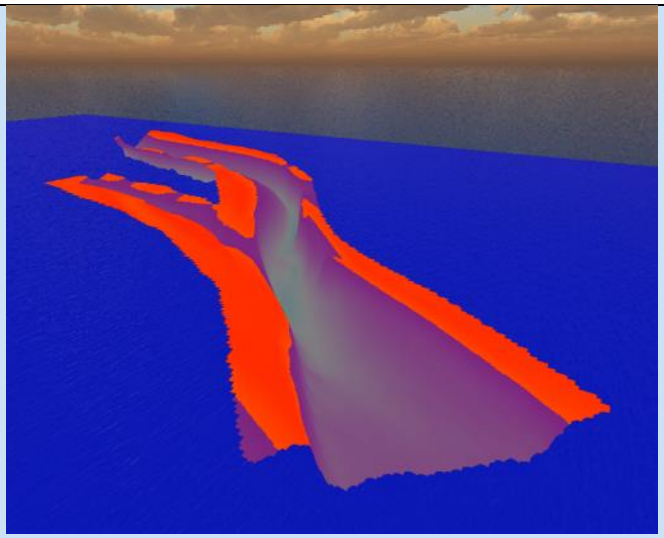


Figure 2-18: 3D model with water level animation at 73.30 m (HVRS71)

It is possible to view cross sections or longitudinal profiles that can be exported to various CAD or other formats. Due to the nature of the Danube River, different shapes of cross-section profiles are possible as show in Figure 2-19, Figure 2-20 and Figure 2-21.

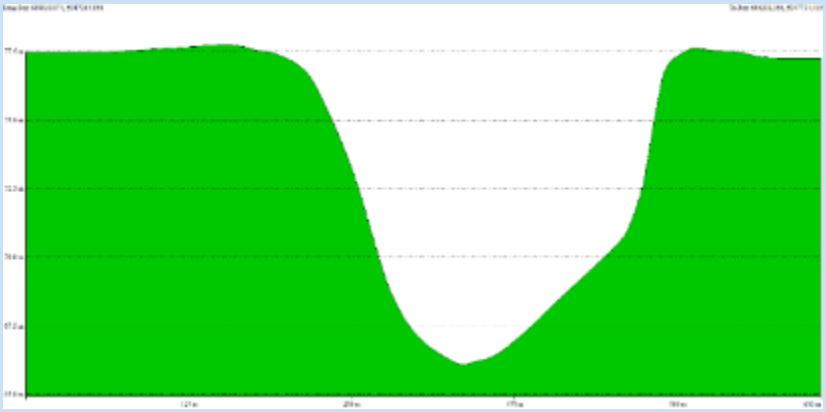


Figure 2-19: Cross section example 1.

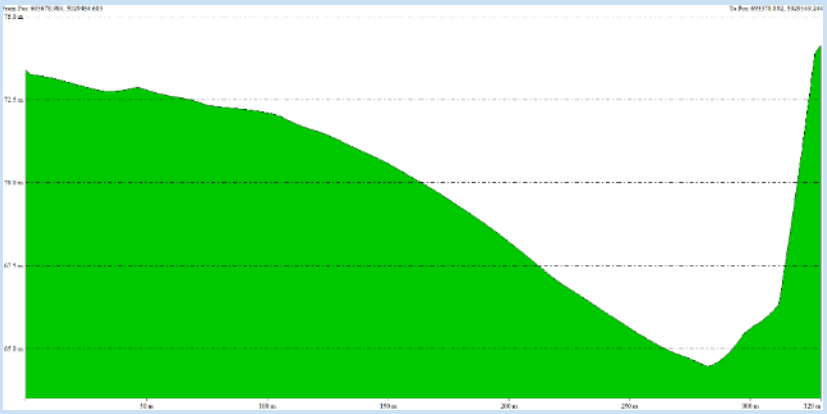


Figure 2-20: Cross section example 2.

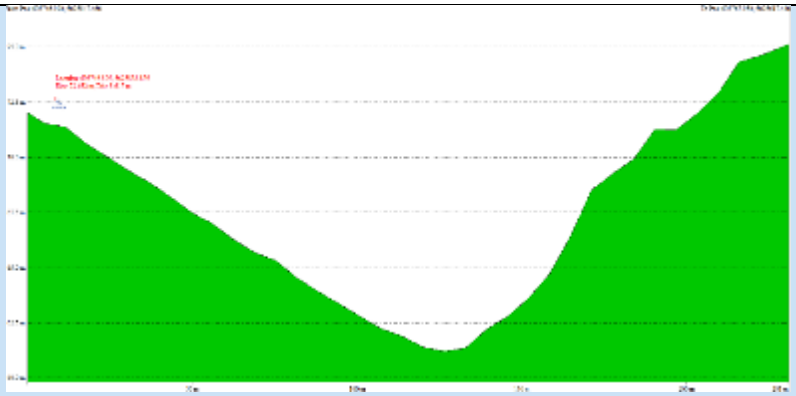


Figure 2-21: Cross section example 3.

Furthermore, it is possible to export a raster of arbitrary density points, etc.

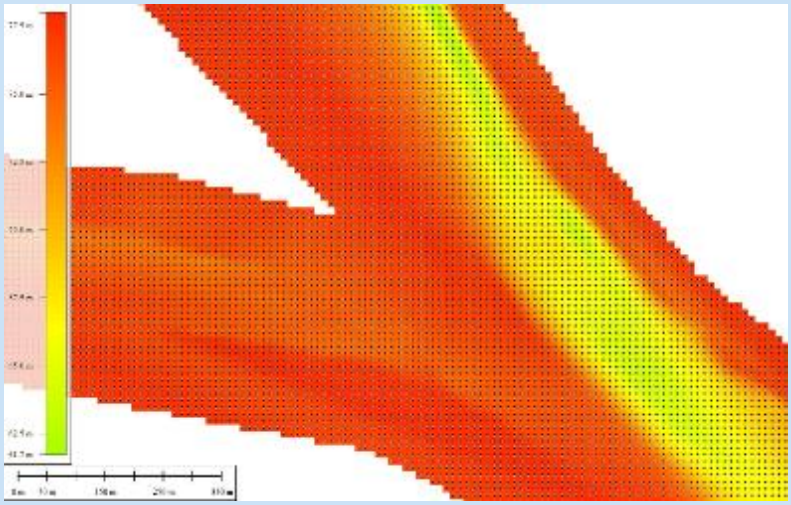


Figure 2-22: Raster of points – density 15x15m

Data are delivered as a textual data file in 3 projections: HTRS96/TM (HVRS71), HDKS (GK) 6 zone (HVRSTRST). Also processed data are delivered by cross-sections in separate textual files in UTM 34 (N) (HVRSTRST). Such data represent cross-section data prepared to be used in any software.

In the next phase of observing the Danube riverbed, it will be necessary to repeat the bathymetric recording and compare the situation from June/July 2023 and April/May 2024.

Given that a large section of the Danube riverbed is sandy ground (so-called sand dunes), changes are possible. It will be very interesting to analyse for planning the arrangement of the waterway.

Where there is a rocky riverbed, no changes are expected, unless some work has taken place in the meantime.

The first hydrographic surveying was started on 8 May, 2023, but was interrupted due to extremely unfavourable weather conditions (rainfall and wind). It continued on 12 June, 2023. About 30 km of the Danube has been surveyed so far, and as more favourable conditions for surveying are expected in the coming period, the completion of the first cycle of these field works was in August 2023.

At the beginning of December 2023 (1 December, 2024), the data from the completed first cycle of recording in HTRS96/HVRS71 and the second in HDKS6/HVRStrst format were submitted to the MMPI.

The next recording was postponed to spring (March-May), while the planned wintering habitats were determined from the developed and delivered 3D model of the riverbed from the first set of recordings.

In accordance with the planned second survey cycle, permits were requested for surveying in the border area, and on 5 February, 2024, a permit was obtained from the Ministry of the Sea, Transport and

Infrastructure, the Port Authority of Vukovar, as well as a surveying permit from the competent institution of the Republic of Serbia.

The second field recording commenced on 9 April, 2024 and was actively carried out in accordance with meteorological conditions, and was completed on 24 May, 2024. By 24 June, 2024, data processing of the second recording cycle was completed and is displayed on the **forum**, which takes place on 3 July, 2024 in Belgrade. Submission of the processed data of the second recording cycle to the MMPI in the same format and form as for the first recording cycle was concluded on 28 June, 2024.

Results

After the surveyingg was completed, all field recordings were processed within the "Geodetic surveying for hydrological morphological monitoring of the Danube River" Elaborate by VPB (as an addition to the "Velocity, flow and sediment Study), see also: **ANNEX 8**, and the following views were prepared based on the processing:

- Situations with the position of the profile on which monitoring is carried out,
- Interpolated digital terrain models from recorded profiles (for each recording),
- Comparison of terrain models on the longitudinal profile,
- Comparison of terrain models on cross-section profiles.

After processing, the results of the hydrographic survey were included in the MMPI's GIS database.

2.1.2.2. Multi-beam hydrographic surveys

The purpose of hydrographic surveying is:

- to collect, with systematic surveys at navigable areas, georeferenced data related to:
  - river bed configuration, including man made infrastructure for navigation i.e. all those features in river that are of interest to navigators;
  - depths in the area of interest (including all potential hazards to navigation and other activities);
  - river bottom composition;
  - water levels and currents;
  - physical properties of the water column;
- to process the information collected in order to create organized databases capable of feeding the production of thematic maps, nautical charts and other types of documentation for the following most common uses:
  - navigation and traffic management;
  - training works and dredging;
  - water environment preservation;
  - laying of underwater structures (cables/pipelines);
  - scientific studies.

Requirements for hydrographic surveys arise as the result of policy decisions, product user reports or requests and other demands. The inception of a specific hydrographic survey project follows an evaluation of all known requirements and the establishment of priorities. Among the many objectives and subjective factors that influence the establishment of priorities are national and agencies goals, quantitative and qualitative measures of shipping, the adequacy of existing surveys, and the rate of change of the bottom topography in the area.

Surveying activities aim at establishing a solid data basis for internal use, namely for decision making related to river engineering, rehabilitation and maintenance measures. These activities are accompanied by the constant provision of high-quality **user information** on various national and transnational platforms, most importantly the Danube FIS Portal, the Electronic Navigation Charts (ENCs) and national information platforms.

Figure 2-23: Fairway management cycle

In 2014, the CRO-SRB expert group established a prioritization of critical bottlenecks on the joint Danube section, where 17 critical sectors were identified. Out of 17 bottlenecks, 7 critical locations were identified as "most critical".

Given the above, there is a possibility that the sectors that are now defined as critical are no longer critical during implementation of the "Preparing FAIRway 2 works in Rhine-Danube Corridor" project and that some other critical sectors might appear.

The following table therefore provides an overview of the bottlenecks in the Croatian Danube sector, as identified jointly with Republic of Serbia:

Table 2-2: List of critical locations on the common Croatian/Serbian section with their characteristics that are surveyed with MB

No.	Name of critical location	Characteristics of critical locations	From rkm	To rkm	Length of section (rkm)
1	Apatin	reduced depth, reduced fairway width at ENR, bank erosion	1404	1400	4
2	Židovski/Čivutski rukavac	reduced depth, reduced fairway width at ENR, bank erosion	1397.2	1389	8.2
3	Drava confluence	reduced fairway width at ENR	1383.4	1381.6	1.8
4	Staklar	reduced depth, reduced fairway width at ENR, bank erosion	1376.8	1373.4	3.4
5	Borovo 1	reduced depth, reduced fairway width at ENR, bank erosion	1348.4	1343.6	4.8
6	Vukovar	reduced depth, reduced fairway width at ENR, bank erosion, wide river bed	1328	1325	3
7	Sotin	reduced depth, reduced fairway width at ENR, right bank erosion	1323	1321	2
				TOTAL:	27.2

In previous years, from the user point of view, Apatin and Mohovo were the most critical bottlenecks with problems of the available fairway depth. Apart from these two critical locations, problems with the

available depth were also encountered at the critical location Sotin. Apatin used to be the most critical location, but due to small river engineering works the sandbar was shifted and monitoring activities were regularly conducted. Sotin and Mohovo sections are most critical locations, but due to rocky bottom on Mohovo there is no change in the river bed. These characteristics were taken into consideration when defining the scope of the pilot operations for multi-beam hydrographic survey.

Hydrographic surveys were executed along the **entire Croatian stretch of the Danube waterway, with specific focus on the critical locations** (bottlenecks listed in the Fairway Rehabilitation and Maintenance Master Plan). Based on the initial surveying of critical locations and determination of their condition and on the basis of the depth control by the marking vessel, additional surveying was performed on locations that are most critical.

Multi beam surveying was entirely performed with the surveying vessel purchased within the FAIRway Danube project.

Figure 2-24: Connecting Europe 1 surveying vessel (source: MMPI)

When the conditions necessary for surveying critical locations are met, the Head of the Service for Marking and Technical Maintenance of the Waterways within MMPI sends the surveyor into the field. After vessel and equipment check, the vessel's commander and the surveyor go out to the location on the Danube via the surveying vessel.

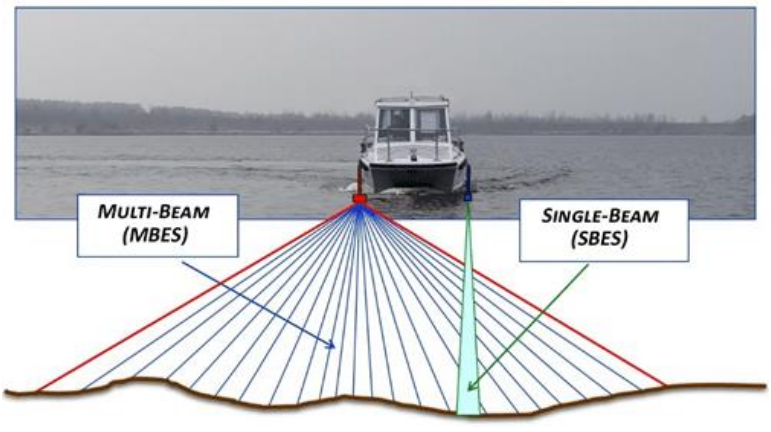


Figure 2-25: MB and SB operation

The surveyor then uses surveying multi-beam sonar equipment that works on the principle of using sound waves for river bed mapping purpose. The emitted sound is reflected of the river bed and the time passing until reflected sound is received is used in measuring the river depth at the location. Unlike the previously used single-beam equpment, multi-beam sonar speeds up the recording process by emmiting more sound waves at once using an array of transducers and creating a larger swath that covers more river bottom and

provides a more detailed map of the river bed. MMPI uses dual head configuration Teledyne Seabat T20 – R multibeam with Teledyne RESON UI software which allows even more riverbed coverage in single survey line passing.

Figure 2-26: Dualhead multibeam system configuration

Positioning, height and movement of the vessel are calculated by two GPS antennas on the port and starboard side on top of the vessel and Applanix Surfmaster software integrated into the multibeam system. RTK-GNSS (Real Time Kinematic) method is used. RTK corrections are received via mobile internet (GPRS/GSM) from CROPOS (Croatian Positioning Service).

The vessel repeatedly navigates the critical section in its full length (starting and ending river kilometres). Surveying starts with the first longitudinal profile usually set on the waterway axis. Based on the initial longitudinal profile and the width of the area, surveying is continued next to the first profile doing as many profiles as the configuration of the terrain allows, reaching to the shallowest parts of the waterway and trying to capture an entire planned area. This way survey lines parallel to the riverbank are created. The profiles are overlapping to a certain degree, depending on the current water depth.

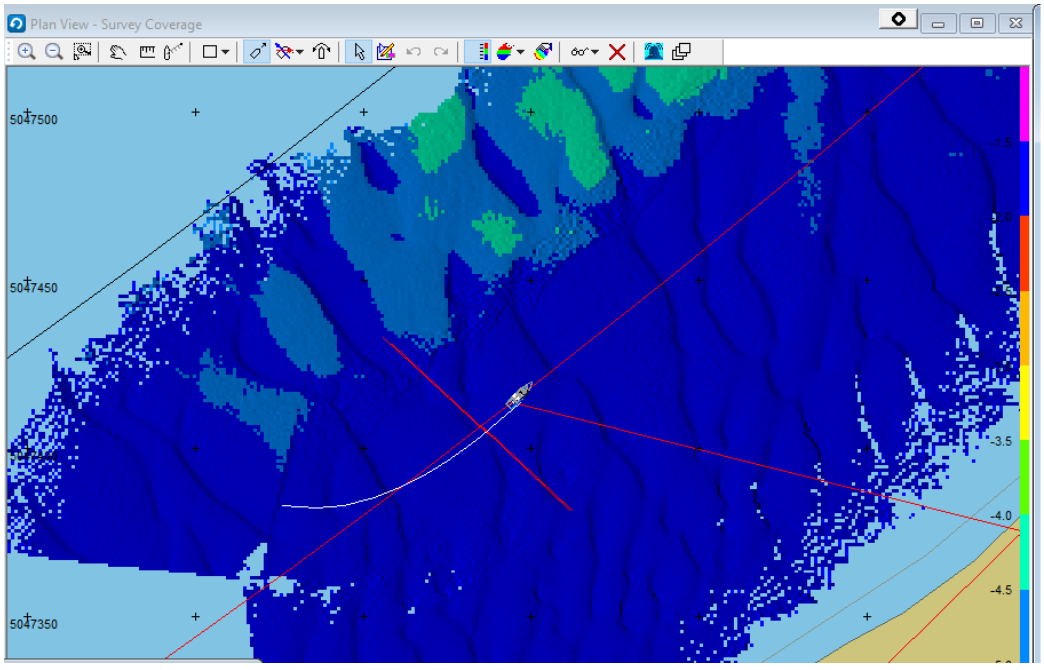


Figure 2-27: MB surveying software Teledyne PDS2000

The results of multi-beam systems are sensor-based raw data (high density point cloud – XYZ coorindates) which is processed by MMPI employees. This data is checked, filtered and cleaned of surveying errors due to different obstacles, changes of water temperature, noises in the water and other factors that affect surveying quality. MMPI uses Teledyne PDS2000 software for all the surveying and data processing purposes.

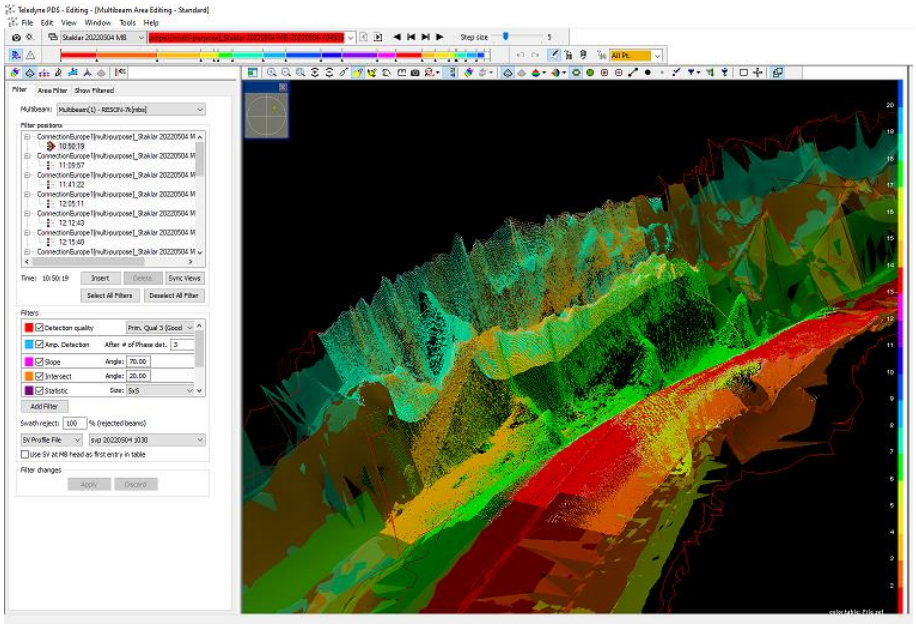


Figure 2-28: XYZ point cloud

On the basis of corrected data, terrain models of the riverbed are calculated which are basis for creating maps of each of the surveyed location and other product issuance. The gathered surveying data and created models are also used for maintenance activities, if there is a need.

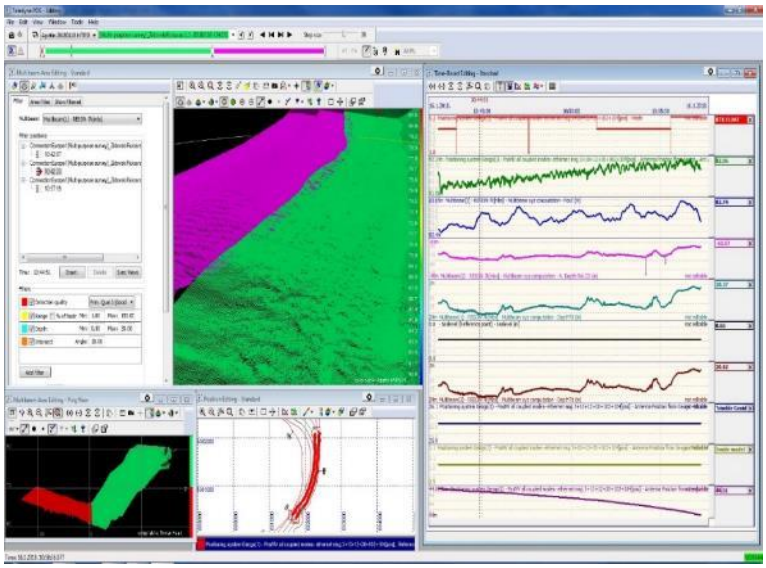


Figure 2-29: Processing sensor raw data

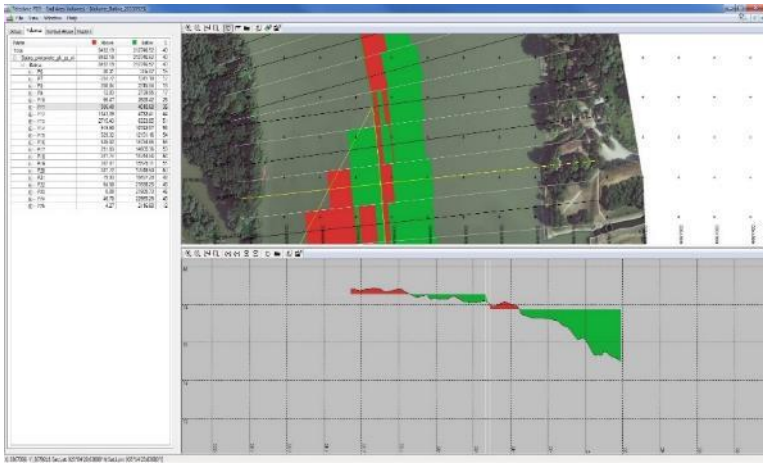


Figure 2-30: Volume calculations

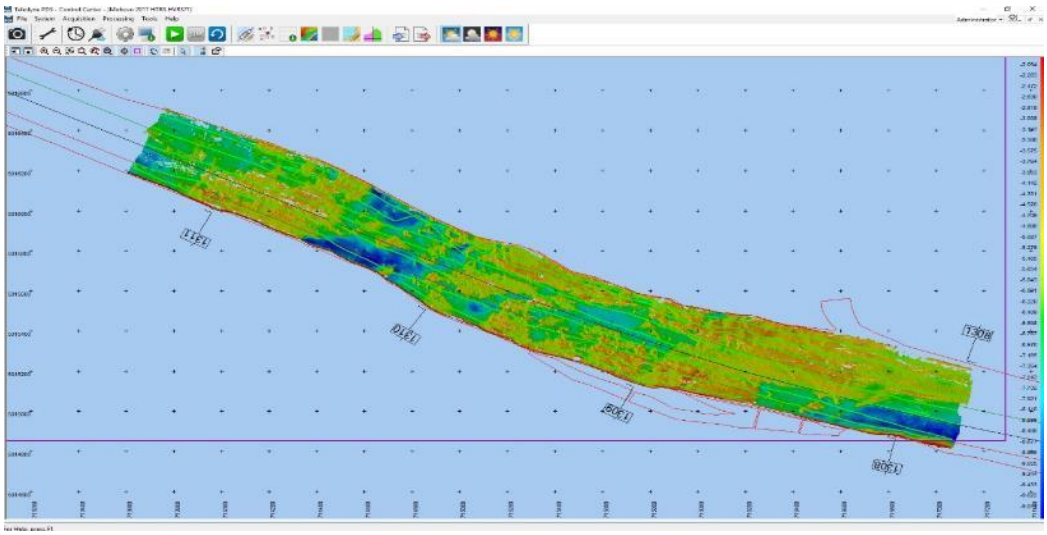
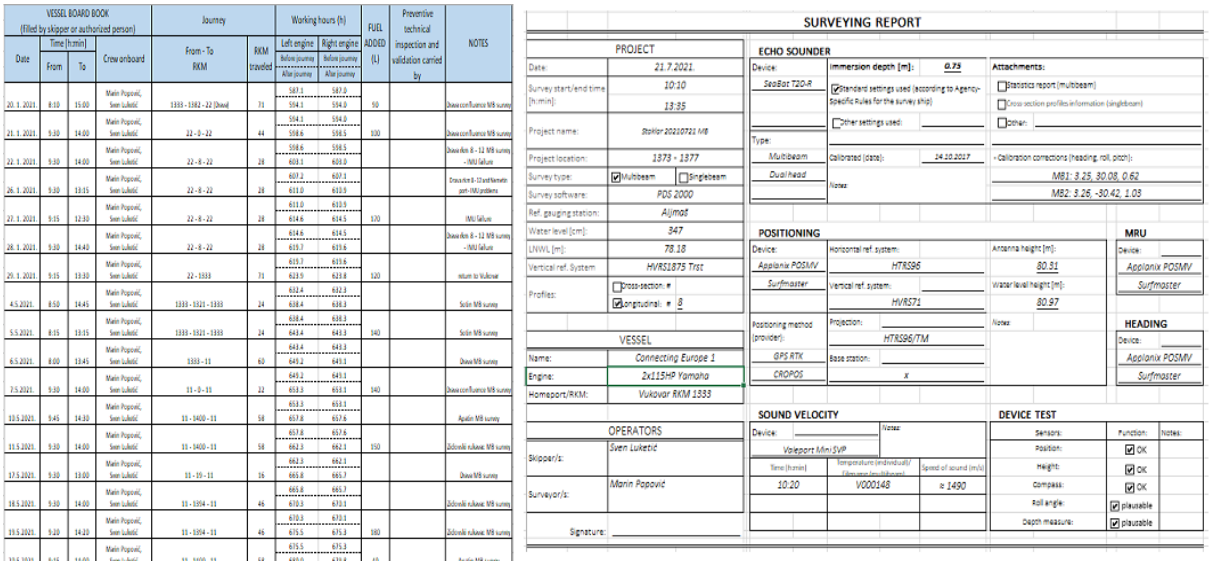


Figure 2-31: Terraing model

Post-proccesed data is stored into internal server and National Waterway Administration System (WAMS) for easy access and further usage.

Surveying is documented by filling Board book (voyage location, RKMs travelled, engine working hours, fuel) and Surveying reports (used vessel, location, parameters, equipment, problems encountered,…).



VESSEL BOARD BOOK (Filled by skipper or authorized person)

Date	Time [h:min] From	Time [h:min] To	Crew onboard	Journey From - To RKM	Journey RKM travelled	Working hours (h) Left engine Before journey	Working hours (h) Left engine After journey	Working hours (h) Right engine Before journey	Working hours (h) Right engine After journey	FUEL ADDED (L)	Preventive technical inspection and validation carried by	NOTES
20. 1. 2021.	8:10	15:00	Matin Popović, Sven Luketić	1333 - 1302 - 22 (Dunav)	71	587.1	594.1	587.9	594.9	50		Dunav-coridunavo M/B survey
21. 1. 2021.	9:30	14:00	Matin Popović, Sven Luketić	22 - 0 - 22	44	594.3	598.6	594.9	598.5	100		Dunav-coridunavo M/B survey
22. 1. 2021.	9:30	14:00	Matin Popović, Sven Luketić	22 - 8 - 22	28	598.6	603.1	598.5	603.0			Dunav-ŠkrŠ 8 - 12 M/B survey - IMU failure
26. 1. 2021.	9:30	13:15	Matin Popović, Sven Luketić	22 - 8 - 22	28	607.1	611.0	607.1	610.9			Dunav-ŠkrŠ 8 - 12 and Nemetin port - IMU problems
27. 1. 2021.	9:15	12:30	Matin Popović, Sven Luketić	22 - 8 - 22	28	611.0	614.6	610.9	614.5	100		IMU failure
28. 1. 2021.	9:30	14:40	Matin Popović, Sven Luketić	22 - 8 - 22	28	614.6	619.7	614.5	619.6			Dunav-ŠkrŠ 8 - 12 M/B survey - IMU failure
29. 1. 2021.	9:15	13:30	Matin Popović, Sven Luketić	22 - 1333	71	619.7	623.9	619.6	623.8	120		return to Vukovar
4.5.2021.	8:50	14:45	Matin Popović, Sven Luketić	1333 - 1321 - 1333	24	632.4	638.4	632.3	638.3			Script M/B survey
5.5.2021.	8:15	13:15	Matin Popović, Sven Luketić	1333 - 1321 - 1333	24	638.4	643.4	638.3	643.3	140		Script M/B survey
6.5.2021.	8:00	13:45	Matin Popović, Sven Luketić	1333 - 11	60	643.4	649.2	643.3	649.1			Dunav M/B survey
7.5.2021.	9:30	14:00	Matin Popović, Sven Luketić	11 - 0 - 11	22	649.2	653.3	649.1	653.1	140		Dunav-coridunavo M/B survey
10.5.2021.	9:45	14:30	Matin Popović, Sven Luketić	11 - 1400 - 11	58	653.3	657.8	653.1	657.6			Apatin M/B survey
11.5.2021.	9:30	14:00	Matin Popović, Sven Luketić	11 - 1400 - 11	58	657.8	662.3	657.6	662.1	150		Zličnički rukavac M/B survey
17.5.2021.	9:30	13:00	Matin Popović, Sven Luketić	11 - 19 - 11	16	662.3	665.8	662.1	665.7			Dunav M/B survey
18.5.2021.	9:30	14:00	Matin Popović, Sven Luketić	11 - 1354 - 11	46	665.8	670.3	665.7	670.1			Zličnički rukavac M/B survey
19.5.2021.	9:20	14:20	Matin Popović, Sven Luketić	11 - 1354 - 11	46	670.3	675.5	670.1	675.3	160		Zličnički rukavac M/B survey
			Matin Popović,			675.5		675.3				

SURVEYING REPORT

PROJECT

Date:	21.7.2021.
Survey start/end time [h:min]:	10:10 / 13:35
Project name:	StaKor 20210721 M/B
Project location:	1373 - 1377
Survey type:	☑ Multibeam ☐ Singlebeam
Survey software:	PDS 2000
Ref. gauging station:	Aljmaš
Water level [cm]:	347
LNWL [m]:	78.18
Vertical ref. System	HVRS1875 Trst
Profiles:	☐ Cross-section: # ☑ Longitudinal: # 8

VESSEL

Name:	Connecting Europe 1
Engine:	2x115HP Yamaha
Homeport/RKM:	Vukovar RKM 1333

OPERATORS

Skipper/s:	Sven Luketić
Surveyor/s:	Marin Popović
Signature:	

ECHO SOUNDER

Device:	SeaBat T20-R
Type:	Multibeam / Dual head
Immersion depth [m]:	0.73
☑ Standard settings used (according to Agency-Specific Rules for the survey ship)	
☐ Other settings used:	
Calibrated (date):	14.10.2017
Notes:	

Attachments:
☐ Statistics report (multibeam)
☐ Cross-section profiles in formation (singlebeam)
☐ Other:
- Calibration corrections (heading, roll, pitch):
MB1: 3.25, 30.08, 0.62
MB2: 3.26, -30.42, 1.03

POSITIONING

Device:	Applanix POSMV / Surfmaster
Horizontal ref. system:	HTRS96
Vertical ref. system:	HVRS71
Positioning method (provider):	HTRS96/TM
GPS RTK	
CROPOS	x
Projection:	
Base station:	
Antenna height [m]:	80.31
Water level height [m]:	80.97
Notes:	

MRU
Device: Applanix POSMV / Surfmaster

HEADING
Device: Applanix POSMV / Surfmaster

SOUND VELOCITY

Device:	Notes:	
Valeport Mini SVP		
Time [h:min]	Temperature [individual] / Files used for M/B survey	Speed of sound [m/s]
10:10	V000148	≈ 1490

DEVICE TEST

Sensors:	Function:	Notes:
Position:	☑ OK	
Height:	☑ OK	
Compass:	☑ OK	
Roll angle:	☑ plausable	
Depth measure:	☑ plausable	

Figure 2-32: Board book and Surveying report

Results of the surveying are then published on the vodniputovi.hr website as in form of PDF map showing water depths in relation to low navigable water level (LNWL) at given location. Users of the waterway have access to all published data which can be found at the following link:

https://www.vodniputovi.hr/en/navigation/critical-sectors/

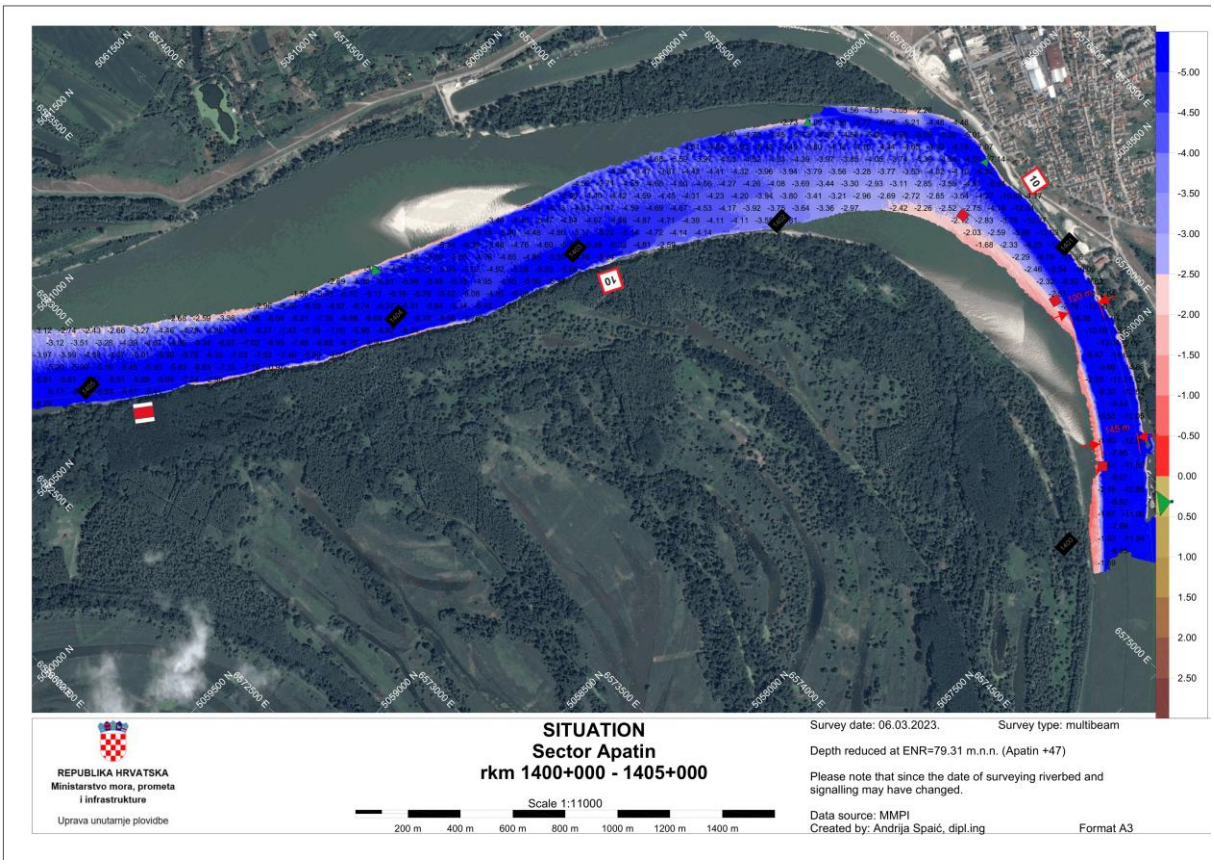


Figure 2-33: The results of the surveying activities at the critical sector Apatin

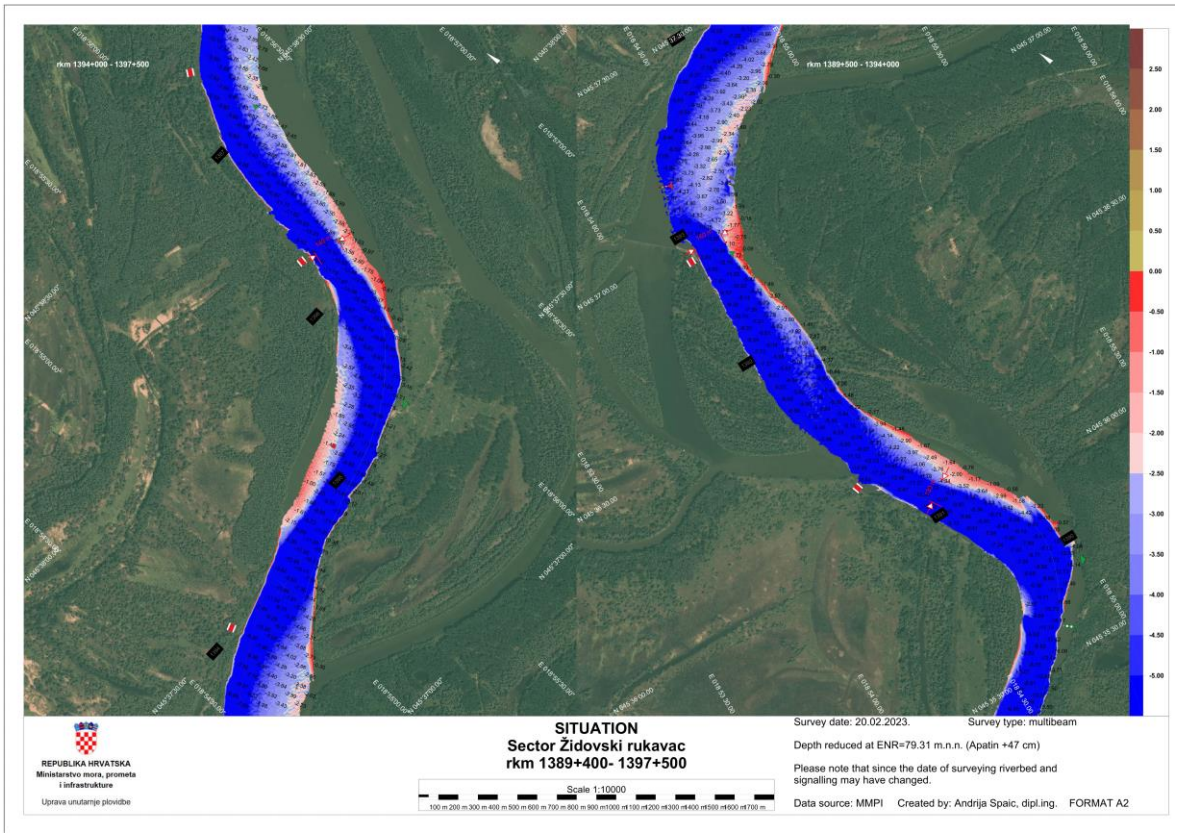


Figure 2-34: The results of the surveying activities at the critical sector Židovski rukavac

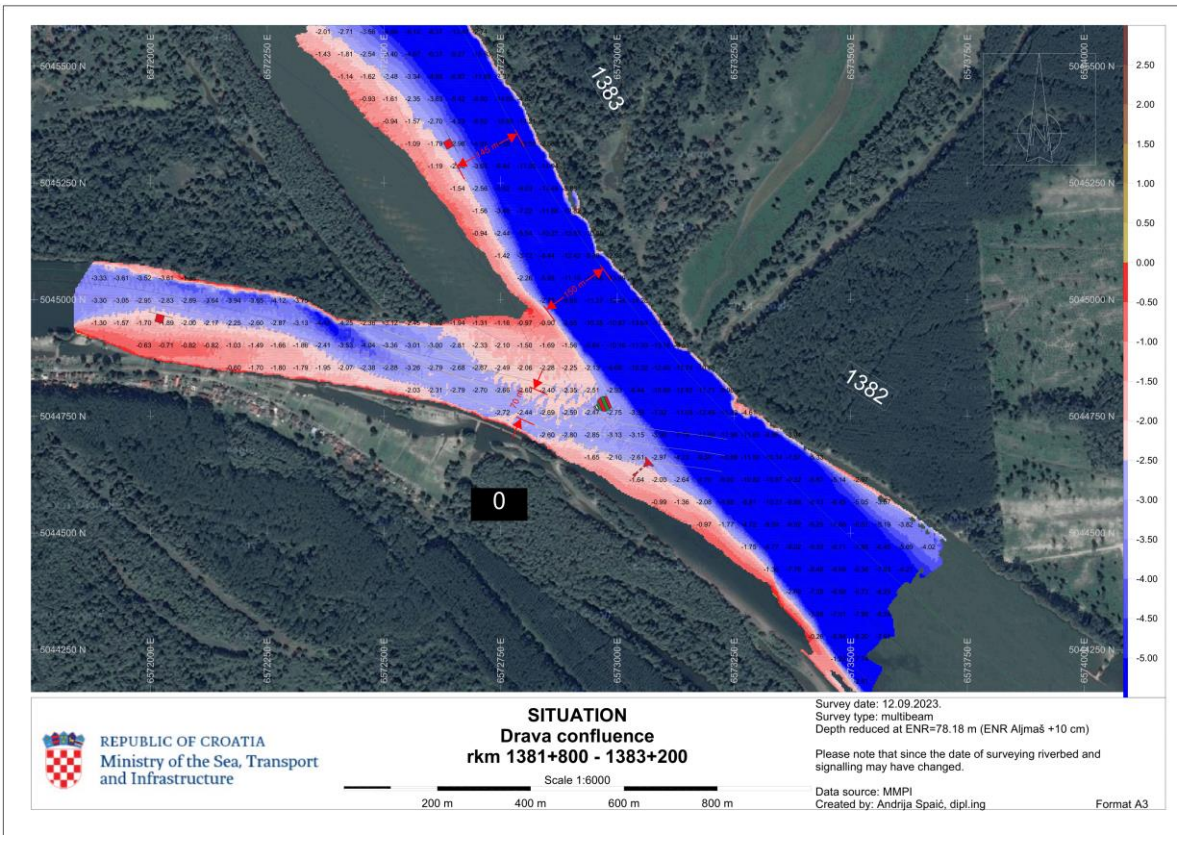


Figure 2-35: The results of the surveying activities at the critical sector Drava confluence

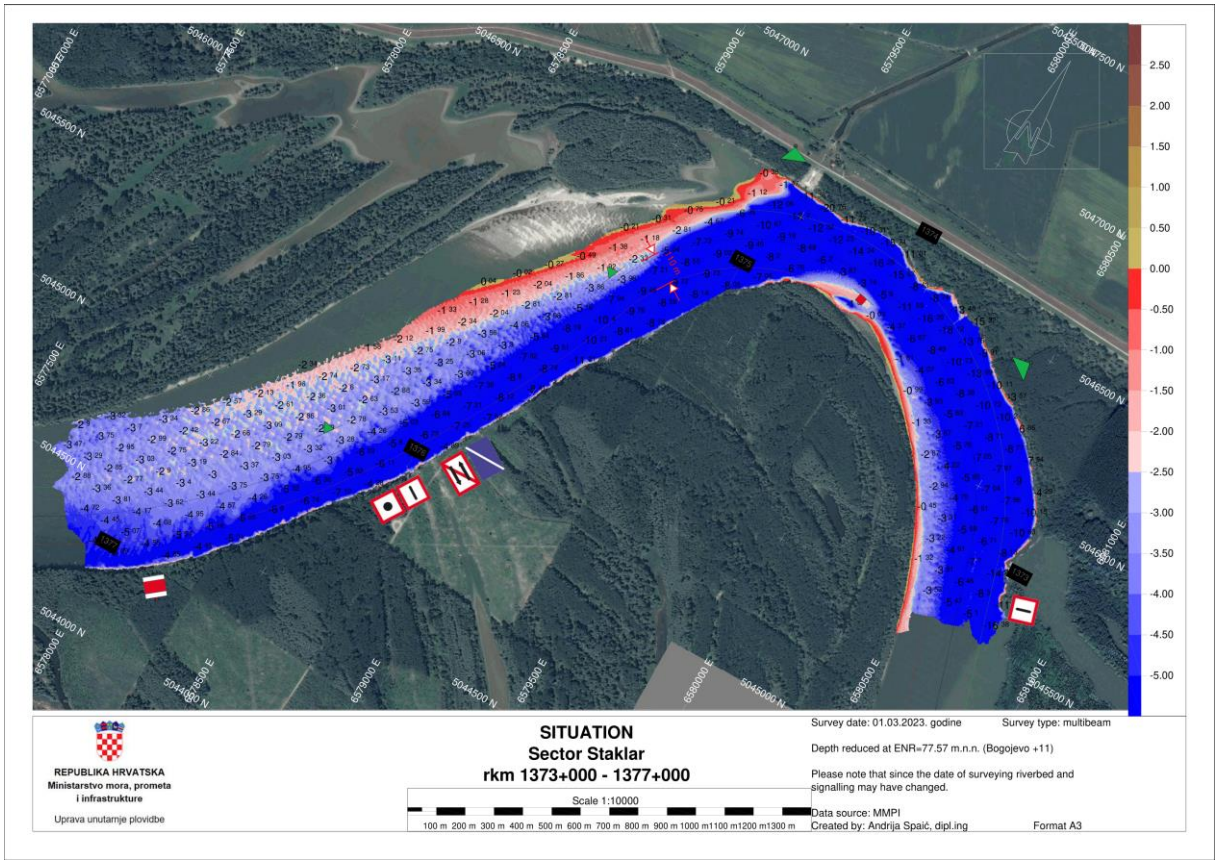


Figure 2-36: The results of the surveying activities at the critical sector Staklar

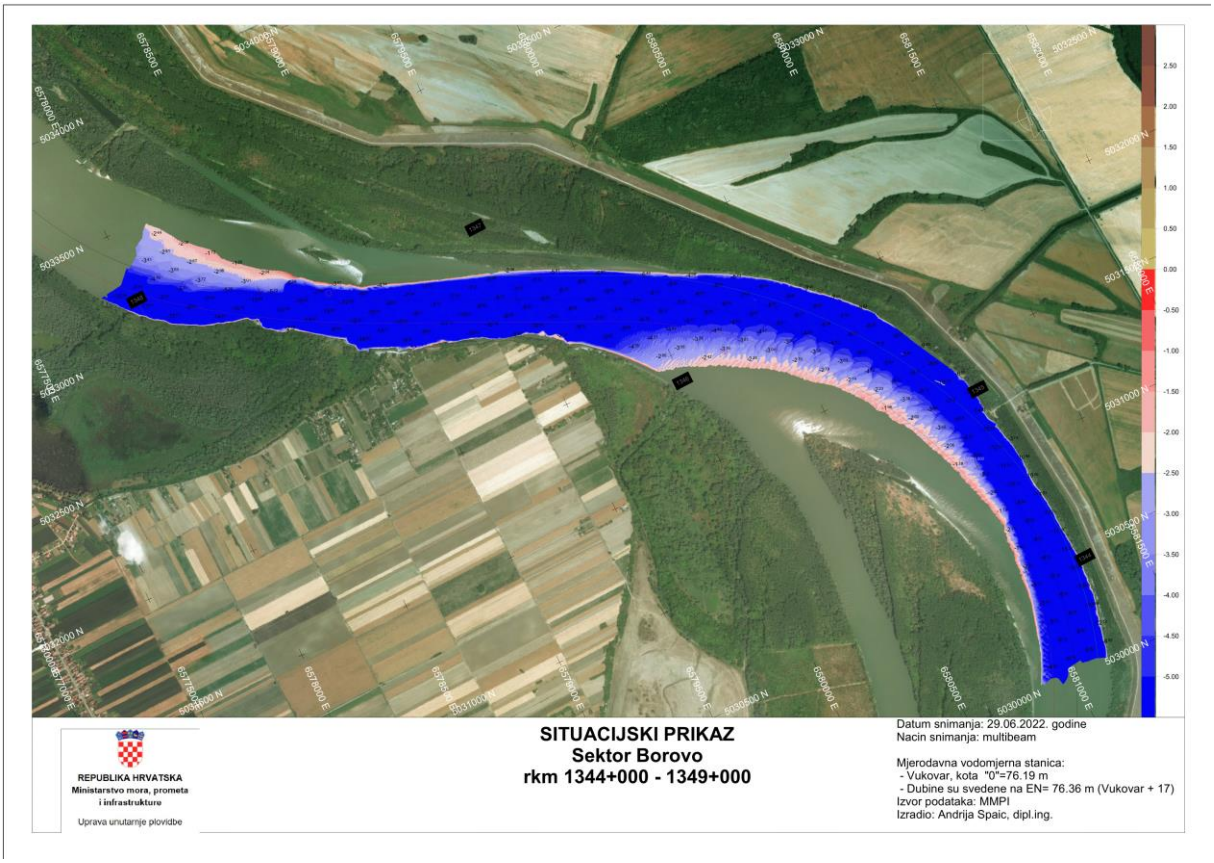


Figure 2-37: The results of the surveying activities at the critical sector Borovo 1

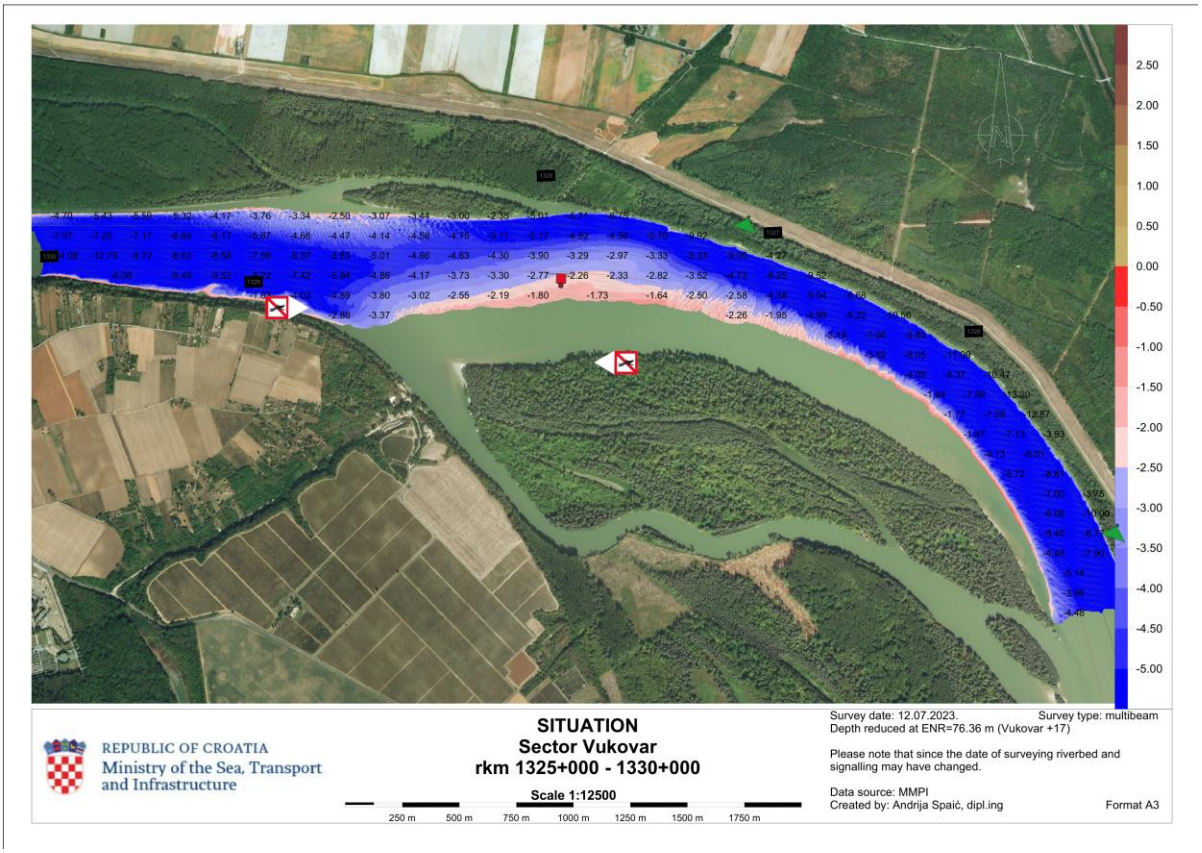


Figure 2-38: The results of the surveying activities at the critical sector Vukovar

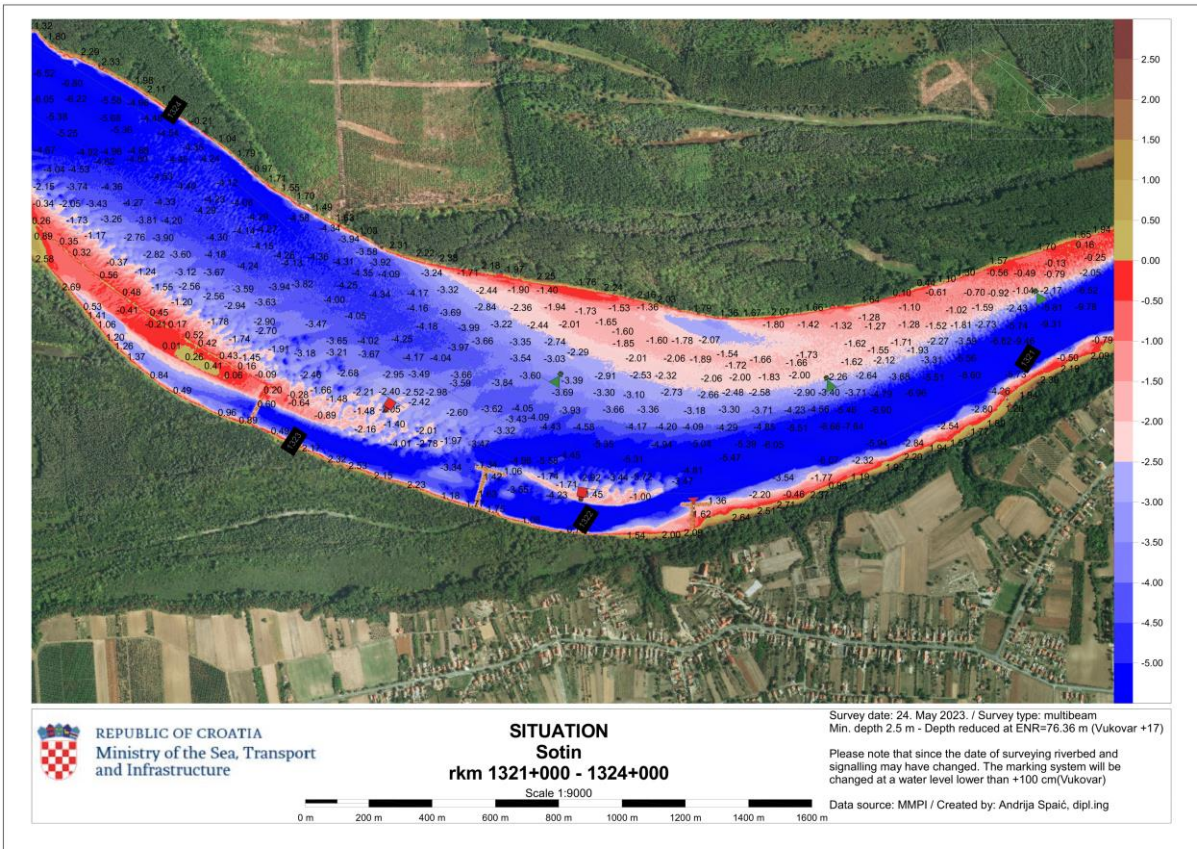


Figure 2-39: The results of the surveying activities at the critical sector Sotin

In the period October 2020 to November 2023 in total 28 survey campaigns were conducted on 7 chosen critical locations. Based on the data from the Board book and surveying reports, surveying vessel/multi-beam equipment was utilized on 56 days in total of 300 hours and covering of 125 river kilometres on the Danube.

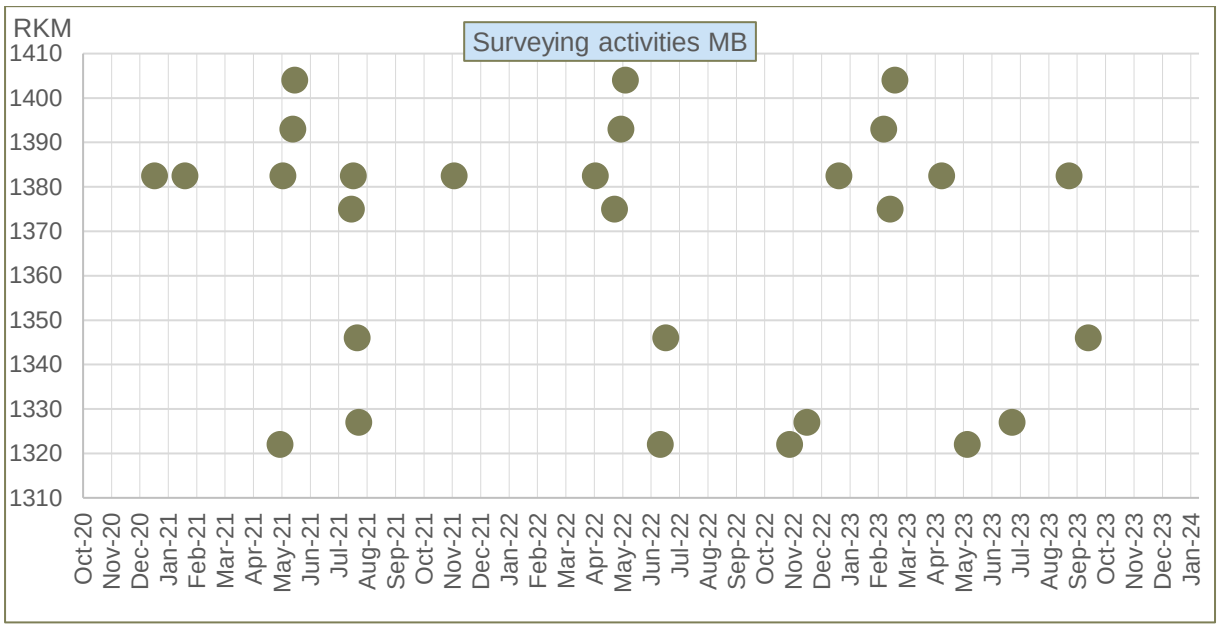


Figure 2-40: Locations and number of surveys chart

The most surveyed critical location is Drava confluence, that was covered 9 times during the period due to constant riverbed changes affected from changing water levels of rivers Drava and Danumbe. Surveys were executed until November 2023 due to equipment failure caused by an accident while on surveying trip and since the beginning of the 2024 multi-beam equipment is on the repairing process at the manufacturer.

Fuel consumption

Fuel cost were entirely covered by MMPI.

Maintenance costs

Vessel and equipment maintenance cost were entirely covered by MMPI.

Costs of human resources for execution of measurements and timely publication of surveying results

A single person working on this project was included in both surveying and processing of the data. Summing direct costs for personnel for both surveying and processing, the MMPI reaches approx. 2,200 EUR of the annual costs, for performing the surveys, data processing and publishing the data within this project.

2.1.3. Velocity and flow recording and measurement of suspended and dragged sediment

Overview

Preparation for the meeting was carried out and a preparatory meeting was held with the Beneficiary (1 February, 2023), where the Beneficiary was presented with the approach to recording velocities and flows and measuring sediment transport in the Danube bed, open issues discussed (locations of measurements, period of measuring and hydrological conditions, criteria for determining relevant hydrological conditions).

The substrates received from the Beneficiary were taken over, examined, and analysed:

- Previous geodetic and hydrographic measurements of the relevant section of the Danube River from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary),
- Characteristic navigable water levels of the Danube,
- Danube River waterway from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary),
- Data on ship movement (logs of navigation), traffic elements, traffic data, cargo structure, passenger ship traffic, etc.
- Water level/flow measurement data at the Batina, Aljmaš, Vukovar and Ilok water-metering stations
- Critical sections (kmz format)
- Map of the Danube on an orthophoto basis in pdf format

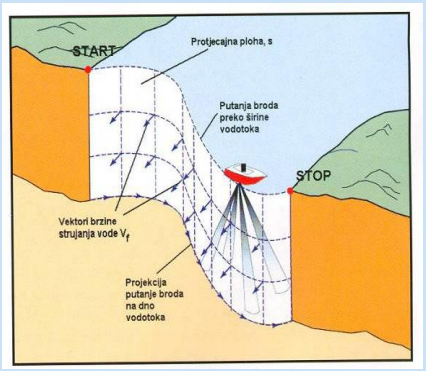
All necessary permits for the implementation of field works in the border area have been collected - see Chapter 3, Table 3-1).

Based on the Terms of Reference and the agreement from the preparatory meeting, the inventory implementation methodology was elaborated. The methodology for measurements of velocities and flows and for measurements of transfer of suspended and bedload sediment are presented below.

Text box 2-3 Methodology for measurements of velocities and flows

Methodology for measurements of velocities and flows

An acoustic flow meter based on the Doppler effect, Acoustic Doppler Current Profiler (ADCP) type RDI Workhorse Rio Grande, frequency 1200 kHz, will be used to measure the flow and current data. This acoustic flow meter is used to measure the spatial direction and speed of the flow. The flow meter is connected to the side of the boat. A GPS-RTK positioning system is used to locate the boat in space, which coordinates the measurement with the selected profile measurement positions and also records the position of the bathymetric points. The acoustic flow meter enables the instantaneous recording of a three-dimensional current image of open watercourses and the sea, as well as the simultaneous recording of the bottom profile. The ADCP device works on the principle of the Doppler effect, that is, it perceives a change in the frequency of the initial sound signal. By reflecting the initial sound signal from small particles, a return sound image is obtained, the frequency of which is proportional to the speed of the particles. The particles are assumed to travel at the same speed as the water. By capturing the current image transversely to the flow direction, the entire three-dimensional current image of the profile is obtained, and by integrating the current image along the transverse profile, the flow is obtained. The device tracks its absolute orientation via a built-in compass and tilt sensor. To determine the rotation of the instrument around its axes, an internal compass with a resolution of 0.01° with an accuracy of ±2° is used to determine the direction angle, and a tilt sensor with a resolution of 0.01° and an accuracy of ±0.5° to determine the rocking and stumbling of the boat. The measurement of these angles during data collection, combined with the use of a GPS device to track the absolute E, N coordinates of the position, enables the transformation of the recorded flow vectors in the beam direction to a Cartesian coordinate system in the plane referenced by the position of true north. For height positioning, it is necessary to know the level of the water surface, which is determined directly using the RTK GPS device.



a) Schematic representation of current image recording *b) Current meter on the boat*

Figure 2-41: Recording of current image with ADCP device.

The measured values from the flow meter can be read directly in real time and stored on the computer. The cross-profile flow is calculated over the mean velocity in each spatial unit. The vertical column of water is divided into a series of equally wide layers. The unit flow in a spatial unit is obtained by multiplying the area of one unit and the associated mean velocity in the cell. The flow in one column is obtained by summing the unit flows in the vertical. By traversing the entire width of the river, the total flow is recorded on the measuring profile. By recording the current image transversely to the flow direction, the entire three-dimensional current image of the profile is obtained, and by integrating the current image over the surface, the flow on the measuring profile is obtained.

Measured data on velocities, boat route, depth of riverbed and other data can be directly controlled on the computer during the measurement campaign and stored for later processing. The computer program WinRiver will be used during the measurement. After recording on the river, the collected data will be processed using a computer program developed at the Institute of Hydrotechnics, which enables the display of a three-dimensional velocity profile by velocity components (u, v, w).

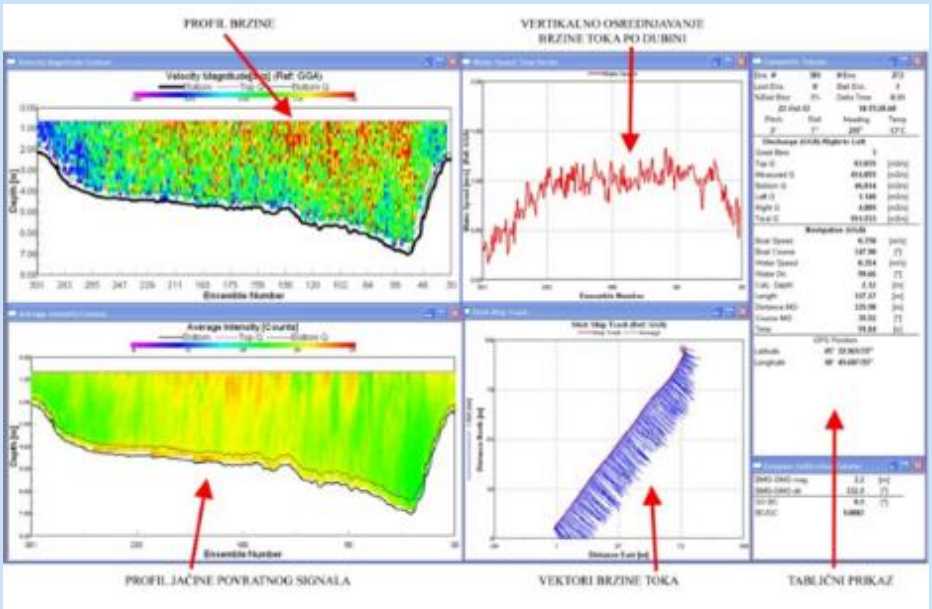


Figure 2-42: WinRiver user interface for one profile

When measuring the velocity profile along the transverse profile, it is common to average the vector over space for graphical display. Spatial averaging will be performed in such a way that several vertical units are averaged into one vertical profile. In this way, the spatially averaged components u, v, w of raw velocities suitable for further analysis will be obtained.

Text box 2-4 Methodology for measurement of transfer of suspended and bedload sediment

Methodology for measurement of transfer of suspended and bedload sediment

Measurements of suspended sediment will be carried out in combination with acoustic and physical sampling: simultaneous physical and acoustic sampling.

For the sampling of suspended sediment, the so-called multi-point measurement method in the verticals of the water column of the river profile. For this purpose, the control profile is divided into three segments: left, middle and right. Measuring verticals are located in the middle of each segment. One control profile will be selected, usually the most upstream profile. Sampling will be performed at several vertical points. The number of verticals for sampling suspended sediment will depend on the depth of the stream, but it should not be less than 3 points per vertical usually every 0.5 m or 1 m per depth, depending on the existing depths. A schematic representation of suspended sediment sampling is shown in the diagram below:

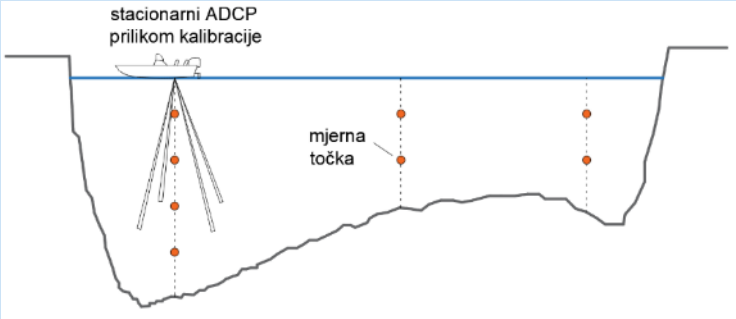


Figure 2-43: Scheme of verticals on the control profiles with the position of the measuring points where the suspended sediment is sampled

An isokinetic sediment trap DH-59 shall be used for physical sampling of suspended sediment. The inlet nozzle of the trap is designed in such a way as to ensure the continuity of the velocity, i.e. the velocity in the nozzle itself is equal to the flow velocity at the same point under undisturbed conditions, i.e. when the trap does not represent an obstacle to the flow. The volume of the measuring vessel for sediment sampling is 0.5 L. The samples are stored in bottles and taken to the laboratory for further analysis.

Figure 2-44: Isokinetic physical sediment trap DH-59

The water samples collected by the isokinetic trap will be analysed in the laboratory. The concentration of suspended solids shall be determined using the filtration method. First, the exact sample of the water is measured. Before filtering, the filter paper is dried at 105°C for an hour and weighed with an analytical balance (mp). Water samples shall be filtered with filter paper with a pore size of 3-5 µm. After filtering, the filter papers will be dried at 105°C for an hour and then weighed (mp+u). The concentration of suspended sediment is calculated by the following equation:

$$\mathrm{SSC}\left[\frac{\mathrm{mg}}{\mathrm{l}}\right] = \frac{\text{mass of sample after filtration [mg]} - \text{mass of sample prior to filtration [mg]}}{\text{volume of the sample [l]}}$$

$$= \frac{m_{p+u} - m_p}{V_V}\left[\frac{\mathrm{mg}}{\mathrm{l}}\right]$$

In addition to physical sampling, a non-invasive, acoustic sensor, LISST-ABS, shall be used at the same time, an instrument that allows the user to determine the local concentration of suspended sediment (SSC) without taking physical water samples. LISST-ABS uses an audio signal to record the backscatter

signal to determine the SSC at the sensor head. The instrument measures continuously at a sampling frequency of 1 Hz and provides sediment concentration values in real time. However, raw values must be moderated (calibrated) against physical samples to obtain accurate concentration data. The results of physical samples will be used for calibration purposes. The sensor will be fixed above the isokinetic trap, so the sediment is measured at the same point where it enters the physical trap.

Figure 2-45: Acoustic sensor, LISST-ABS

Data on the concentration of suspended sediment measured by LISST-ABS will be used to determine the transport of suspended sediment, and the acoustic sensor will be calibrated based on the data collected by the physical sediment trap. Using a large number of concentrations simultaneously measured using physical and indirect sampling, a calibration curve shall be established. During suspended sediment sampling, the vertical velocity field will be measured in all verticals with a stationary ADCP device, i.e. a series of velocity time series will be available for each point. Based on these time series of velocities, the average time profiles of the velocities at the point will be calculated, which will then be used to calculate the unit sediment transport.

The method of calculating suspended sediment transport approximates the concentration of suspended sediment in a cross profile based on the concentration measured at the points of one vertical and the flow velocity measurement. The product of speed and concentration gives the unit transfer of sediment (g/cm2) in the vicinity of the measuring points. The total sediment load per profile results from the integration of the unit sediment transport over the entire width and depth of the river profile (kg/s) or (t/year). Interpolation of such discrete data means summing the areas of triangular, rectangular and trapezoidal surfaces to approximate sediment concentration.

Since the development of acoustic measurement techniques enabled the measurement of flow velocity continuously along the entire transverse profile of the river, the assessment of suspended sediment transport was also adapted to such a sampling method. In order to measure the spatial distribution of suspended sediment over the entire cross-section, data on the backscattering of the acoustic signal recorded by the ADCP device during the measurement of the flow velocity field along the cross-section will be used. By applying the sediment concentration estimation procedure proposed by Baranya and Józsa (2003), the measured values of acoustic signal backscatter recorded by ADCP can be converted into local suspended sediment concentration values.

For the purpose of calibrating the ADCP device, the average values of the relative scattering of the acoustic signal from the stationary ADCP measurements from the same points where the sampling of the suspended sediment was carried out will be used. In this way, the simultaneous signal from ADCP and sediment concentration from physical measurements can be connected. Since both LISST-ABS and ADCP are acoustic devices, the results of these devices can be made dependent on the data on backscattering of the acoustic signal, and the concentration measured by the LISST-ABS device can be applied to all cells in which the ADCP measures velocity. In the described way, it is possible to calculate the spatial distribution of the concentration of suspended sediment along the entire profile.

Some of the traditional standard methods for measuring or determining the second flow of bedload sediment will be used for the purpose of measuring the bedload sediment.

A Helley-Smith type mechanical towed sediment catcher will be used to measure the amount and transfer of bedload sediment. The mechanical trap is hydraulically shaped with an opening on the upstream side through which sediment enters and is retained in a porous bag (image below). The sediment collection process begins when the catcher is lowered to the bottom of the riverbed. After a certain period, which is measured with a stopwatch, the catcher is removed from the riverbed, and a

sample of the dragged sediment that is caught in the net is prepared. On one vertical, the drift is measured at least 3 times.

Figure 2-46: Helley-Smith type trailed sediment catcher

After drying, by weighing the total mass of sediment that was caught in the total duration of capture can be determined for each vertical. Then, for each vertical, the specific sediment transport is calculated using the following expression:

$$q_v = \frac{G_v}{b \cdot t}$$

qv – unit flow of bedload sediment [kg/m/s],

Gv – mass of the total affected bedload sediment [kg],

b – width of the entrance to the crate/catcher in [m]

t – time duration to capture the sample in [s].

From the calculation, a diagram of the distribution of the specific transport of the bedload sediment can be give along the riverbed, and the total transport can be obtained by planimetry of the area of the diagram under the curve.

During the deposit analysis, a granulometric analysis will also be carried out.

Preliminary analyses of the taken and collected materials were carried out, in order to prepare for field work in accordance with the methodology. These analyses are presented in a separate document: *Analysis of the Existing Situation* (see: **ANNEX 4**), in which the following are given:

- Analysis of hydrological and hydraulic state
- Analysis of navigable water levels of the Danube River
- Assessment of the state of the existing waterway

A meeting, organized by the Forum, was held on 5 May, 2023, with the authors of the Study of Sediment Transport and Equilibrium in River Beds (Boku Institute, Austria), prepared as part of the Interreg Mura-Drava-Danube project (project code: D.T1.2.3 Sediment balance and transport study). Experiences and conclusions were exchanged, which will be useful in the context of analysing the results (sampling) of bedload and suspended sediment in the Danube.

All equipment (Figure 2-44, Figure 2-45, Figure 2-46) and vessels have been prepared and team members have been appointed to carry out the field work.

In accordance with the Terms of Reference (at least) one measurement of velocity/flow/sediment is planned in 3 characteristic cases: high, medium, low water level. To define them, a hydrological analysis was carried out in the previously described document (*Current Status Analysis)* which defined the following unique values (intervals) for the high, medium, and low water level of the entire subject area of the Danube River from rkm 1433.1 (Batina) to rkm 1295, 5 (Ilok):

- Low water level < 100 cm
- Average water level from 100 cm to 400 cm
- Large water level > 400 cm

Velocity and flow measurements will be performed at three locations (Batina, Vukovar, Ilok, Figure 2-47), as follows:

- 1x for the duration of the low water level;
- 1x for the duration of the average water level;
- 1x after the occurrence of high water level.

The measurement of suspended and bedload sediment transport will be carried out at three locations (Batina, Drava estuary, Ilok, Figure 2-47), as follows:

- 1x for the duration of the low water level;
- 1x for the duration of the average water level;
- 1x after the occurrence of high water level.

The recording groups differ in the choice of the middle section, since the section where the Drava meets the Danube is important for recording sediment transport.

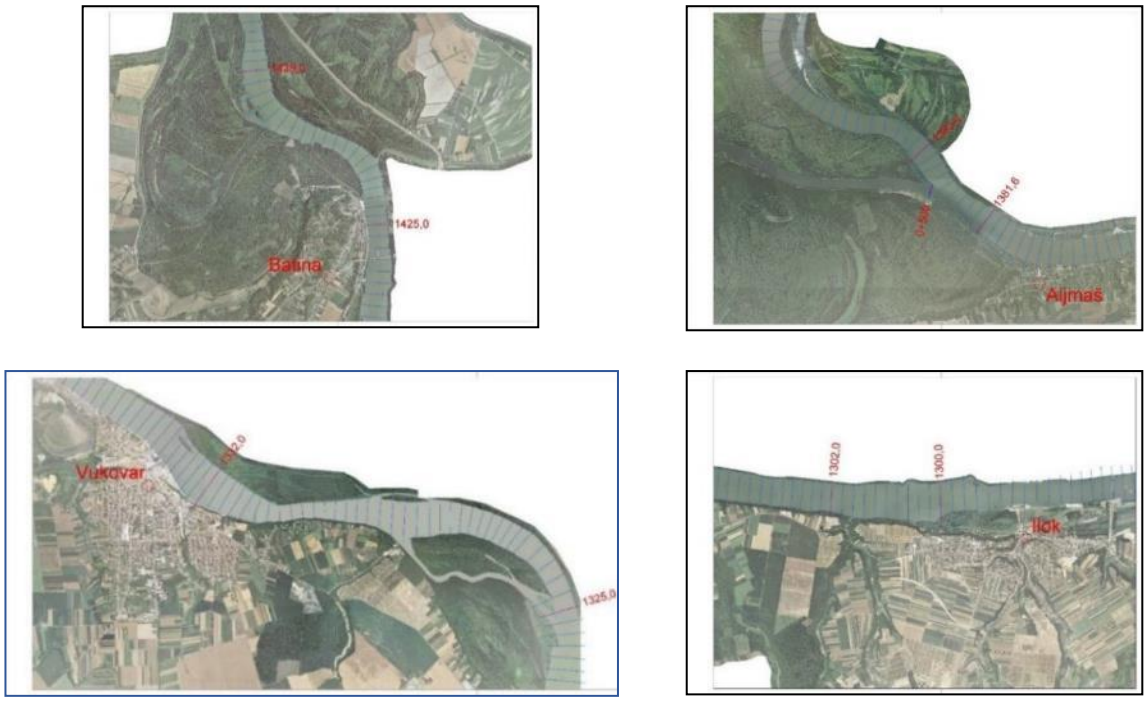


Figure 2-47: Sections of the Danube where monitoring is carried out

All measurement campaigns have been conducted, as follows:

- High water levels: May 2023
- Medium water levels: June 2023
- Low water levels: December 2023

Below are the level charts of 4 water metering stations on the Danube (Batina, Aljmaš, Vukovar, Ilok) for the period 03/2023-11/2023. The break between medium and high-water levels is marked with a red solid line, the date of measurements for different scenarios with dashed lines.

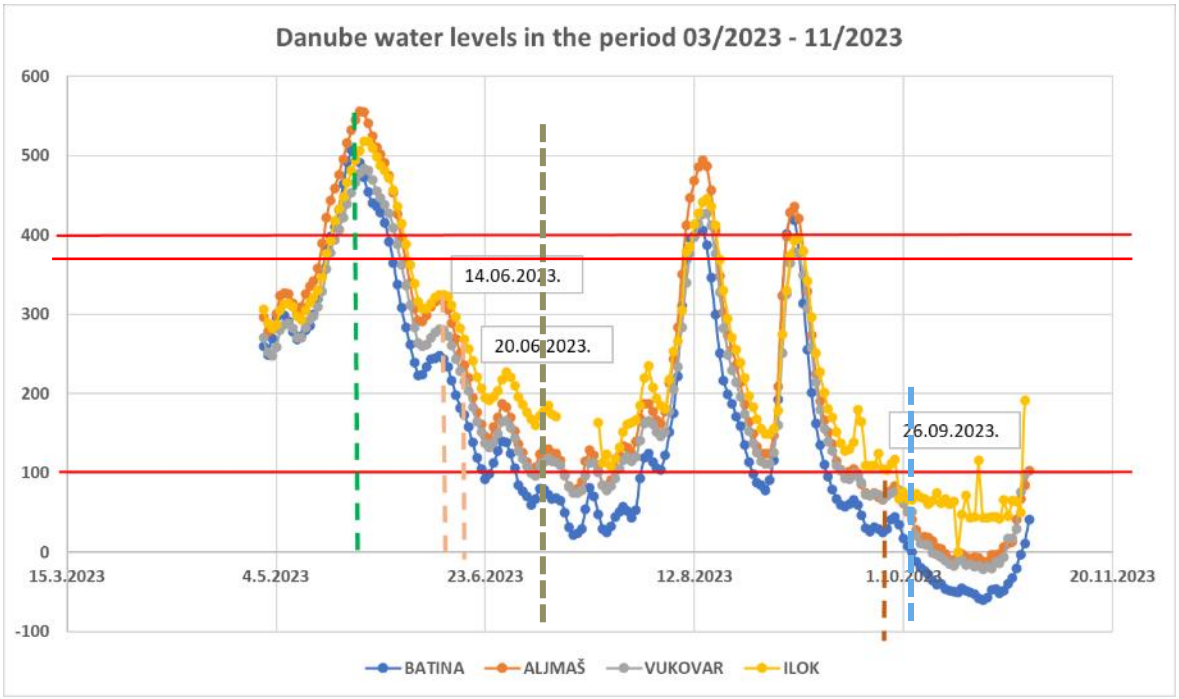


Figure 2-48: Recorded water levels on the Danube in the period 03/2023-11/2023 with indicated measurement dates

After the recording of sediment data, laboratory processing and numerical data processing have been conducted. In the laboratory, the water samples collected by the isokinetic trap were analysed by filtering in order to determine the concentration of suspended sediment, and for the bedload sediment after its drying, its total mass will be determined by weighing. The laboratory also carried out granulometric analysis of sediment. Upon completion of all measurements, the obtained data was analyzed and explained within the Elaborate "*Velocity, Flow and Sediment Study*" (see: **ANNEX 6**).

Scope of the document:

- Presentation of measurements of velocities, flow and morphology by ACDP in a wider subject area,
- Presentation of the results of the hydraulic-morphological analysis of the bed stability,
- Presentation of hydraulic analysis results,
- Multidimensional current picture,
- layout view of velocity distribution,
- Presentation of the detailed transfer of sediment along the transverse profiles and the spatial distribution of the intensity of sediment movement.

After processing, the results of the measurements of velocities and flows and measurement of transfer of suspended and bedload sediment were included in the MMPI's GIS database.

Results

In the document: ***Analysis of the existing situation*** (mark: I-2206/23; Hidroing Ltd. Osijek, July 2024) analysis of hydrological and hydraulic substrates, traffic substrates, analysis of the navigable water levels of the Danube and the analysis on the condition of the existing fairway is given.

Hydrological and hydraulic substrates

Through statistical analysis mean values were obtained in certain time intervals, namely:

- The highest water level (Hmax) = the highest recorded water level from the 20-year observation period.

- High water level (H10%) = the water level determined on the basis of a statistical calculation of the duration of the water level from a 20-year period of observation which corresponds to a water level of 10% duration.
- Normal/average water level (H50%) = the water level is determined based on a statistical calculation of the duration of the water level from the 20-year period of observation which corresponds to the water level of 50% duration.
- Low water level (H90%) = the water level is determined based on a statistical calculation of the duration of the water level from the 20-year observation period which corresponds to a water level of 90% duration.
- Lowest water level (Hmin) = The lowest recorded water level from the 20-year observation period.

Table 2-3: Water level (high, medium and low water levels) for the water meter stations Batina, Aljmaš, Vukovar and Ilok:

Water meter station	H_{max}	$H_{10\%}$	$H_{50\%}$	$H_{90\%}$	H_{min}
Batina	772,0	385,6	192,0	36,7	-82,0
Aljmaš	815,0	417,5	224,9	68,5	-68,0
Vukovar	723,0	365,7	201,6	66,2	-48,0
Ilok	752,0	383,1	233,5	99,0	-27,0

Below, a graphic analysis of the water meter stations in question is given, i.e. a display of the series of characteristic annual water levels of the Danube River at the water meter stations Batina, Aljmaš, Vukovar and Ilok in the period from 2002 to 2021 with a display of high, medium and low water levels.

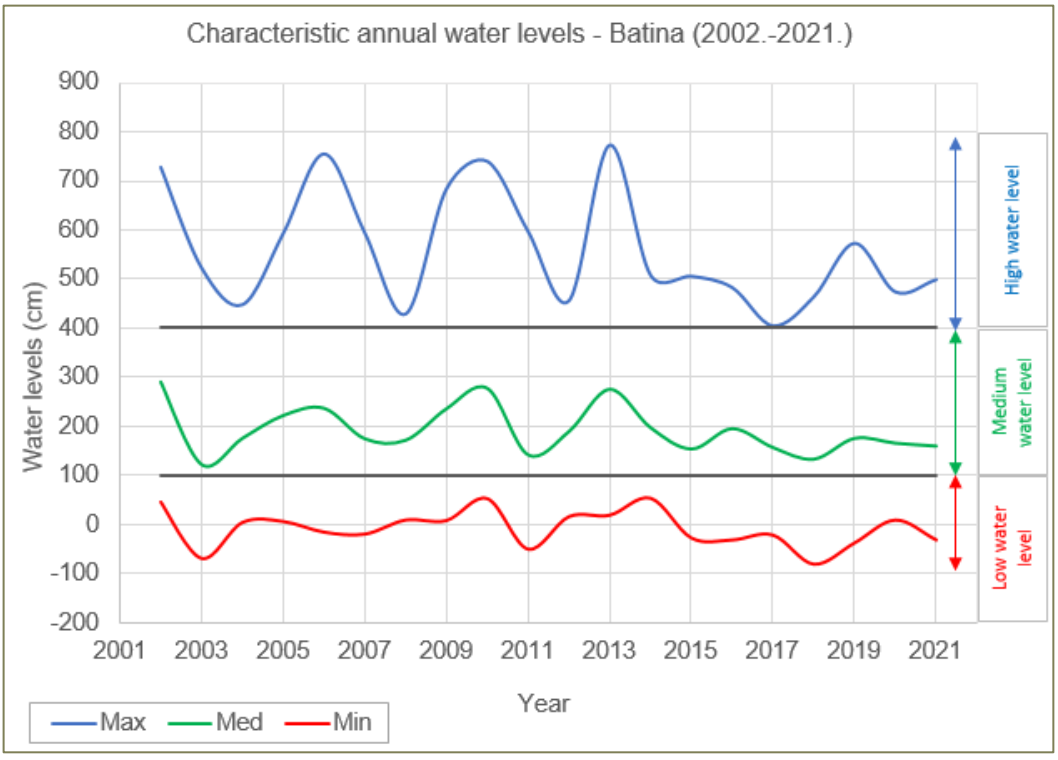


Figure 2-49: Display of a series of characteristic annual water levels of the Danube at the water meter station Batina in the period from 2002 to 2021 with the display of high, medium and low water levels.

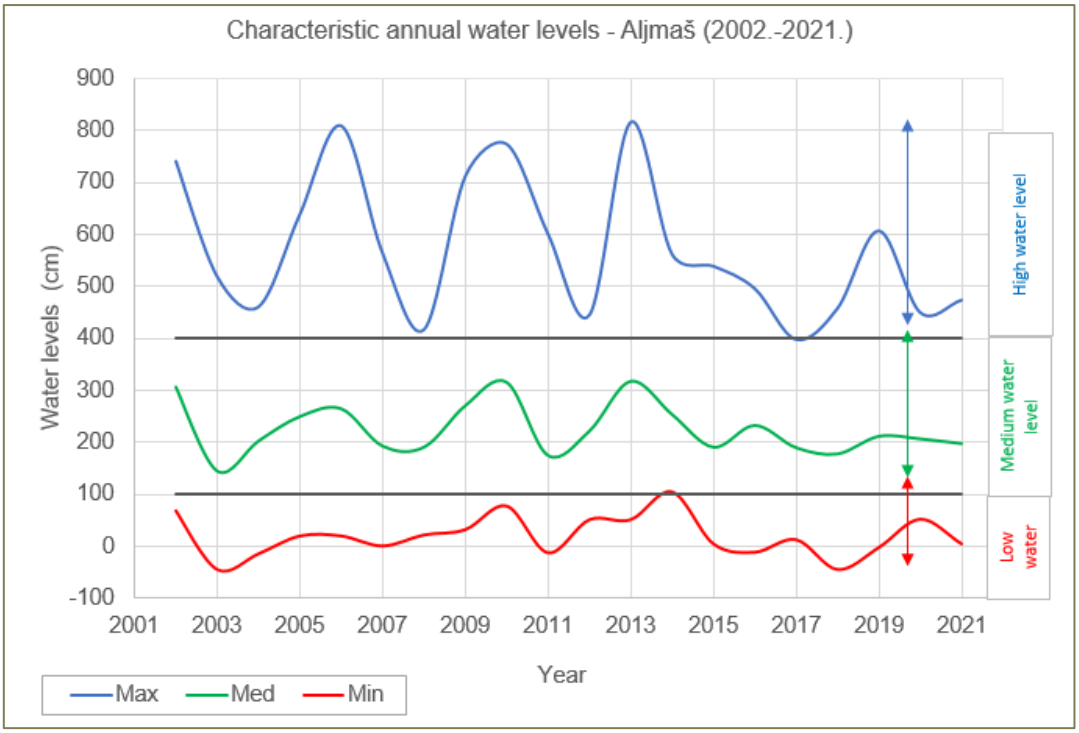


Figure 2-50: Display of a series of characteristic annual water levels of the Danube at the water meter station Aljmaš in the period from 2002 to 2021 with the display of high, medium and low water levels.

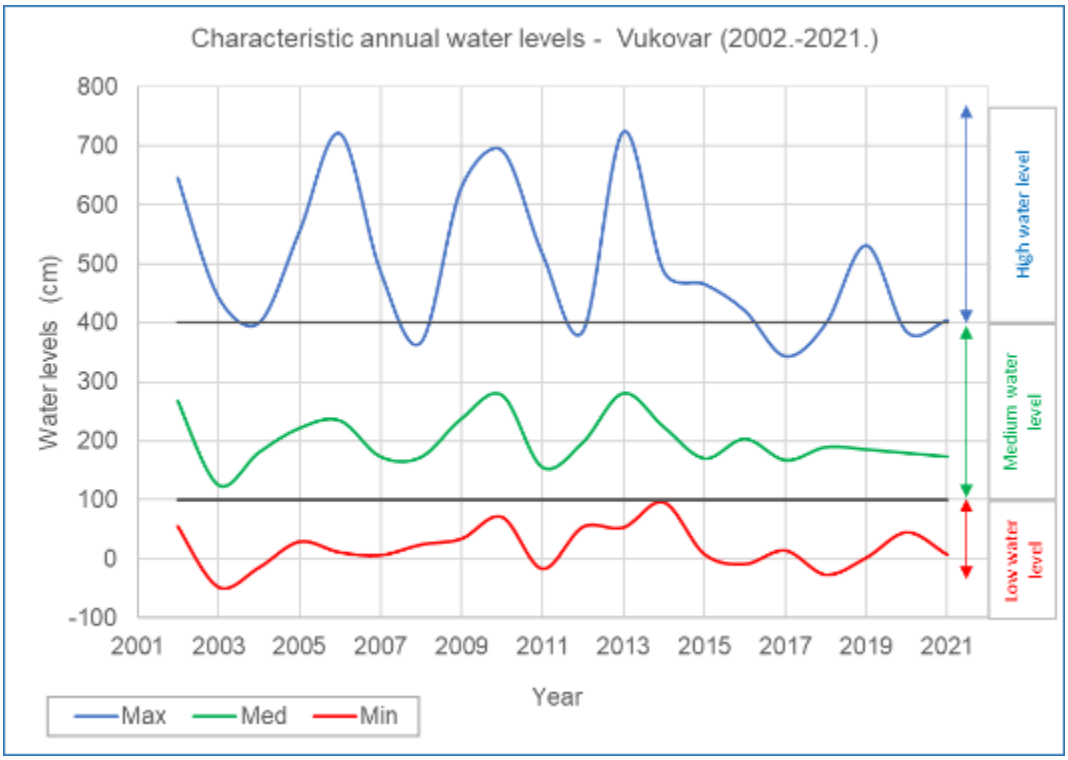


Figure 2-51: Display of a series of characteristic annual water levels of the Danube at the water meter station Vukovar in the period from 2002 to 2021 with the display of high, medium and low water levels.

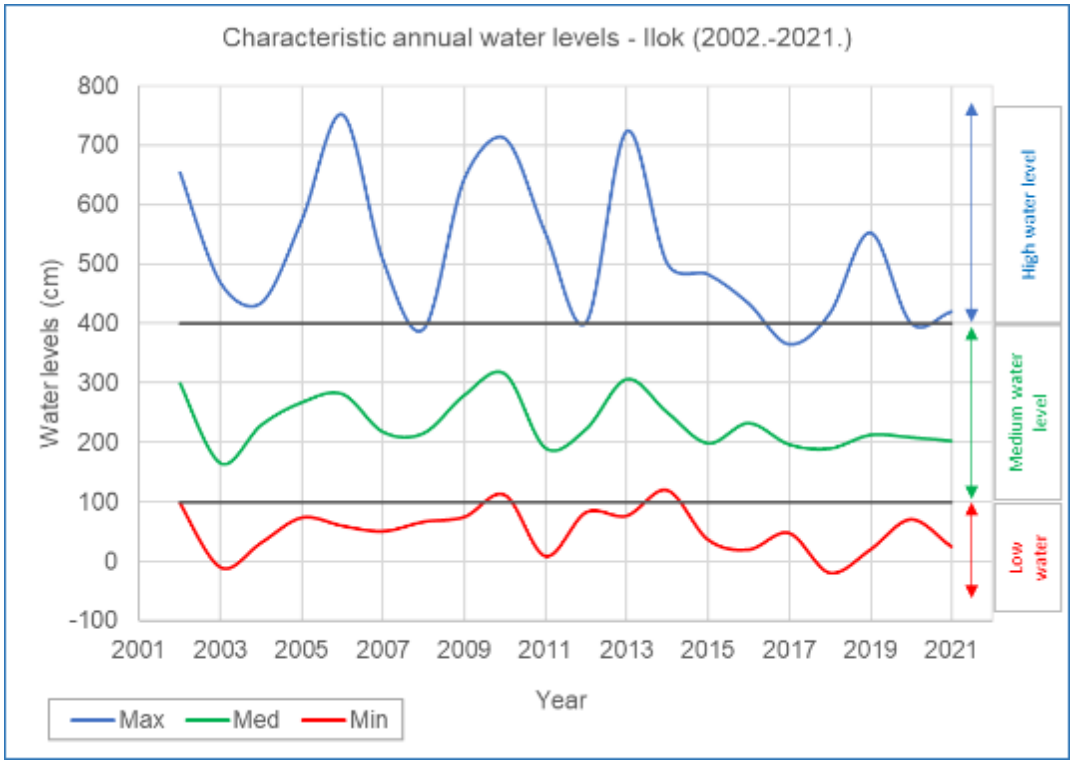


Figure 2-52: Display of a series of characteristic annual water levels of the Danube at the water meter station Ilok the period from 2002 to 2021 with the display of high, medium and low water levels.

In accordance with the data processed above, to facilitate the monitoring of the water levels during the project and due to needs of field measurement campaigns, unique values (intervals) were selected for the high, medium and low water levels of the entire area of the Danube River in question, from km 1433.1 (Batina) to km 1295.5 (Ilok):

- **Low water level < 100 cm**
- **Average water level from 100 cm to 400 cm**
- **High water level > 400 cm**

Traffic substrates

The fairway is an area of inland waters of a certain depth width and prescribed dimensions that are arranged, marked and open for safe navigation. It is defined by the navigable trough and the turning radius at low navigable water level (LNWL) and free gauges under bridges and overhead cables under high navigable water levels (HNWL).

- LNWL – is the water level determined based on a statistical calculation of the duration of the water level from a 30-year timeline on ice-free days, and it corresponds to the water level of 94% duration (defined by the Danube Commission).
- HNWL – is the water level determined based on the statistical calculation of the duration of the water level from a 30-year timeline on ice-free days, and it corresponds to the water level of 94% duration (defined by the Danube Commission)

Based on Article 135, Paragraph 6 of the Law of Navigation and Inland Water Ports (OG 144/21) Ordinance on classification and opening of fairways on inland waters (OG 77/11, 66/14 and 081/15) was issued. This Ordinance classifies and opens the fairways on the internal waters of the Republic of Croatia according to the navigability standards determined by international agreements for international and interstate fairways and the standards established by the Ordinance on determining the standards for determining the navigability on fairways.

Table 2-4: Class of the fairway of the Danube River (source: Ordinance on classification and opening of fairways on inland waters OG 77/11, 66/14 and 081/15):

River	**Type of waterway/river section**	**Length of the waterway (km)**	**Waterway class**
INTERNATIONAL WATERWAYS			
DANUBE	1295+500 (Ilok) - 1433+000 (Batina)	137,50	VI.c class

The classification of Europe's fairways of international importance establishes the following:

Class VIc fairway – used by pusher assemblies with a pusher in the arrangement P+2+2+2, length 270 - 280 m, width 22.8 m, draft 2.5 - 4.5 m and carrying capacity 9,600 - 18,000 t, as well as assemblies of thrusters in the arrangement P+3 +3 length 195 - 200 m, width 33 - 34.2 m, draft 2.5 - 4.5 m and carrying capacity 9,600 - 18,000 t.

Analysis of the navigable water levels of the Danube

The aim of this analysis was to determine the state of navigability in terms of the available depths for navigation, in relation to the low navigable water levels (LNWL) and different widths of the fairway.

Below is a presentation of the quantities necessary for dredging in order to achieve the prescribed dimensions of the fairway (2.5 m deep and 200 m wide), defined by the document*: Application of the critical sector prioritization methodology on the joint SRB-CRO section of the Danube River, Plovput (RS) and the Agency for fairways (HR), July 2014*.

Table 2-5: Ranking of critical sections according to quantities for dredging of material

Legenda

-		0,00
0,01		10.000,00
10.000,01		25.000,00
25.000,01		75.000,00
75.000,01		

Rangiranje	Naziv	od rkm	do rkm	h	200
1	Borovo I	1348,40	1343,60	2,5	85.065,32
2	Židovski/Čivutski rukavac	1397,20	1389,00	2,5	83.865,61
3	Apatin	1408,20	1400,00	2,5	58.570,39
4	Borovo II	1340,60	1338,00	2,5	51.804,63
5	Ušće Drave	1383,40	1381,60	2,5	42.927,77
6	Staklar	1376,80	1373,40	2,5	10.166,37
7	Mohovo	1311,40	1307,60	2,5	3.914,10
8	Dalj	1357,00	1351,00	2,5	9.202,99
9	Sotin	1324,00	1320,00	2,5	8.013,52
10	Batina / Bezdan	1429,00	1425,00	2,5	1.664,97
11	Bogojevo	1366,20	1361,40	2,5	1.283,23
12	Vukovar	1332,00	1325,00	2,5	843,86
13	Erdut	1371,40	1366,40	2,5	436,33
14	Opatovac	1315,40	1314,60	2,5	9,72
15	Siga-Kazuk	1424,20	1414,40	2,5	9,27
16	Ilok	1302,00	1300,00	2,5	0,00
17	Aljmaš	1381,40	1378,20	2,5	0,00
				UKUPNO:	**357.778,08**

The total amount of necessary dredging is about 360,000 m3, of which critical sections under no. 1-5 represent about 90% of the required quantities.

Analysis on the condition of the existing fairway

Fairway depth

The depth analysis on critical sections was made for the existing route of the VI.c class fairway. An analysis was made of critical sectors and transverse profiles where, with LNWL=94%, the depth of the waterway with a width of 200 m is less than 2.5 m.

From the analysis of the depths of the existing fairway for VI.c. class, it can be seen that out of a total of 17 critical shares, 7 of them are critical, i.e. that 44% of the shares in question are critical.

Therefore, it can be concluded that, if a fairway depth of 2.5 m is to be achieved on the entire analyzed section of the Danube at a 94% water level duration and a defined width of the fairway of 200 m, it is necessary to carry out regulatory works and/or works technical maintenance on 41% of the section, i.e. in a length of approx. 32.80 km (out of a total of 79.40 km).

Critical sections are: Borovo I, Židovski/Čivutski rukavac, Apatin, Borovo II, Ušće Drava (confluence), Staklar and Mohovo (bearing in mind that on this section the bottom is solid and obstacles are created by underwater rocky structures/elevations)

Non-critical sections are: Dalj, Sotin, Batina/Bezdan, Bogojevo, Vukovar, Erdut, Opatovac, Siga-Kazuk, Ilok and Aljmaš.

Fairway width

The analysis depending on the width of the waterway on the section in question was made for widths of 200, 150, 120, 100 and 80 m. From the analysis of the widths, it is evident that out of a total of 17 critical sections:

- 6 sections are critical for a width of 200 m (Apatin, Židovski/Čivutski rukavac, Ušće Drava (confluence), Staklar, Borovo I and Borovo II),
- 4 sections for a width of 150 m (Apatin, Židovski/Čivutski rukavac, Borovo I and Borovo II),
- 1 section for a width of 120 m (Apatin),
- none of the sections is critical for widths of 100 and 80 m,
- The Mohovo section is critical for all widths of the waterway except for the width of 80 m, because underwater rocky structures/elevations are spread over the entire width of the fairway.

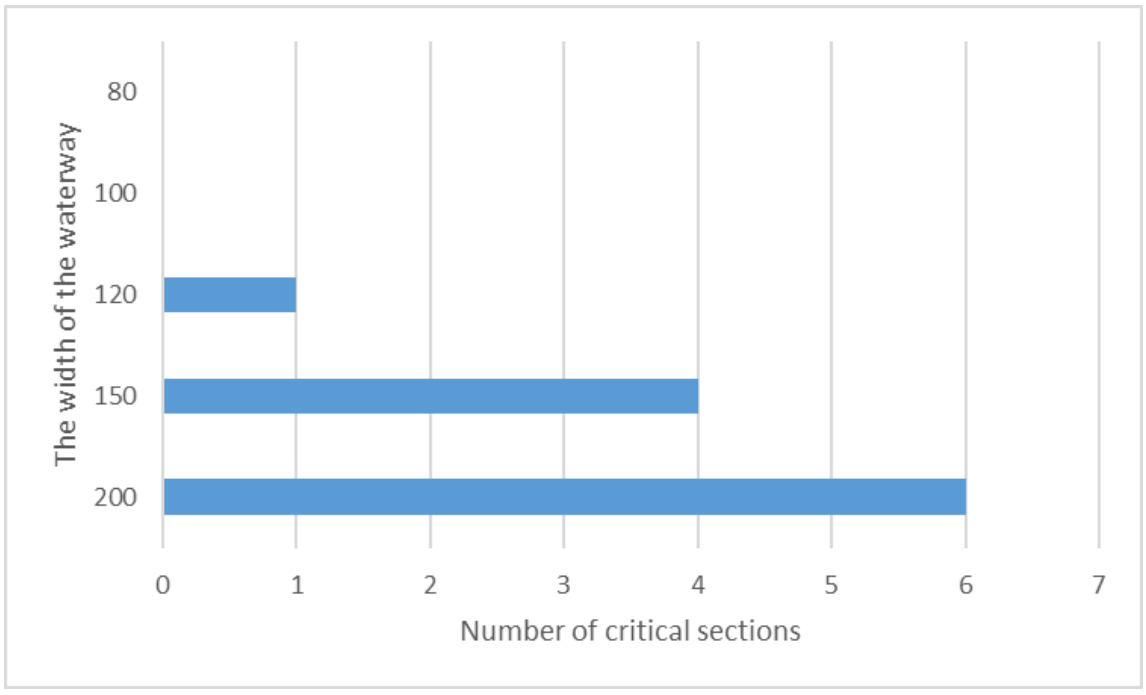


Figure 2-53: Analysis of the criticality of sections in relation to the width of the fairway

Fairway curve radius

For the purposes of this analysis, the minimum radius of the fairway is Rmin=1000m. On morphologically inadequate sections, Rmin = 750 m is exceptionally permitted.

In the entire analyzed area, the axis of the existing fairway consists of 101 bends and 34 intermediate sections. Out of a total of 101 bends, 10 of them have a smaller radius than Rmin=1000m and 1 bend has a smaller radius than Rmin=750 m (at rkm 1390 with a length of approx. 200m, i.e. on the critical section Židovski/Čivutski rukavac).

The width and height of the free fairway profile under the bridges

Required criteria:

- minimum free width under the bridges 50 m
- minimum clearance under bridges 9,10 m

There are four bridges in the subject section shown in the following table.

The bridge	Stationary [rkm]	B_{pl} [m]	H_{vpl} [m]	HNWL [m.a.s.l.]	ELBS [m.a.s.l.]
Road bridge Batina - Bezdan	1424+425	120,00	**9,30**	86,64	95,94
Road bridge Erdut - Bogojevo	1366+625	125,00	**9,61**	83,41	93,02
Railway bridge Erdut - Bogojevo	1366+443	80,00	**8,59**	83,40	91,99
Road bridge Ilok - Bačka Palanka	1297+050	120,00	**10,13**	79,67	89,80

where:

- *B_{pl} (m) is the horizontal distance between the endpoints that limit the waterway*
  H_{vpl} (m) – the vertical distance between the high navigable water level and the lower bridge structure
- *HNWL – the high navigable water level in the bridge profile*
- *ELBS – the lowest elevation of the lower edge of the bridge structure*

Out of a total of 4 bridges on the Danube River section from Batina to Ilok only the road and railway bridge Erdut – Bogojevo is located within the critical sections defined by the project. It is evident from the analysis that only the railway bridge Erdut - Bogojevo does not meet the required minimum clearance height of 9,10 m.

Sections where the fairway located adjacent to the bank potentially threatens the stability of the bank and the safety of navigation (side erosion of the banks).

On the section in question, 6 sections were observed that do not meet the criteria, i.e. the fairway is located right next to the banks, thus jeopardizing the stability of the banks (side-erosion) and the safety of navigation. The sections located directly along the banks are: Apatin, Židovski/Čivutski rukavac, Staklar, Borovo I, Vukovar and Sotin.

Overall evaluation of the state of the existing fairway

The assessment of the state of the existing VI.c fairway was based on previously conducted analyses. According to the conducted analyses:

- Fairway depth — partially satisfies (10/17)
- Fairway width — partially satisfies (10/17)
- Fairway curve radius — generally satisfies (16/17)
- Width and height of the free fairway profile under the bridges — partially satisfies (3/4)
- Sections where the fairway located adjacent to the bank potentially threatens the stability of the bank and the safety of navigation (side erosion of the banks). — partially satisfies (11/17)

In the current conditions, disturbances due to insufficient depth and/or width and the small radius of bends do not cause substantial delays in navigation on any critical section, because these are short sections and one-way navigation is always possible, for which there is sufficient width at any time if the navigation is conducted in prescribed compositions. However, long-term the lack of measures at critical sections will (presumably) continue to narrow the fairway and more one-way navigation shall probably be needed, causing higher risk(s). Additionally, traffic-related restrictions such as one-way traffic can intensify delays. When vessels must wait for others to pass—similar to delays caused by lock operations—this increases transport times and undermines the confidence/trust in the reliability and predictability of inland waterways.

In the document: Elaborate ***"Velocity, flow and sediment Study" (***mark: I-2206/23, Hidroing Ltd., Osijek, July) the results of measuring velocities, flow and morphology, results of hydraulic-morphological analysis of riverbed stability, results of hydraulic analysis, multi-dimensional current picture, layout representation of velocity distribution and representation of detailed sediment transport in transverse profiles with spatial distribution of intensity of sediment movement are given. Key summary results are presented below.

Velocities, flows and sediment

Table 2-6: Results of velocity, flow and sediment measurements

Element / Location	***Measuring unit***	***Batina/Bezdan***	***The confluence of Drava***	***Vukovar***	***Ilok***
The position of the upstream profile	*rkm*	rkm 1429+000	1383+000	1332+000	1302+000
The position of the downstream profile	*rkm*	rkm 142+5000	1381+600	1325+000	1300+000
Medium depth					
m01 (high water level)	*m*	8,3-9,9		7,6-10,3	8,8-8,1
m02 (medium water level)	*m*	5,1-7,0		5,4-8,2	6,6
m03 (low water level)	*m*	4,1-5,9		4,0-6,4	4,6-5,4
Maximum depth					
m01 (high water level)	*m*	10,9-13,0		11,1-13,8	10,0-12,1
m02 (medium water level)	*m*	8,0-9,9		8,4-11,5	8,0-9,7
m03 (low water level)	*m*	6,4-8,7		6,2-9,3	5,9-7,0
Measured velocities					
m01 (high water level)	*m/s*	0,91-1,02		0,99-1,18	1,17-1,05
m02 (medium water level)	*m/s*	0,72-0,72		0,88-0,91	1,01-0,85
m03 (low water level)	*m/s*	0,66-0,67		0,76-0,67	0,82-0,88
Maximum velocity (mainstream)	*m/s*	~ 1,5		~ 2,0	~ 1,5
Measured flows					
m01 (high water level)	m^3/s	3.862-3.916	4.009-5.373	5.439-5.082	5389-5301
m02 (medium water level)	m^3/s	1.833-1.839	1.963-2.797	3.484-3.112	3559-3232
m03 (low water level)	m^3/s	1.367-1.393	1.348-1.863	1.736-1.691	1956-1876
Transport of bedload sediment					
m01 (high water level)	*kg/s*	5,9-9,5	10,5-5,1		7,8-18,0
m02 (medium water level)	*kg/s*	12,6-3,6	8,5-5,0		11,3-15,0
m03 (low water level)	*kg/s*	14,3-3,0	5,0-3,4		7,9-9,5
Transport of suspended sediment					
m01 (high water level)	*kg/s*	128-130	135-189		198-184

Element / Location	*Measuring unit*	*Batina/Bezdan*	*The confluence of Drava*	*Vukovar*	*Ilok*
m02 (medium water level)	*kg/s*	55	61-90		118-109
m03 (low water level)	*kg/s*	43,-44	42-63		62-63
Granulometric curve		D50 ~ 0,3 mm	D50 ~ 0,25 mm		D50 ~ 0,2 mm

Although the measurements cover the entire range of flow and water level (low, medium and high water level), it is evident that discrete measurements do not reflect the complex dynamics of the interaction of turbulent flow and sediment movement. This is most pronounced in measurements of bedload sediment, where there are considerable variations of sediment transport within a single profile during the same event. The aforementioned deviation is a consequence of discrete physical sampling that cannot cover the entire spatial variability of sediment transport in riverbeds. Therefore, traditional sediment monitoring methods are complemented by indirect methods such as monitoring the velocity of the moving bottom, which is an indicator of the intensity of the movement of the bedload sediment (Gilja et al. 2017). Also, in order to reduce the error caused by the limiting factors of the method, it is necessary to collect a large amount of data that can only be obtained by systematic and regular measurement of sediment transport.

From the display of water levels from relevant water meter stations, it is evident that the measurement was carried out on different hydrographic conditions (low, medium, high water-levels). It is known that the sediment transport hysteresis is not synchronized with the flow hysteresis, which means that there is no direct dependence between water and sediment regimes. Therefore, monitoring should be continuous and include several measurements during the same hydrological event in order to determine the simultaneous water and sediment regime of the entire hydrological event.

Analysis of linear riverbed erosion

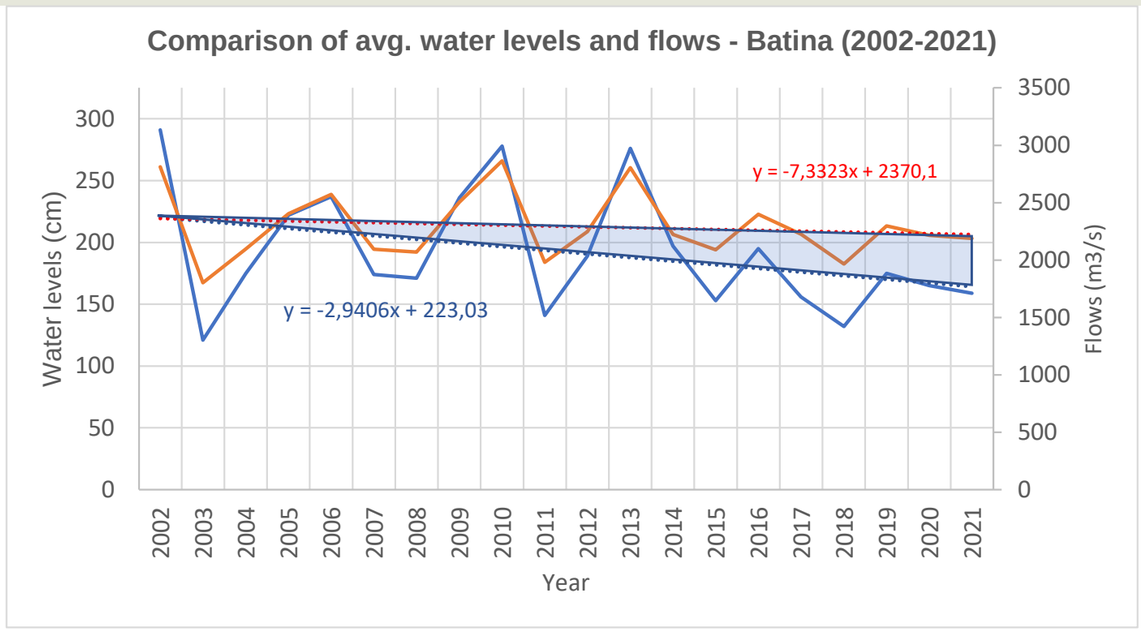
With the aim of determining broader trends on the observed section of the Danube, a broad analysis of statistical trends of water levels and flows was carried out at 4 water meter stations (Batina, Aljmaš, Vukovar, Ilok) with the aim of identifying trends in linear riverbed erosion (incising effect). The data sequence is identical to the hydrological analysis, period 2002-2021. The basic assumption related to the thesis is that the difference in the trends of water level and flow reduction at the water meter stations represents linear riverbed erosion of the Danube bed at that location, where the average yearly flow reduction is caused by climate changes, while the average yearly water level reduction, in addition to climate changes, is also caused by the deepening of the riverbed.

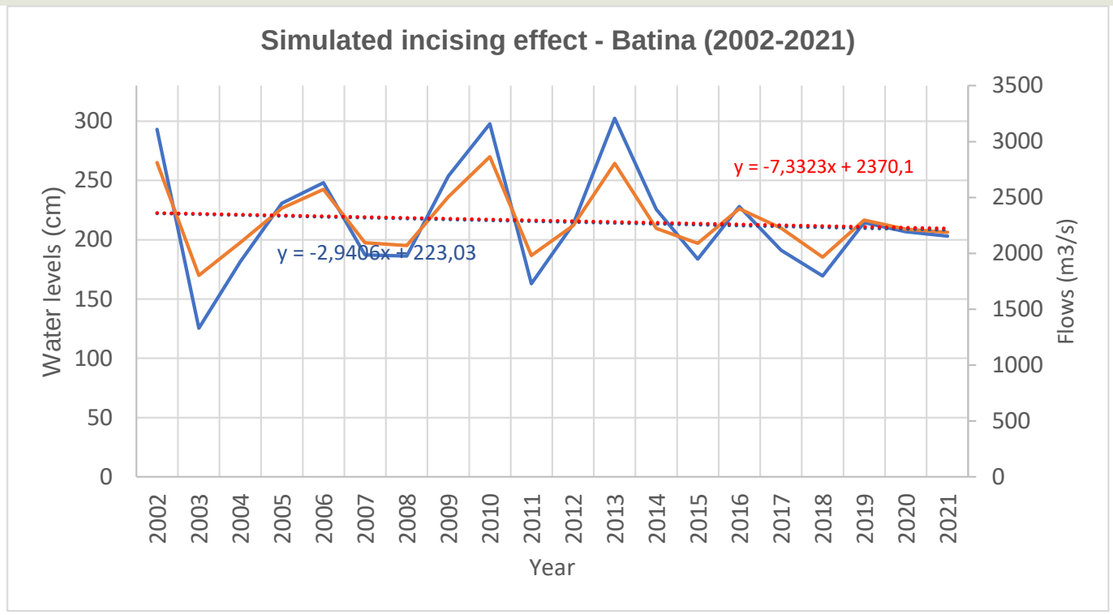
The effects of riverbed deepening were simulated on an annual basis until water level and flow trends matched. In this way, an estimate of the average annual effect of riverbed deepening is given.

Below is a graphic analysis by water meter stations, the images on the left show a comparison of trends in flow and water level, the images on the right show simulated conditions with the specified results.

The simulated influence of linear riverbed erosion is estimated at 1.6 cm/year (most upstream station: Ilok) to 2.2 cm/year (most upstream station: Batina). The exception is the Aljmaš station, where a linear erosion simulation of 1.1 cm/year is recorded, which is expectedly a lower result compared to others considering the inflow of sediment from Drava River.

Batina location

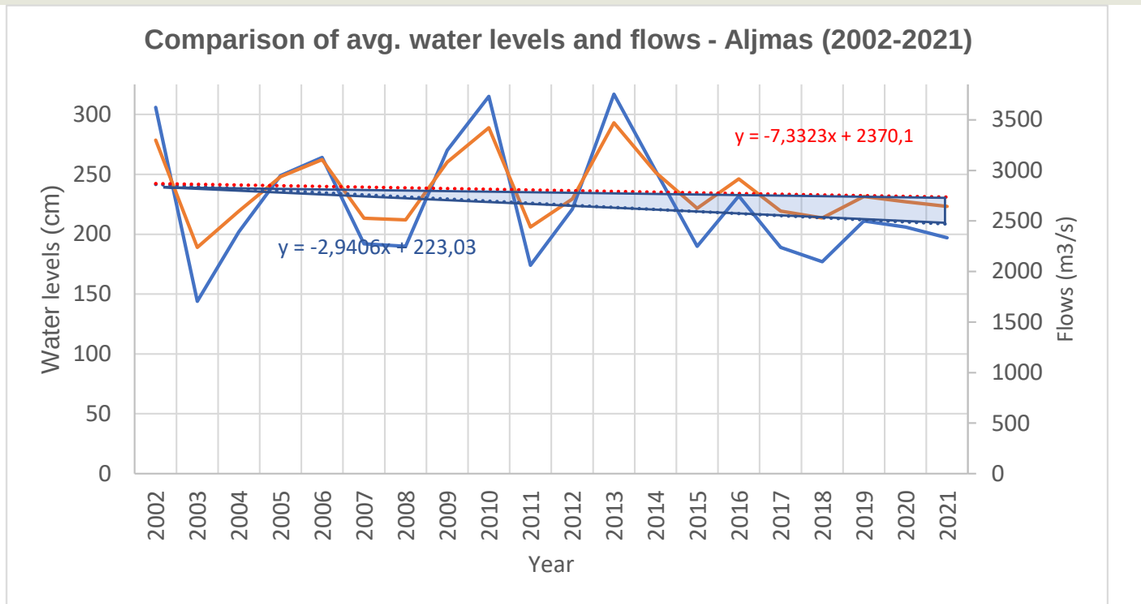


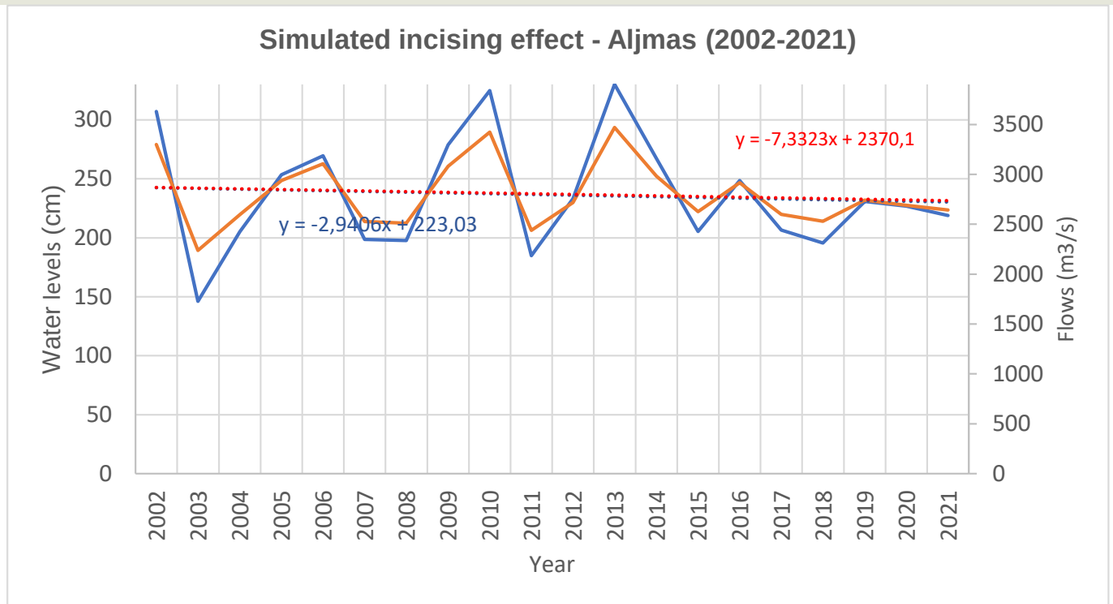


Simulated linear riverbed erosion value: **2,2 cm/ann.**

Figure 2-54: Comparison of water level trends and simulated trends at WM station Batina

Aljmas location

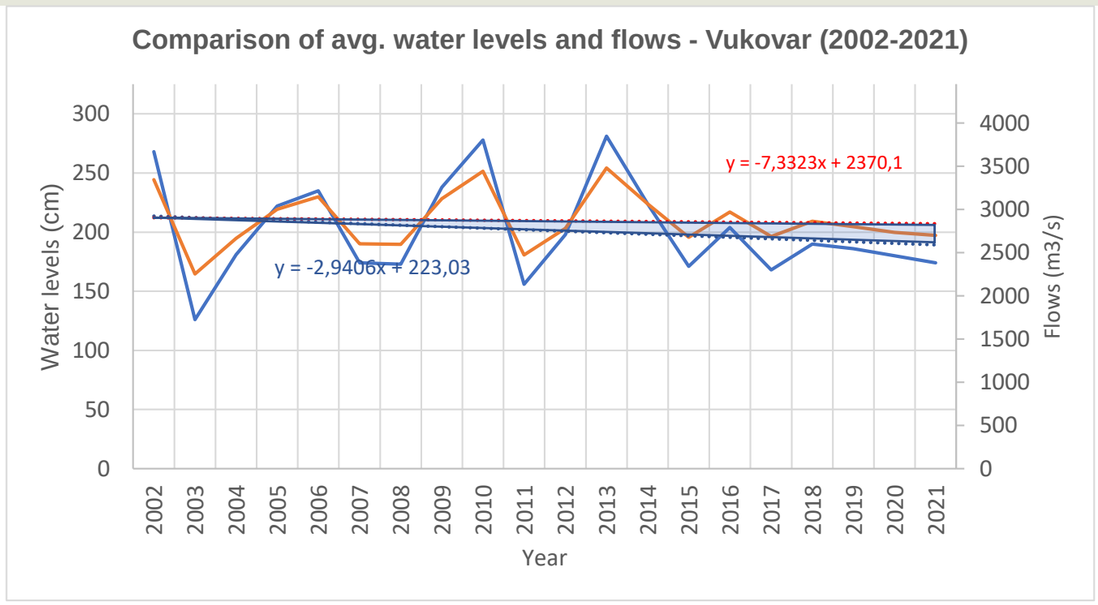


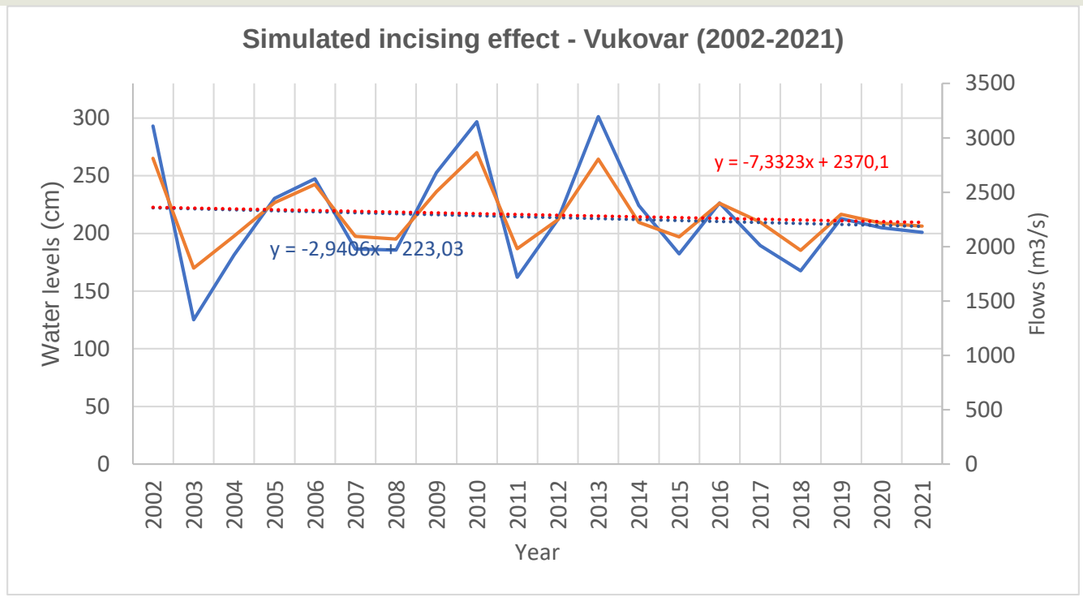


Simulated linear riverbed erosion value: **1,1 cm/ann.**

Figure 2-55: Comparison of water level trends and simulated trends at WM station Aljmaš

Vukovar location

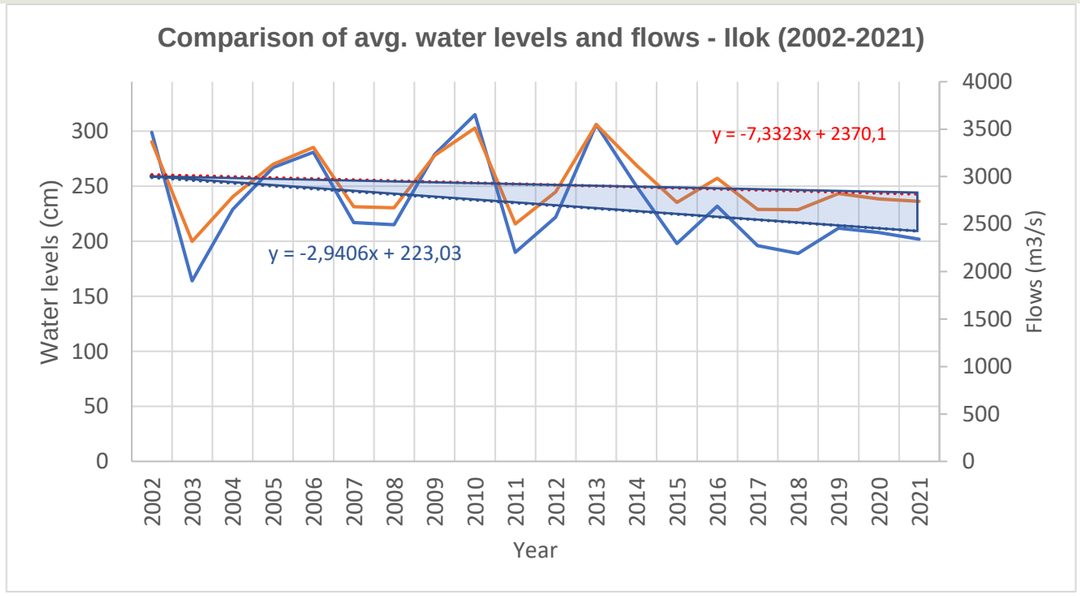


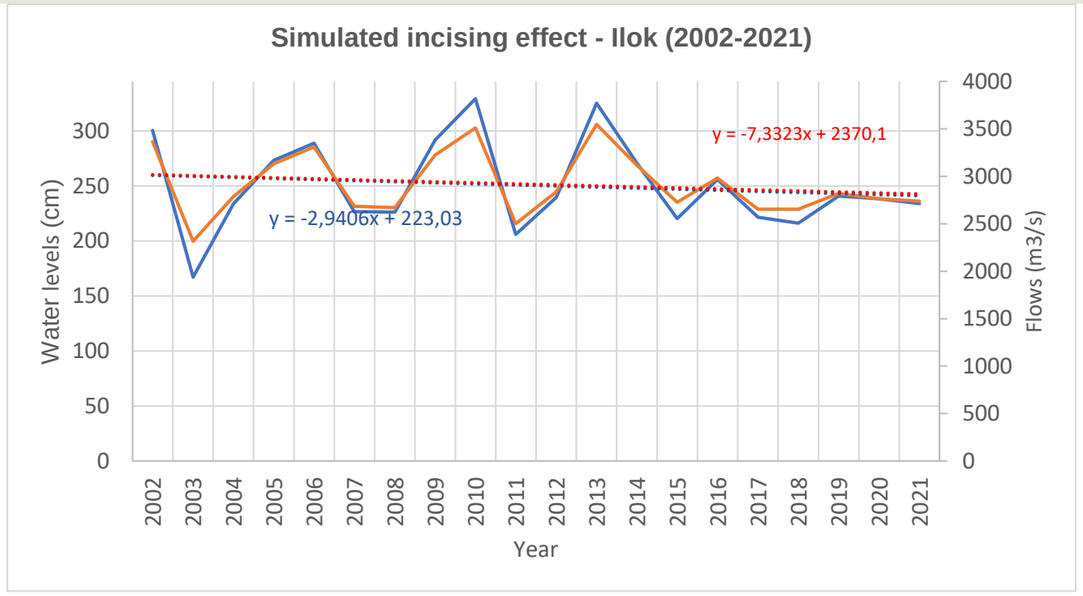


Simulated linear riverbed erosion value: **2,1 cm/ann**

Figure 2-56: Comparison of water level trends and simulated trends at WM station Vukovar

Ilok location





Simulated linear riverbed erosion value: **1,6 cm/ann.**

Figure 2-57: Comparison of water level trends and simulated trends at WM station Ilok

2.1.4. Piezometer installation

Overview

Preparation was carried out and a preparatory meeting was held with the Beneficiary (1 February, 2023), where the approach to the installation of piezometers (performance, equipment, proposed locations) was presented to the Beneficiary.

After the preparatory meeting, the analysis of possible locations for the installation of piezometers was undertaken. Preliminary locations on the upper, middle and lower sections of the Danube were proposed (Figure 2-58), as follows:

1. Batina (rkm 1425+250), cp. no. 441/5, REPUBLIC OF CROATIA, CROATIAN WATERS - PUBLIC WATER WELL FOR GENERAL USE

2. Aljmaš (rkm 1380+000), cp no. 1924, ERDUT MUNICIPALITY

3. Ilok (rkm 1299+100), cp no. 1479/3, REPUBLIC OF CROATIA, CROATIAN WATERS - PUBLIC WATER GOOD FOR GENERAL USE

Preliminary locations were proposed considering:

- purpose of measurement
- scope of intervention (beginning, middle, end of the project section)
- provided access to drilling machinery
- settled property-ownership relations at the location - all locations are public areas
- coverage of the area by video surveillance (considering the installation of automatic loggers in piezometers, it is considered advisable to have some form of surveillance over the locations. All locations are next to existing or planned docks, which are or will be covered by video surveillance by port authorities)

The procedure for approving the performance of the piezometers at the above locations was initiated, and the Beneficiary responded positively to the proposed locations of the piezometers, after coordination with the CEF project forum.

General purpose of the piezometers is to enable continuous measurements of water levels and temperature for 3 proposed location. This shall enable up-to-date information which can be used for correlation of measured hydrographic data from measurement campaigns. Additionally, it is envisioned that these 3 piezometeres shall be included in national piezometer grid which serves in gathering data of groundwater conditions per Water Framework Directive.

Based on of the Terms of Reference and on the agreement from the preparatory meeting, the general technical conditions for the performance of the piezometers were developed, which are presented below.

Text box 2-5 Technical conditions for the performance of the piezometers

Technical conditions for the performance of the piezometers

Drilling of three piezometer wells, sealing with a PVC construction made of full pipes and a filter (predictable) diameter 3", installation of gravel backfill and clay-bentonite buffer, cleaning and securing of the piezometer are planned. Piezometers are installed within a radius of up to 100 meters from the Danube bank, depth of up to 15 meters. Below is a brief technical description of the basic steps when drilling piezometers.

The drilling of the piezometer well will be carried out by a machine (predictably) using a direct rotary method with flushing the well with water. The excavated material is taken from out, laid on a flat surface and mapped by geological determination of the samples.

For the installation of the piezometer structure, high-pressure full PVC pipes equipped with perforation filter layer (predictably) 1 mm with an additional dense PVC mesh ("filter plastica") will be prepared.

At the bottom of the structure, a conical PVC cap wound on the opening will be placed, i.e. the bottom of the full PVC pipe that makes up the settling tank.

In the free annular space around the well structure, a granular backfill of double-washed quartz gravel with a grain size of 1-3 mm will be installed. After backfilling and securing the piezometer, the remaining free ring space of 10.00 m to the ground surface is filled with clay material with the addition of bentonite (clay buffer), in order to protect the entry of surface water into the piezometer well and underground water.

Upon completion of the installation of the technical structure, backfill and buffer, the piezometer will be secured (cleaned). Cleaning will be carried out by the "air-lift" method using a compressor. A compressor rubber hose will be installed in the piezometer, through which air will be pressed, first at a depth of 20 m, and then it will gradually rise to the zone with the sieve.

Cleaning will be carried out until the water is completely clear.

The construction of the top of the piezometer will include a PVC pipe top and a steel protective pipe with a cover and a padlock. The protective pipe near the ground will be secured with a concrete block (approx. 0.5 x 0.5 x 0.3 m.

Piezometers must enable continuous measurements of oscillations of the underground water level and temperature. The collection of data on the level of underground water will be done using automatic meters (loggers) that measure and record water levels and temperature. The loggers will have an internal memory for 72,000 measurements and the possibility of storing a backup copy of 72,000 measurements.

The Conditions on piezometer installation were formally issued by Hrvatske vode for all 3 locations (5 February 2023), and after receiving them, piezometers were installed in May and July 2023. Below, photo from the field work is given (Figure 2-59).

According to the received Conditions, three piezometer wells were drilled, sealed with a PVC construction made of solid pipes and a filter layer of 3" diameter, installation of gravel backfill and clay-bentonite buffer, cleaning, conquest and securing of the piezometer. The piezometers were installed in a radius of up to 100 meters from the Danube bank, depth up to 15 meters.

Figure 2-58: Location of piezometer performance

Figure 2-59: Piezometer installation conducted (Ilok and Ajmaš locations)

From 29 March 2024, piezometers are equipped with automatic meters (loggers) that measure water level and temperature. Eijkelkamp TD Diver piezometers are installed, with a water level measurement range of 100 m, and temperatures from -20 to +80ºC. Pressure sensor: piezo resistant ceramic Al2O3, housing stainless steel 316L. Accuracy 0.05% of the level range, and temperature +0.1°C. The meters have a memory storage of 72,000 records (+ 72,000 records as back-up) and are set to record twice a day.

Below are descriptions of meter set-up, i.e. the initial settings of the meter in the supplied software.

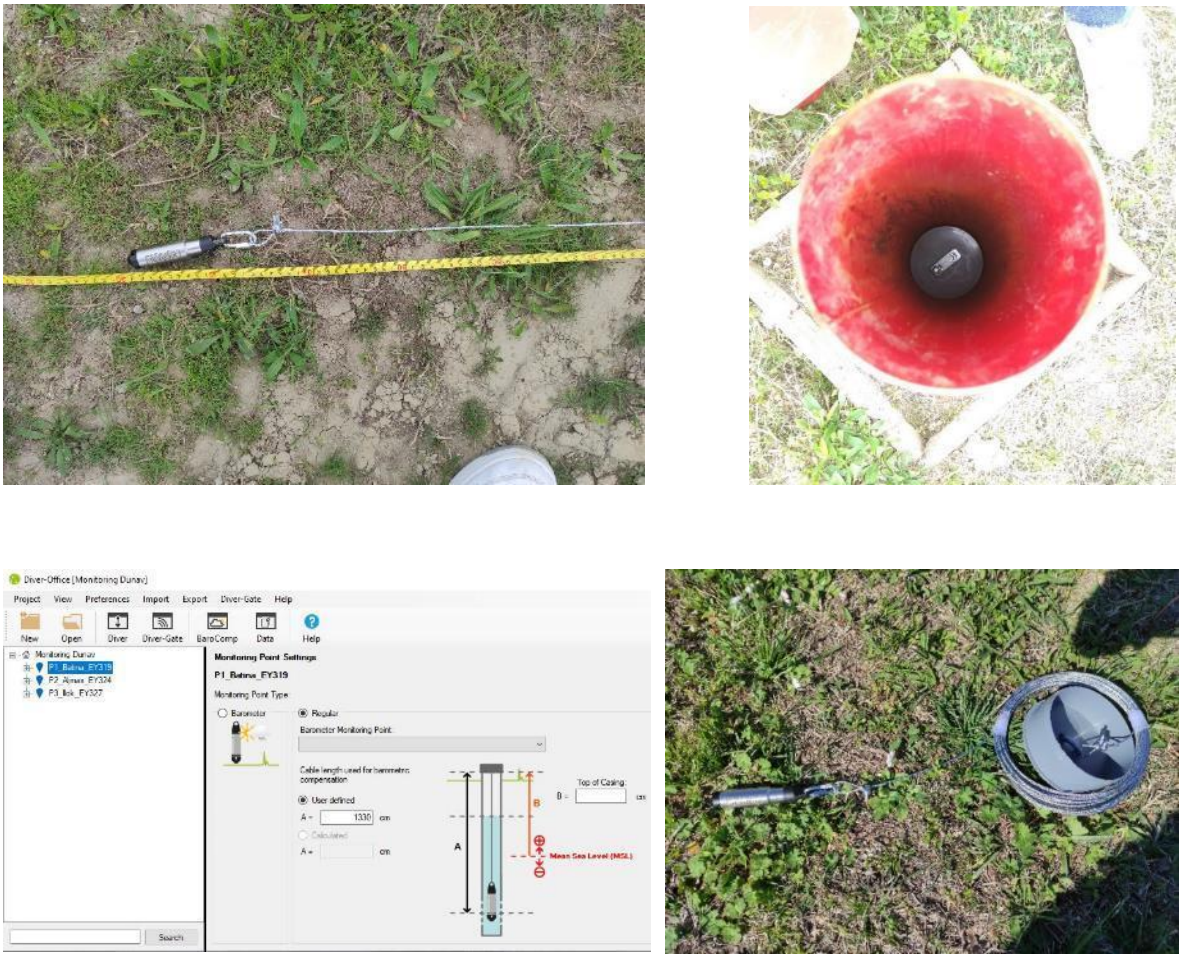


Figure 2-60: Completed equipping of piezometers with automatic meters (loggers)

The report under the chapter related to "Piezometers on the joint Croatian-Serbian sector of the Danube River" (see: **ANNEX 5**) contain the following:

- information on piezometer locations,
- information on profiles of piezometric wells
- information on the method of installation, i.e. implementation of works on the installation of piezometers.

All that information and measurements data were also included in the MMPI's GIS database.

Results

Measurement of water level and temperature parameters started on 29 March, 2024, and below are the results of the water level measurement up to 29 April, 2024. The loggers continue to measure continuously after project completion.

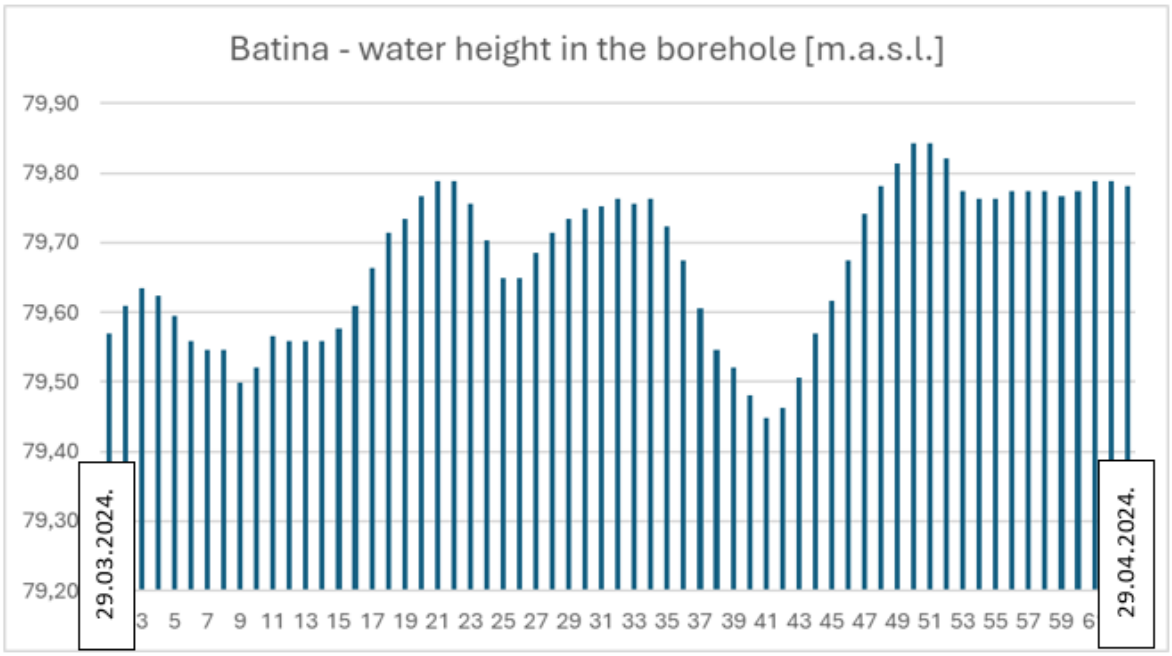


Figure 2-61: Water level changes on Batina piezometer

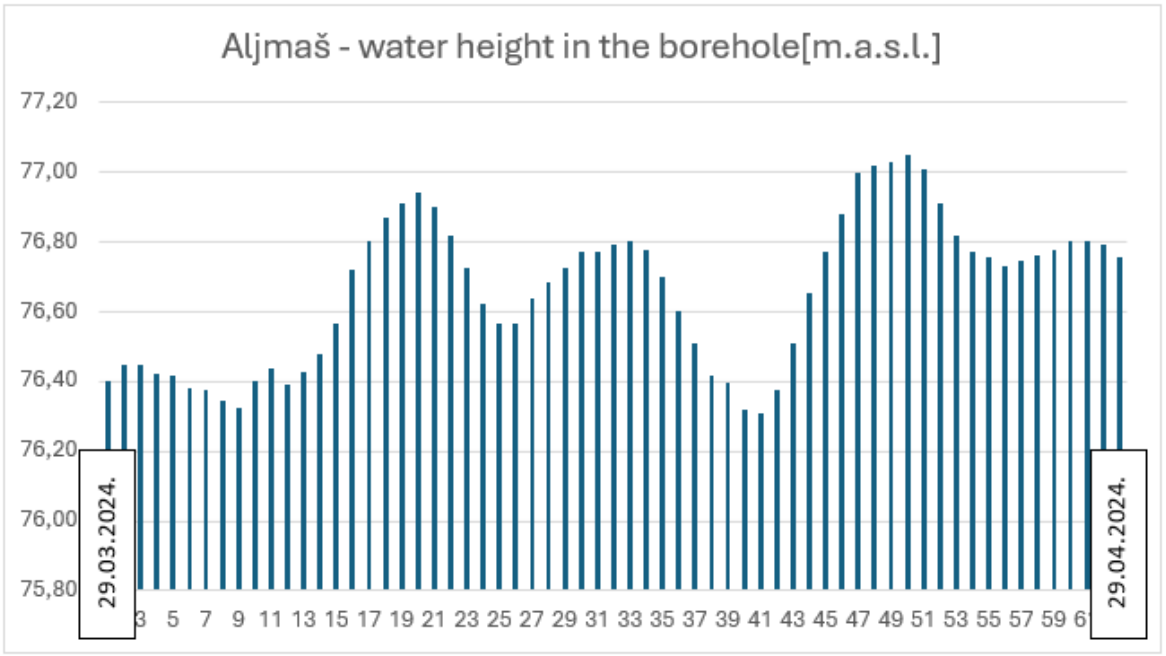


Figure 2-62: Water level changes on Aljmaš piezometer

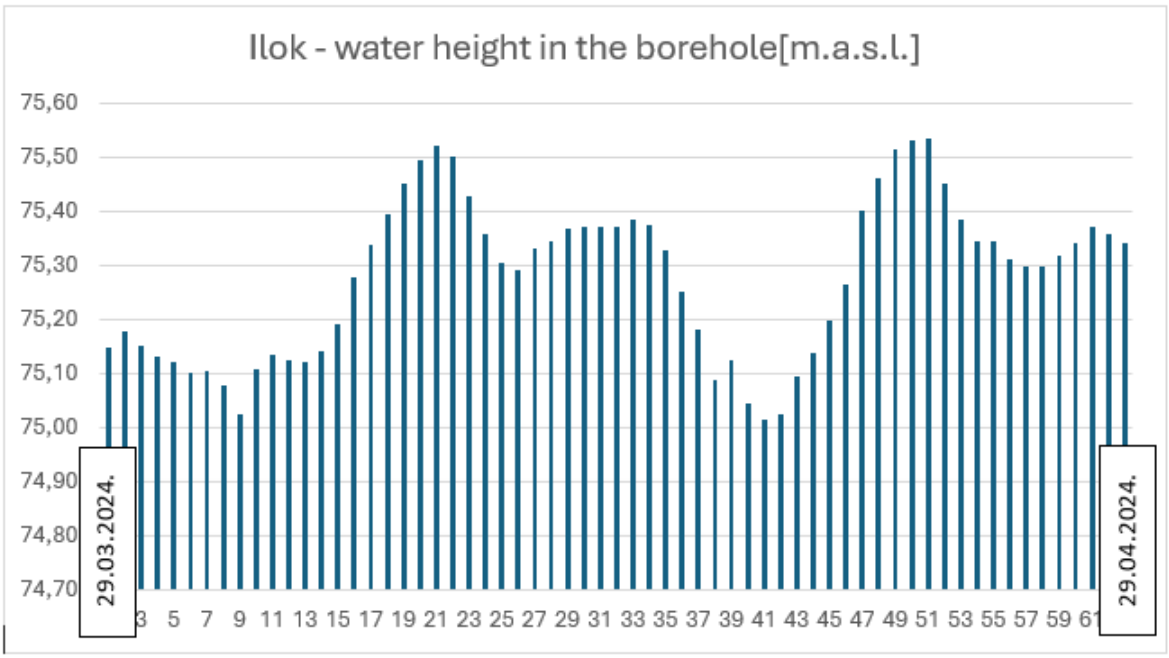


Figure 2-63: Water level changes on Ilok piezometer

2.2. Biodiversity inventory

2.2.1. Fish inventory

Overview

A preliminary meeting was held with the Beneficiary (1 February 2023), where the approach to fish inventory was presented to the Beneficiary (research locations, meteorological and hydrological conditions, research periods and overall dynamics, research methods).

The collection and review of materials on earlier ichthyofauna research on the Croatian-Serbian section of the Danube was carried out, including the materials published on the Project Forum (link: https://www.plovput.gov.rs/forum-zainteresovanih-strana). Cooperation was established with ichthyologists from the Republic of Serbia.

The status of the procedures is shown below in Chapter 3, Table 3-1.

Based on the project task and the agreement from the preliminary meeting, the inventory implementation methodology was elaborated. The methodology for field research is presented below.

Text box 2-6 Field research methodology for fish inventory

Methodology for field research

The following report is used as a key basis for the preparation of field research, according to which the preparation and implementation of the inventory and recording of results will be carried out:

Mustafić, P., Zanella, D., Ćaleta, M., Marčić, Z. (2016) Final report for the groups *Actinopterygii* and *Cephalspidomorphi.* In: Mrakovčić M., Mustafić P., Jelić D., Mikulić K., Mazija M., Maguire I., Šašić Kljajo M., Kotarac M., Popijač A., Kučinić M., Mesić Z. (ur.) EU Natura 2000 Integration Project - Field research and laboratory analysis of newly collected inventory data for taxonomic groups: *Actinopterygii and Cephalaspidomorphi, Amphibia and Reptilia, Aves, Chiroptera, Decapoda, Lepidoptera, Odonata, Plecoptera, Trichoptera*. OIKON-HID-HYLA-NATURA-BIOM-CKFF-GEONATURA-HPM-TRAGUS, Zagreb.

Research will be conducted in 17 critical areas (refer to Annex I) from Batina to Ilok (12 locations on the right bank, 5 locations on the left bank). Depending on their length, which is from 0.8 km to 9.8 km, sampling will be carried out according to the following dynamics:

- On 2 sections up to 2 km long, sampling is carried out on a total length of 500 m on one section or on two sections of 250 m length in such a way as to cover as many suitable habitats as possible.
- On 10 sections with a length of 2 to 5 km, sampling is carried out on a total length of 1000 m, in at least two or more sections, each at least 250 m long.
- On 5 sections longer than 5 km, sampling is carried out on a total length of 2000 m, in at least four or more sections, each at least 250 m long.
- On 30% of the total sampling length, i.e. 6.3 kilometres of the stream, it is necessary to carry out night electrofishing in order to record the species active at night. Each section where night electrofishing is carried out will be 250-500 meters long.

Three methods will be used in the field research of fish:

1. Electrofishing
2. Electrified benthic trawl (electrified dredge)
3. Winter monitoring of fish wintering habitats with sonar

Field research with an electrofishing device will be carried out in the period between June and October, in the period when the water temperature is optimal, the water level is lower than the annual average and during favourable meteorological conditions (sampling with an electrofishing device must not be carried out during heavy rain, when the water temperature is lower of 5 °C and more than 30 °C or in case of high water turbidity). Sampling with an electrified benthic trawl (electrified dredge) will be carried out once, exclusively during the day, during the 18 months of the project. Sampling with an electrified dredge must not be carried out during heavy rain, when the water temperature is lower than 5 °C and higher than 30 °C, or when the water is very turbid.

Winter monitoring of fish wintering habitats with sonar will be carried out once between December and February. The locations of wintering habitats within the Danube River (from bank to bank) and the main tributaries should be mapped using a GPS device.

During a fish sampling, the following data will be recorded:

- sampling stations [geographical position (x and y coordinates)], description of habitat, type of coast/bottom, aquatic/riparian vegetation, shading, depth and similar)
- sampling methods
- caught individuals (scientific name of the species, quantification of the fish stock, number of individuals, age structure, frequency of individual species in the sample, age structure of the fish population (proportion of juvenile fish) and other).

In accordance with that methodology, an inventory protocol (recording of field results) was prepared, a plan for the implementation of field trips was prepared (approaches, locations of entrances and exits to the coast according to daily sections, checking the locations of mine-suspected areas along the right bank of the Danube (on 14 April, 2023), instructions were prepared for the protection of stakeholders at work during the works (general measures and safety measures related to the use of electrofishing device and other associated equipment) and in emergency situations, and equipment for field work adapted to the special conditions of work on large rivers was prepared: (echo-sonder, electrified benthic trawl, electrofishing units, depth gauges (see examples in Figure 2-64), including a boat with a reinforced bottom and a spare engine, as well as protective equipment for team members (life belts, auxiliary ladder in case of a person falling into the water, raincoats, fluorescent vests, head protection, gloves and boots, flares and a loaded signal gun). Members of the team for the implementation of field work have been determined.

The hydrological situation on the Danube is monitored in order to decide on the start of field work.

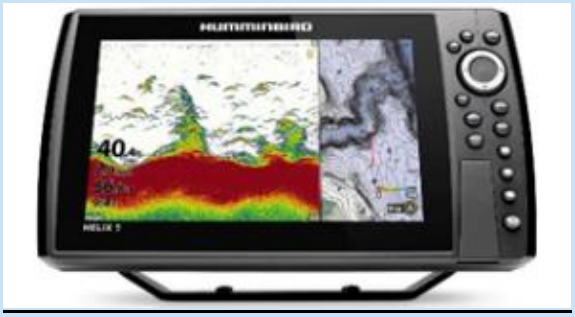


Figure 2-64: Equipment for carrying out an inventory of ichthyofauna (boat, use of electrofishing device, use of echo sounder)

In the period from July to October, part of the filed work was carried out, which includes electrofishing on 17 critical sections of Danube from Batina to Ilok. Depending on the length of each critical section, one to four transects of 500 meters length were conducted. A total of 43 transects of daytime electrofishing with a length of 500 meters were made on all 17 critical sections. During this period was also conducted nighttime electrofishing on 30% of the transects which is 13 transects in total. The locations for night electrofishing were chosen to cover the entire course of the Danube from Batina to Ilok, aiming to select localities with

greater habitat diversity and with easy, safe access (such as, for example, the confluence of the Drava into the Danube). Ichthyologists from Serbia conducted electrofishing on 5 transects on the Serbian side of the Danube (Figure 2-65).

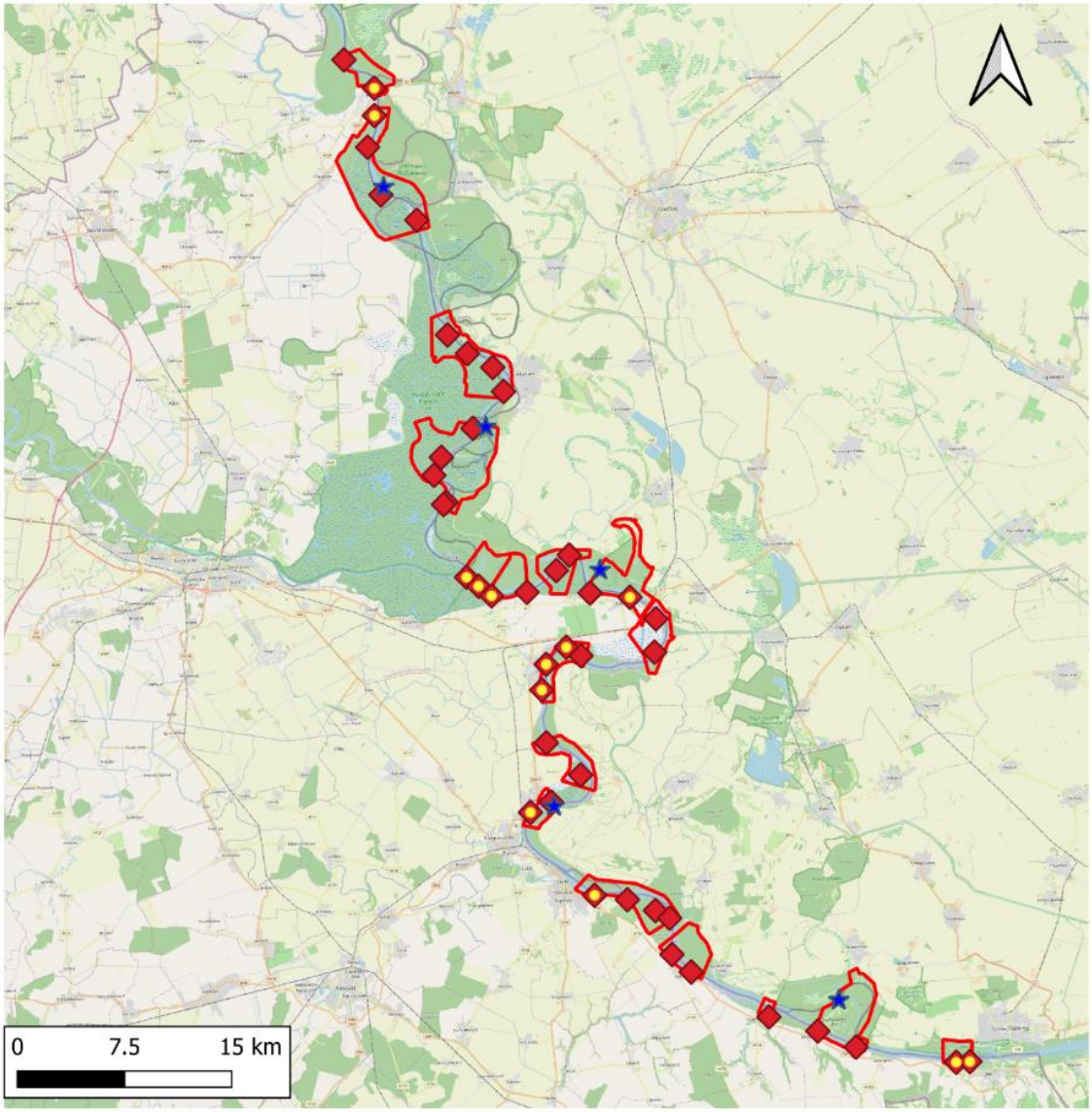


Figure 2-65: Conducted transects of electrofishing on 17 critical sections of Danube. Red diamonds represent transects of daytime electrofishing, yellow dots represents transects for nighttime electrofishing and blue stars are transects on the Serbian side of the Danube.

The following data were recorded on the transects themselves during fish sampling:

- date, name of the critical section, name of the locality, name of the transect, coordinates of the transect,
- habitat features: type of shore and bottom, aquatic and riparian vegetation, depth, flow velocity),
- pressures, threats, and habitat conservation
- catch data: Croatian name of the species, scientific name of the species, number of individuals, age structure, frequency of individual species in the sample, age categories.

Using the electrofishing method during the day and night, 39 species of fish, i.e. more than 3000 fish individuals were sampled, among which the most numerous are common bleak (*Alburnus alburnus*), asp (*Aspius aspius*) and carp (*Cyprinus carpio*). The zander (Sander lucioperca) was abundant during the night electrofishing. Among the target species of the Natura 2000 ecological network area, the asp (Aspius aspius), the European bitterling (Rhodeus amarus) and the cactus roach (Rutilus virgo) were sampled. As expected, the greatest diversity and abundance of fish species was at the confluence of rivers and backwaters with the Danube, and the smallest on the flat sections of the Danube with eroded shores, greater depth, and turbidity.

The research was carried out along the right bank of the Danube and in the backwaters and at the confluence of the Drava and the Danube. Sampling was carried out with the aim of covering the greatest possible diversity of habitats on the Danube. Also fish sampling aimed to cover as many suitable habitats for invasive species as possible, with a focus on riverbank fortifications and T-groins. Physical and chemical parameters were also measured on the field: the water temperature ranged from 26 to 28 degrees Celsius, the pH value ranged between 7.5 and 8, the oxygen level between 90% and 100%, while the water depth in the middle of the stream transect varied between 3 and 12 meters. The shores are earthy with rip-rap present, mostly overgrown with trees and grass, while the bed is a mixture of sand and silt with slow to moderate water flow. Photos of fieldwork are presented below.

Figure 2-66: Preparation of boat and equipment for field research

Figure 2-67: Complete field equipment with protective clothing, footwear, headgear, polarized glasses, and protective gloves

Figure 2-68: Measurement of morphometric parameters of fish on the field

Figure 2-69: Preparation of the boat and equipment for night electrofishing (head lamps, reflectors on the front of the boat)

Figure 2-70: Nighttime electrofishing

Winter fish monitoring of fish wintering habitats with sonar was carried out in February 2024. 19 locations of wintering habitats were selected according to a 3D model obtained from hydrographic measurements of the river bed, according to fishing data from local concessionaires and from scientific works and historical data. Research has shown that there are 7 active fish wintering habitats on the Danube from Batina to Ilok, and these sites are in the vicinity of Apatin, Židovski rukavac, Staklar, Erdut, Dalj and Borovo. Of the remaining 12 locations, 5 still possess good morphological characteristics of the riverbed (bottom) for the presence of wintering habitats, but no fish were recorded in those areas (Figure 2-71, Figure 2-72, ANNEX 2).

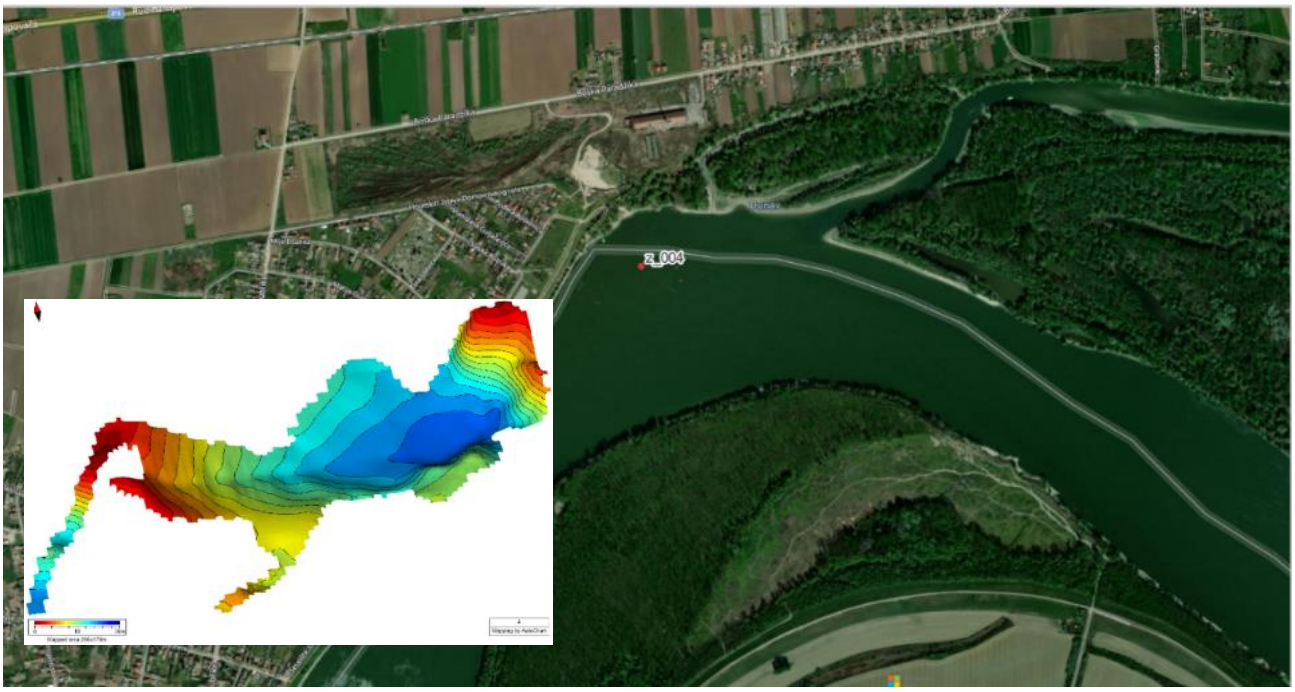


Figure 2-71: An example of a wintering habitat on the critical Dalj section

The research was carried out with the help of the Humminbird Helix 9 sonar, which has a built-in GPS device and maps the riverbed together with depth and water temperature measurement and fish detection.

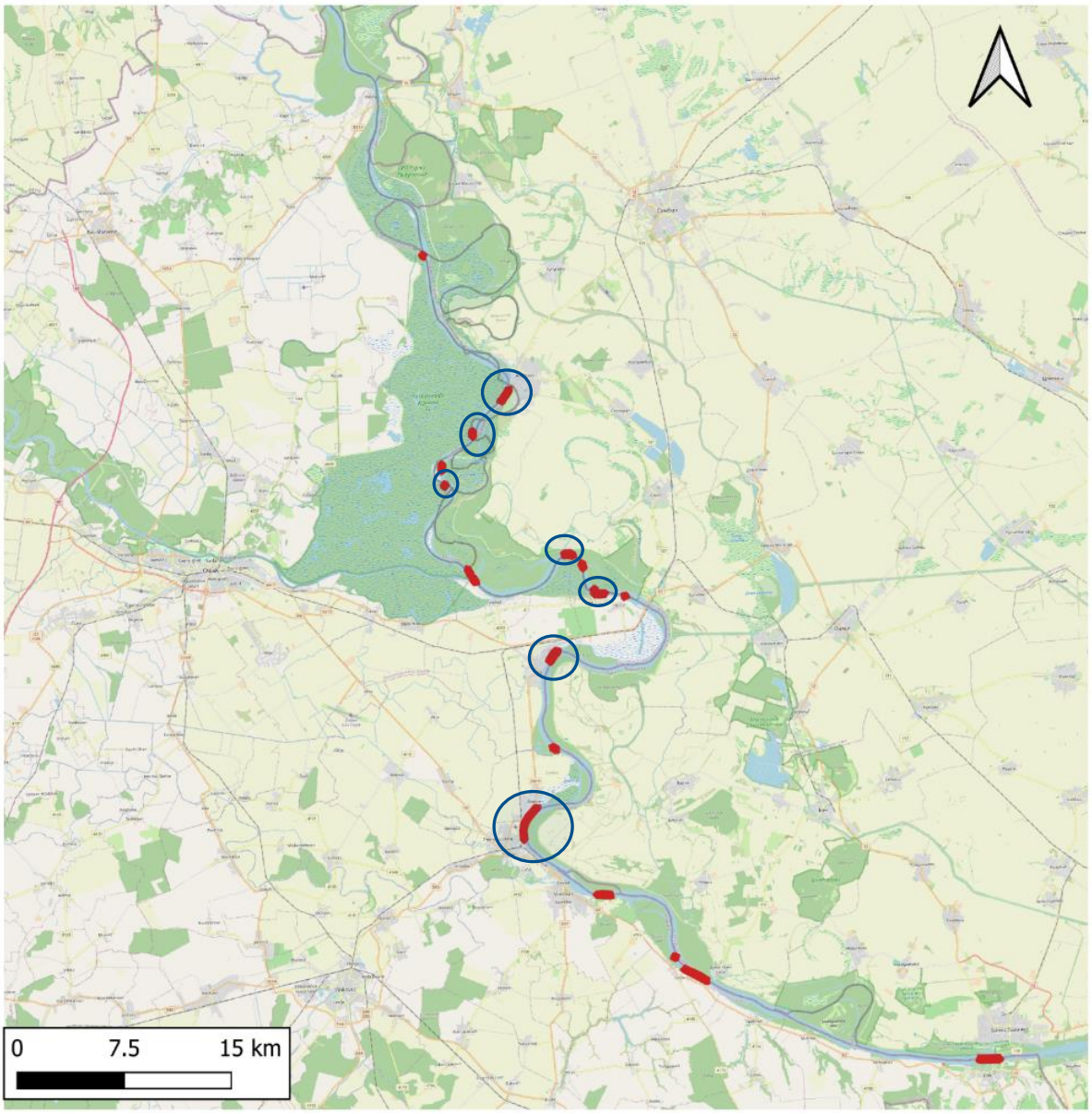


Figure 2-72: Wintering habitats monitoring locations on the Danube, the circled locations show the most important fish habitats

Figure 2-73: Sonar monitoring of wintering habitats

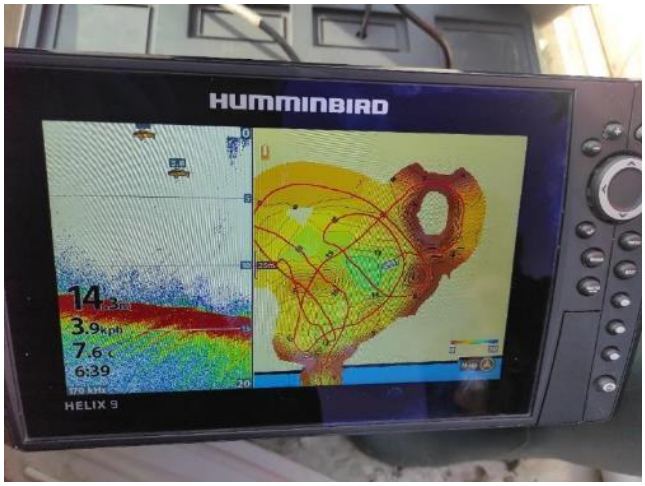


Figure 2-74: Humminbird sonar, on screen fish detection

Fish sampling with an electrified bottom trawl (electrified dredger) was carried out in March 2024. A transect with a minimum length of 500 meters was made on 17 critical sections of the Danube from Batina to Ilok. The electrified dredger was pulled upstream with the help of a boat. The dredger was connected to a 10 kW power unit that transmits electricity to the frame. At the end of each transect, the dredger was taken out of the water, and the sampled fish were returned to the watercourse at the catch point after processing.

Figure 2-75: Electrified dredger

Figure 2-76: Electrified dredger in operation with power unit

Results

A total of 39 species of fish (3443 individuals) were sampled using the method of electrofishing and electrified dredging. The most frequently sampled age classes were 2+, 3+, 4+, and 5+, while juvenile individuals of age classes 0+ and 1+ were observed along the shoreline. The most numerous fish family in the research are carp, which were present in all 17 critical sections (Figure 2-77). The final results are comparable to all other studies of ichthyofauna on the Danube.

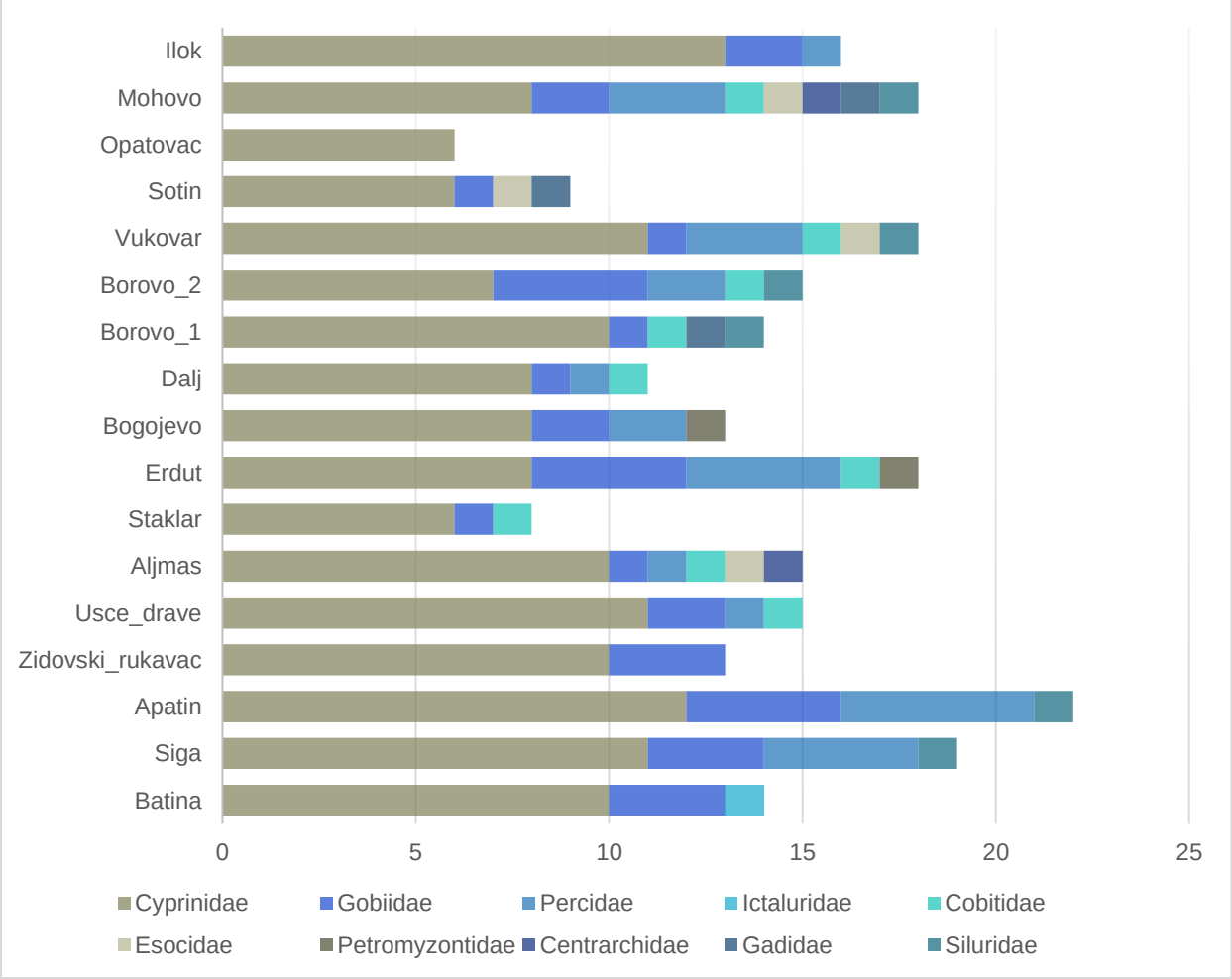


Figure 2-77: Number of fish families in certain critical sections

Below is a list of the species sampled in the study divided by families:

Table 2-7: List of species sampled in the study divided by families

Family	Species
Cyprinidae	*Abramis brama*
Cyprinidae	*Alburnus alburnus*
Cyprinidae	*Alburnus sava*
Cyprinidae	*Aspius aspius*
Cyprinidae	*Barbus barbus*
Cyprinidae	*Blicca bjoerkna*
Cyprinidae	*Carassius gibelio*
Cyprinidae	*Chondrostoma nasus*
Cyprinidae	*Ctenopharyngodon idella*
Cyprinidae	*Cyprinus carpio*
Cyprinidae	*Gobio obtusirostris*
Cyprinidae	*Hypophthalmichthys molitrix*
Cyprinidae	*Leuciscus idus*
Cyprinidae	*Pseudorasbora parva*
Cyprinidae	*Rhodeus amarus*
Cyprinidae	*Rutilus rutilus*
Cyprinidae	*Rutilus virgo*
Cyprinidae	*Squalius cephalus*
Gobiidae	*Babka gymnotrachelus*
Gobiidae	*Neogobius fluviatilis*
Gobiidae	*Neogobius melanostomus*
Gobiidae	*Ponticola kessleri*
Gobiidae	*Proterorhinus semilunaris*
Percidae	*Gymnocephalus baloni*
Percidae	*Gymnocephalus cernua*
Percidae	*Gymnocephalus schraetser*
Percidae	*Perca fluviatilis*
Percidae	*Sander lucioperca*
Percidae	*Zingel zingel*
Ictaluridae	*Ameiurus melas*
Cobitidae	*Cobitis elongata*
Cobitidae	*Cobitis elongatoides*
Esocidae	*Esox lucius*
Petromyzontidae	*Eudontomyzon vladykovi*
Centrarchidae	*Lepomis gibbosus*
Centrarchidae	*Micropterus salmonides*
Gadidae	*Lota lota*
Siluridae	*Silurus glanis*

The features of the fish community that define its structure are species composition, species diversity, abundance and size (De Leeuw et al. 2003). However, the basic feature of a community in biology is still considered its diversity, which jointly forms the number of species present in the sample (richness) and the similarity of their numbers (equality). Diversity is a feature of a community related to its stability, productivity, trophic structure and migration (McIntosh 1967; McNaughton 1977; Tilman 1996; Wisheu and Keddy 1996; Caley and Schluter 1997). When analyzing communities, different indices are mostly used, and it is extremely important to choose the appropriate index. The most important indices of diversity are indices of richness, indices of uniformity and indices of dominance, and they differ only in the relative weight given to individual factors. So far, no ideal measure and way of calculating the diversity of species has been found, and it is difficult to express the diversity with a single number. It is also known that all

indices have limitations and certain assumptions. Therefore, it is necessary to understand the sensitivity of an individual index to the features of the ecosystem and community being analyzed, and to be sure that these features are relevant and to have an objective way of determining that the differences between the values are significant. The values of the most important biodiversity indices are shown in Table 2-8 and Figure 2-78.

Table 2-8: Diversity index values by critical sections

	Batina	Siga	Apatin	Žid._rukavac	Usce_Drave	Aljmas	Staklar	Erdut	Bogojevo	Dalj	Borovo_1	Borovo_2	Vukovar	Sotin	Opatovac	Mohovo	Ilok
Dominance_D	0.2252	0.2782	0.09156	0.1602	0.2443	0.1786	0.5057	0.1813	0.3039	0.2926	0.4499	0.2849	0.3643	0.3041	0.6079	0.3888	0.1849
Simpson_1-D	0.7748	0.7218	0.9084	0.8398	0.7557	0.8214	0.4943	0.8187	0.6961	0.7074	0.5501	0.7151	0.6357	0.6959	0.3921	0.6112	0.8151
Shannon_H	1.988	1.889	2.707	2.119	1.91	2.069	1.09	2.211	1.71	1.509	1.295	1.768	1.611	1.537	0.8218	1.52	2.077
Evenness_e^H/S	0.5214	0.3149	0.7132	0.6404	0.4825	0.5658	0.3717	0.507	0.4606	0.4523	0.2809	0.3908	0.313	0.5169	0.3791	0.2857	0.532
Brillouin	1.827	1.777	2.346	1.917	1.714	1.822	1.003	2.032	1.564	1.467	1.234	1.636	1.485	1.476	0.7807	1.433	1.997
Menhinick	1.219	1.242	2.425	1.355	1.436	1.65	0.7184	1.47	1.1	0.4757	0.7009	1.179	1.203	0.5582	0.4027	0.9684	0.7884
Margalef	2.662	3.536	4.632	2.654	2.855	3.04	1.452	3.393	2.302	1.478	2.055	2.752	2.898	1.439	0.9255	2.674	2.376
Equitability_J	0.7532	0.6205	0.889	0.8262	0.7239	0.7842	0.5241	0.765	0.688	0.6554	0.505	0.653	0.5811	0.6997	0.4587	0.5482	0.767
Fisher_alpha	3.959	5.222	9.685	4.13	4.532	5.184	1.91	5.341	3.33	1.819	2.672	4.035	4.268	1.809	1.136	3.711	3.158
Berger-Parker	0.4318	0.4895	0.2133	0.3043	0.4526	0.2917	0.6935	0.3733	0.521	0.4638	0.6483	0.4938	0.5819	0.5	0.7658	0.6044	0.3536

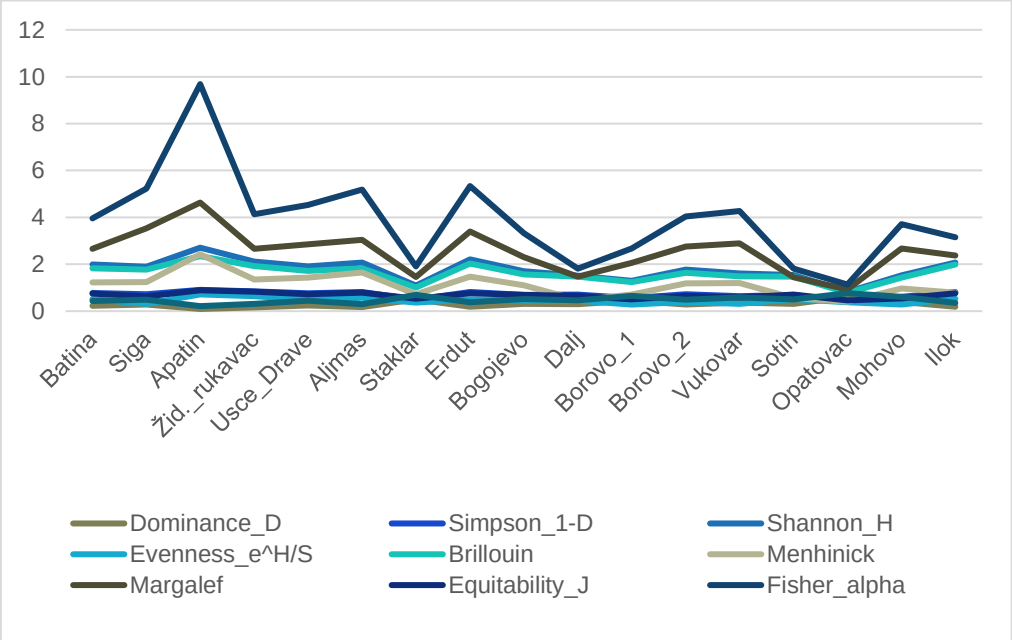


Figure 2-78: Graphic representation of diversity index by critical sections

Diversity indices were calculated using the Professional, Ecological Methodology and Past software packages. Microsoft Excel was used in numerical and graphical data processing.

The most significant pressures and measures observed in the research are listed in the tables below. The codes and names of pressures and measures are taken from the official Eionet website, which contains reference documents related to the information provided in the Article 17 report formats of the Habitats Directive for the period 2019-2024 (https://cdr.eionet.europa.eu/help/habitats_art17). The description of measures has been adapted to the Danube region.

Table 2-7a: Pressures Identified in the Research and Their Description

Pressure	Description
PE02 - Shipping lanes and ferry lanes transport operations	Operation and use inland water transport corridors, as well as pressures linked to transport activities on these freshwater waterways (e.g. disturbance from shipping at feeding/nesting areas, death or injury by collision, wakes from cargo ship traffic). Includes the anchorage of ships and vessels (industrial, commercial).
PG06 - Freshwater fish and shellfish harvesting (professional)	Professional freshwater fishing and shellfish harvesting causing increased direct mortality, reduction of species and/or prey populations and disturbance to species.
PG07 - Freshwater fish and shellfish harvesting (recreational)	Recreational freshwater fishing and shellfish harvesting causing increased direct mortality, reduction of species and/or prey populations and disturbance to species.
PG22 - Introduction and spread of new species in aquaculture (including GMOs)	Introduction and/or spread of allochthonous species or allochthonous genotypes and of genetically modified organisms in freshwater aquaculture and other newly-introduced species that are naturally not found in this area. It also includes changes in interspecific relations between native wild species induced by aquaculture (e.g. changes in sexual behaviour of autochthonous population due to aquaculture, increased food supply for piscivorous or native freshwater species, and an increase of piscivorous freshwater fish due to aquaculture practices that would exert added pressure on endangered amphibians).
PI01 - Invasive alien species of Union concern	Problems related to invasive alien species of Union concern (under Regulation (EU) No 1143/2014)
PI02 - Other invasive alien species (other than species of Union concern)	Problems related to other 'invasive' alien species (any species introduced in modern period that is established in the wild outside its natural range and whose introduction and/or spread represent a threat or a potential threat to habitats and species, regardless of the invasive population dynamics) other than invasive alien species of Union concern (under Regulation (EU) No 1143/2014).
PL06 - Physical alteration of water bodies (mixed or unknown drivers)	This threat includes constructed riverbank reinforcements and T groynes.

Table 2-7b: Key Mitigation Measures for the Identified Pressures

Measure	Description
ME01 - Reduce impact of transport operation and infrastructure	Reducing the impact of transport infrastructures (shipping lanes, canals, ports) and transport operations on habitats and species targeted by the nature directives. This includes managing fluvial traffic and infrastructure to, for example, reduce erosion of banks.
MG01 - Management of professional/commercial fishing, shellfish and seaweed harvesting (incl. restoration of habitats)	Managing of e.g. quantities, methods, periods, areas, and species for professional fishing in inland waters. This can include enforcement and control of e.g. fishing quotas and other regulations or stopping/avoiding fishing.
MG02 - Management of hunting, recreational fishing, and the recreational or commercial harvesting or collection of plants and fungi (incl. restoration of habitats)	Managing methods, periods, areas, quotas and species for recreational angling . This can include stopping or avoiding recreational fishing, harvesting or collecting.
MI01 - Early detection and rapid eradication of invasive alien species of Union concern	"Controlling invasive alien species of Union concern (under Regulation (EU) No 1143/2014) through establishing and operating a system of early detection, monitoring and rapid eradication.
MI02 - Management, control or eradication of established invasive alien species of Union concern	Managing and controlling established invasive alien species of Union concern (under Regulation (EU) No 1143/2014) through establishing and operating a management system of monitoring and eradicating.
MI03 - Management, control or eradication of other invasive alien species	Managing, controlling the spread of other 'invasive' alien species (i.e. any species introduced in modern period that is established in the wild outside its natural range and whose introduction and/or spread represents a threat or a potential threat to habitats and species, regardless of the invasive population dynamics.
MI04 - Restoration of habitats affected by invasive alien species (incl. of Union concern and others)	Habitat restoration affected by invasive species of union concern and/or other invasive alien species.
MK03 - Restoration of habitats impacted by multi-purpose hydrological changes	Restoring freshwater, wetlands and coastal habitats impacted by multi-purpose hydrological modifications.

All research data collected are presented in the "Catalogue of Biodiversity Components of the Joint Croatian-Serbian Sector of the Danube River" (see: **ANNEX 3**), and in the form of a spatial display within an interactive map of the subject area (within the establishment of a geoinformation system), which will also include collected photo documentation.

2.2.2. Habitat inventory

Overview

Preparation was carried out and a preparatory meeting was held with the Beneficiary (1 February 2023), where the habitat inventory approach (locations, i.e. research areas, periods and overall research dynamics and conditions) was presented to the Beneficiary, and some open questions were discussed (inventory obligation is on both sides of the river).

For the project area, existing data for the area from embankment to embankment were collected from the competent institutions, which includes:

- Habitat Map of the Republic of Croatia (Habitat Map 2004, Map of terrestrial non-forest habitats 2016), other habitat maps that cover smaller areas in the floodplain,
- Land cover map – CLC and high-resolution layers (CRO layers and RS layers).

Baseline documentation essential for the determination of forest habitats on the right side of the Danube was obtained from Croatian Forests (25 April, 2023), and data on biodiversity in the project area and EN areas was requested and received from MESD (12 May 2023):

- HR1000016 Danube and Lower Podravlje
- HR2000394 Kopački rit
- HR2001309 Danube N from Kopački rit
- HR2000372 Danube – Vukovar

The procedures for obtaining the necessary permits for research in protected areas and in the border area have been carried out for both sides of the joint Croatian-Serbian section of the Danube. All necessary permits for conducting habitat survey are issued. The status of the procedures is shown below in Chapter 3, Table 3-1.

In order to ensure safe access to the area, a map of mine-suspected areas for the entire Republic of Croatia was obtained from the Ministry of Internal Affairs, Directorate of Civil Protection (received on 26 April, 2023).

Based on the project task and the agreement from the preparatory meeting the inventory implementation methodology was elaborated. The methodology for field research is presented below.

Text box 2-7 Field research methodology for habitat inventory

Methodology for field research

Habitat inventory is carried out on floodplains on both the left and right banks of the Danube, which are defined by critical sections of the river (sections of the Danube where interventions are most often needed to maintain the waterway). A total of 17 such critical sections and associated flood areas were determined along the joint Croatian-Serbian stretch of the Danube (see **ANNEX 1**).

The field work plan is made based on the previous experience of working in this area and the ecology of the key species for determining these habitats:

- **3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea*** - research should be carried out when the water level is lower, and the vegetation is fully developed (period between June and the beginning of October)
- **3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*** - type vegetation - research should be carried out when the water level is lower, and the vegetation is fully developed (period between June and the beginning of October)
- **3270 Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation** - research should be carried out when the water level is lower, and the vegetation is fully developed
- **6440 Alluvial meadows of river valleys of the *Cnidion dubii*** - research should be carried out when the water level is lower, and the vegetation is fully developed (period between June and the beginning of October)

- **91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)** – research should be carried out when the water level is lower, and the vegetation is fully developed (period between June and the beginning of October)

A preliminary Habitat Map (Figure 2-79) is created for the right and left bank of the Danube based on the collected data, and a map is being prepared. The preliminary map of both right and left flood area is created not only based on existing data collected so far, but also on the basis of visual interpretation of orthophoto images, and this map is the basis for further planning and implementation of field tours.

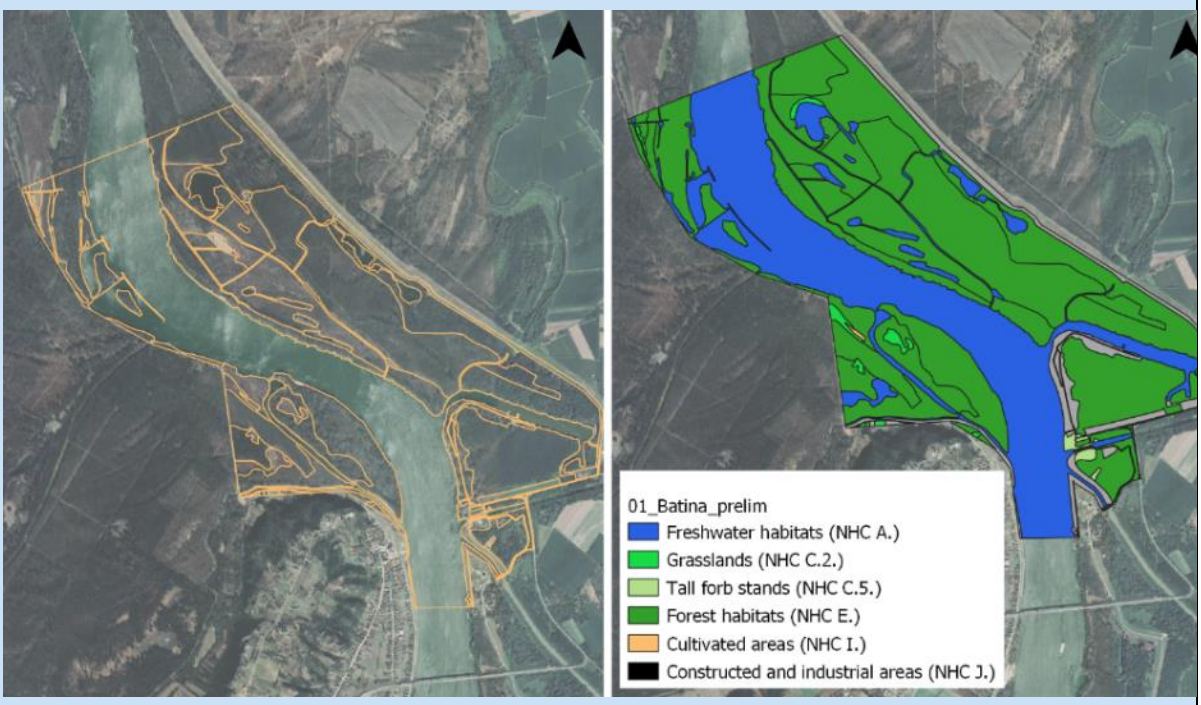


Figure 2-79: Example of a preliminary map for the critical location of Batina (left – polygon delineation, right polygon interpretation according to basic habitat classes according to the NHC of the Republic of Croatia)

Implementation of field work on habitat inventory itself on the joint Croatian-Serbian sector of the Danube includes the collection and mapping of priority habitats of the NATURA 2000 floodplains, which are dependent on water and sensitive to changes in the water level and the natural hydromorphological dynamics of the river, in order to supplement and elaborate the preliminary Habitat Map.

During implementation of field research, data on the field are entered into pre-defined field forms (protocols) for each point where the research is carried out. Field forms contain fields with basic data on the point (locality) and time of research, the researcher, data on the habitat type, data on the type of vegetation or plant community, observed typical, indicator and other types of plants important for the habitat type.

The map of the defined Natura 2000 habitat types of the "critical areas" will be integrated into the preliminary Habitat Map, and in this way the final Habitat Map will be created for the interactive map of the subject area, which will contain data on Natura 2000 habitat types and habitat types according to the National Habitat Classification at level III for the Republic of Croatia, i.e. for the left side of the Danube coordinated according to the special agreement of the involved experts from the HR and the RS.

According this methodology a preliminary Habitat Map was created for the right bank of the Danube based on the collected data, and a map is being prepared for the left bank. The preliminary map of the right flood area was created not only based on existing data collected so far, but also on the basis of visual interpretation of orthophoto images, and this map is the basis for further planning and implementation of field research.

A protocol has been prepared for the inventory (recording of field results) and a plan for the implementation of field trips is being prepared (access to locations, checking the locations of mine-suspected areas along the right bank of the Danube), instructions have been prepared for research team safety at work during the

works (general measures and safety measures related to use of associated equipment) and in emergency situations, and the equipment for field work is prepared and adapted to special working conditions. The members of the team for the implementation of field work have been determined.

The hydrological situation on the Danube has been monitored continuously in order to access the flooded area. Field survey started late in the vegetation season, after awaiting the period of low water levels stabilization. Field works are finished on both sides of the Danube during November 2023. Collected data from the right side of the Danube (HR) are integrated into Oikon's internal database.

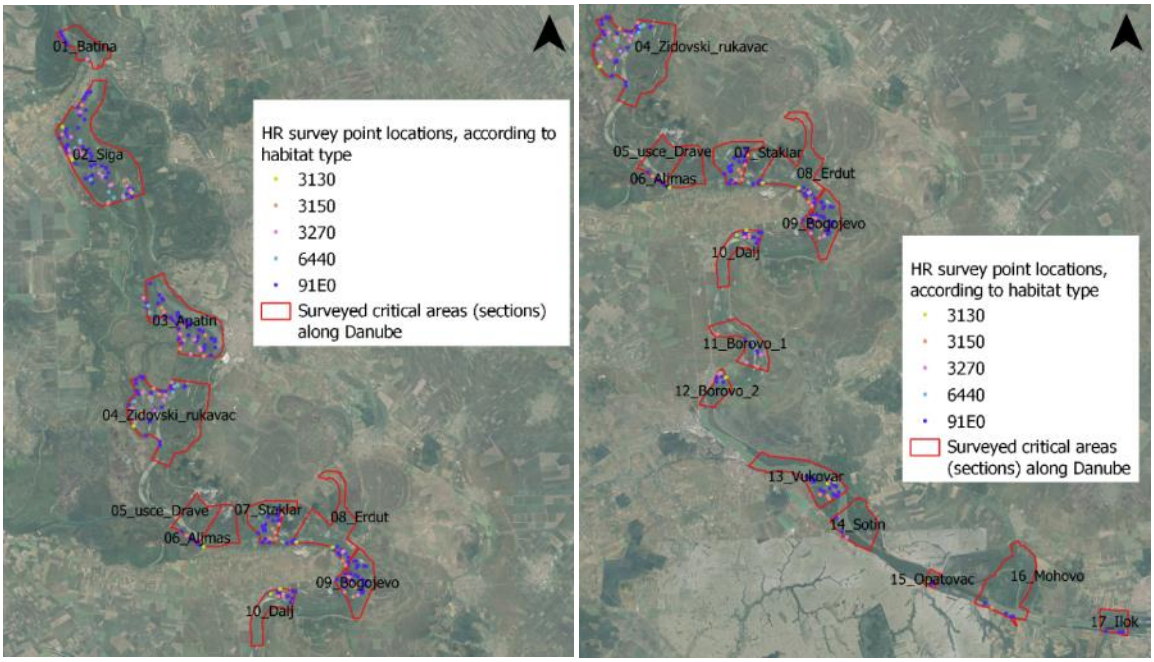


Figure 2-80: Presentation of surveyed locations on the right side of the Danube for the purposes of habitat mapping (on the left, the upstream part of the investigated section of the Danube, on the right, the downstream part of the cultivated section of the Danube) (Note: only the data that is currently in Oikon's internal database is shown and the final state is not shown, it shall be updated with the data on the left side of the Danube in the following period)

Cooperation was established with habitat and flora expert from the Republic of Serbia.

Field work has been carried out on both sides of the Danube.

Based on established cooperation with habitats and vegetation experts from the Republic of Serbia, who conducted research on the left side of the Danube, data on forests (PC "Vojvodinašume") and additional existing data that the partner from the Serbian side has from previous research, all with the aim of developing the final habitat map.

Finally, all field data collected on both sides of the Danube were integrated into the Contracts internal database upon field work completion. The data collected through field research were then processed and, with consultation of other existing available data, a final habitat map the was created for 17 critical sections with the corresponding flood area.

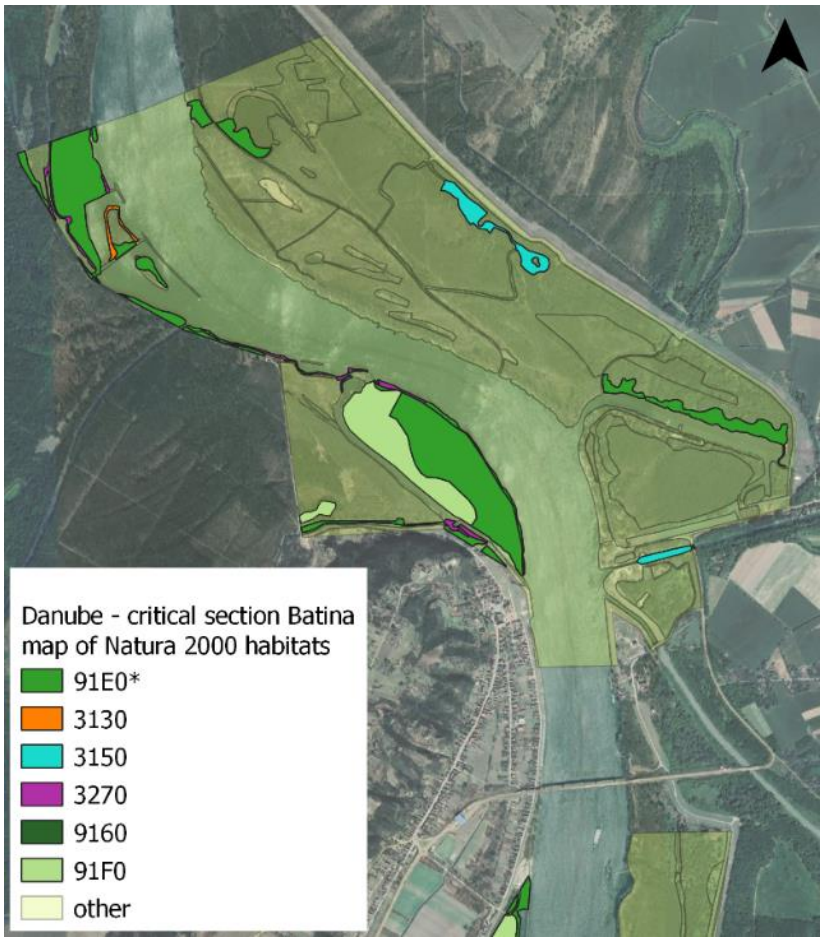


Figure 2-81: Display of the Natura 2000 habitat types map for the critical location of Batina

Results

The map of the defined Natura 2000 habitat types of the "critical areas" had been integrated into the preliminary habitat map, and in this manner the final habitat map had been created for the interactive map of the area in question, which had contained data on Natura 2000 habitat types and habitat types according to the National Habitat Classification on level III for the Republic of Croatia, i.e. for the left side of the Danube coordinated according to the special agreement of the involved experts from the Republic of Croatia and the RS.

Upon research ending, all collected and processed data had been presented in the "Catalogue of Biodiversity Components on the Joint Croatian-Serbian Sector of the Danube River" (see: **ANNEX 3**), and in the form of a spatial display within an interactive map of the subject area (as part of geoinformation system establishment), which had also included collected photo documentation (photos of stations, types, equipment, etc.).

The vegetation of the surveyed Natura 2000 habitat types was sampled in the field at 383 sampling locations. Habitat type 91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) was sampled at 244 locations and confirmed at 185 locations. The habitat type 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea* was sampled and confirmed at 20 sampling locations. Habitat type 3150 Natural eutrophic lakes with Hydrocharition or Magnopotamion type vegetation was sampled at 62 sampling locations and recorded at 55 locations. Habitat type 3270 Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation it was recorded in 27 locations, out of a total of 41 sampled locations. Habitat type 6440 Alluvial meadows of river valleys of the *Cnidion dubii* were sampled at a total of 16 locations and the habitat type was not confirmed at any of them. The table below shows the distribution of surveyed Natura 2000 habitat types according to critical sections.

During the field research of habitat types, plant species related to the mentioned habitat types were also recorded. In the research area along 17 critical sections of the joint Croatian-Serbian sector of the Danube River, a total of 233 plant species were recorded. Of the listed plant species, 25 are invasive alien species, and 14 are strictly protected in the Republic of Croatia. 15 species are assessed in accordance with the IUCN categories, whereby 2 critically endangered species in Croatia were recorded (CR), 6 sensitive species (VU), 5 near threatened (NT), and for two species the data for assessment is deficient (DD).

Table 2-9: Occurrence of surveyed Natura 2000 habitat types along the critical sections of the joint Croatian-Serbian sector od the Danube River

Habitat type	Batina	Siga	Apatin	Zidovski rukavac	Usce_Drave	Aljmas	Staklar	Erdut	Bogojevo	Dalj	Borovo_1	Borovo_2	Vukovar	Sotin	Opatovac	Mohovo	Ilok
91E0*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3130	x	x		x		x		x		x		x	x		x		
3150	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x
3270	x	x	x	x		x		x	x		x	x		x		x	
6440																	

Within the mentioned document "Catalogue of Biodiversity Components on the Joint Croatian-Serbian Sector of the Danube River" (**ANNEX 3**), each investigated Natura 2000 habitat type is processed so that the general features of the habitat type in terms of threat and protection are presented, and the habitat type is briefly described with regard to its ecological characteristics. Also presented for each habitat type is a list of typical and indicator species that were recorded along the critical sections of the Danube and their occurrence within the floodplain of each critical section. Below is an example of processing for habitat type 91E0*.

"**91E0 Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)**

General information

Natura 2000 habitat type	*91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)
Vegetation type or community	Alliance *Salicion albae* Soó 1951 Alliance *Populion albae* Br.-Bl. ex Tchou 1949, alliance *Salicion albae* Soó 1951 Alliance *Alnion incanae* Pawłowski et al. 1928 Alliances *Alnion incanae* Pawłowski et al. 1928 & *Alnion glutinosae* Malcuit 1929
Status (EU legislation)	Annex I. HD
Status (national legislation)	listed as rare and endangered habitat type (Annex III, Ordinance – RC OG 027/2021)

Habitat description

*Habitat type *91E0 includes occasionally flooded and very important forests in which the main tree species in the area are* Salix alba, Populus nigra, P. alba, Fraxinus angustifolia *and* Prunus padus*. A majority of the stands are dominated by white willow or have a mixed character and, according to the NHC, represent type E.1.1. The rest are stands dominated by domestic poplars (*Populus alba, P. nigra*) and belong to the NKS type E.1.2. Narrow-leaved ash (*Fraxinus angustifolia*) is rarely a dominant species, it is mostly mixed in individually or in smaller groups. In the layer of shrubs and ground growth, hygrophytes predominate, among which the typical species listed in table are particularly emphasized. Type *91E0 potentially occupies a much larger areas, but artificial stands of euroamerican poplars have grown on it.*

*Figure 2-82: White willow forest – type 91E0**

*Table 2-10 List and occurence of observed plant species important for the habitat type *91E0*

Species name	Batina	Siga	Apatin	Zidovski rukavac	Usce_Drave	Aljmas	Staklar	Erdut	Bogojevo	Dalj	Borovo_1	Borovo_2	Vukovar	Sotin	Opatovac	Mohovo	Ilok
Trees and schrubs																	
Fraxinus angustifolia	x	x	x	x	x		x		x	x			x	x	x	x	x
Populus alba		x	x	x	x		x	x	x	x	x	x	x		x		x
Populus nigra	x	x	x	x	x		x	x	x	x	x		x	x		x	x
Prunus padus	x	x	x					x	x				x				
Salix alba	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Salix x fragilis		x												x			
schrubs																	
Humulus lupulus		x						x	x	x		x					x
Rubus caesius	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Viburnum opulus		x								x	x	x					
Herbs																	
Agrostis stolonifera	x	x					x	x			x	x	x	x		x	x
Carex brizoides	x	x	x	x			x	x	x	x			x				x
Carex elata	x	x	x		x		x	x	x	x	x		x		x		
Carex elongata		x	x	x		x			x								
Carex remota		x	x	x			x										
Carex riparia	x	x	x	x		x	x	x	x	x	x	x	x				
Galium palustre	x	x	x	x	x	x		x	x	x			x		x		
Iris pseudacorus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Leucojum aestivum				x										x			
Lycopus europaeus	x	x						x			x		x	x			
Lysimachia nummularia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lysimachia vulgaris				x													
Lythrum salicaria		x	x	x		x	x		x		x	x					
Mentha aquatica				x													
Polygonum hydropiper	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Ranunculus repens			x	x	x	x		x				x	x			x	x
Rumex sanguineus		x	x	x	x	x				x		x					
Solanum dulcamara	x	x	x	x				x	x			x	x	x			
Stachys palustris		x	x						x	x	x	x	x	x		x	
Urtica dioica	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	

In addition to each habitat type, strictly protected and endangered species that have been recorded by research are shown and briefly described. Below is an example for the strictly protected species I*ris pseudacorus*.

"*Common name: yellow iris*

Latin name: Iris pseudacorus *L.*

Status (global): IUCN European Red List - LC

Status (HR): protected species

*Habitat type(s) most preferred in project area: *91E0*

*The yellow iris is a perennial herbaceous plant with an upright, cylindrical and smooth stem, usually up to 1 m high. The leaves are upright, linear, acuminate, with entire edges, up to 90 cm long, 1-3 cm wide. They are green in winter, but usually change in spring. The flowers are yellow, bisexual, large, grouped 3-5 per inflorescence, and are located on long stalks in the axils of green bracts. The fruit is a 4–7 cm capsule with a short claw and contains numerous flattened, brown and smooth seeds. It is propagated by cuttings and seeds and is also grown as an ornamental plant. It blooms from April to July. Its habitats are open to semi-shady, occasionally flooded and wet places in meadows, along the banks of rivers and canals, shallow water wetlands, as well as willow and poplar forests. Soils are clayey, humus, nitrogen-rich, usually impermeable to water and low in oxygen (helomorphic plant). It is an entomophilous plant, geophyte and hydrophyte in relatively warmer continental valley areas rich in water. It is a widely distributed species, common in the entire project area in type *91E0.*

Table 2-11 Presence of species along the critical sections (1. – 17.)

Species name	Batina	Siga	Apatin	Zidovski rukavac	Usce_Drave	Aljmas	Staklar	Erdut	Bogojevo	Dalj	Borovo_1	Borovo_2	Vukovar	Sotin	Opatovac	Mohovo	Ilok
Iris pseudacorus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Figure 2-83: Iris pseudacorus (photo: Oikon)

In addition to what has been described, in the attachment "Catalogue of Biodiversity Components on the Joint Croatian-Serbian Sector of the Danube River" invasive alien species are presented and recorded. Below is an example for the false indigo bush (*Amorpha fruticosa*).

„*Common name: false indigo bush*

Latin name: Amorpha fruticosa *L.*

Amorpha fruticosa *is a perennial, deciduous shrub that often forms thickets on riverbanks. It grows as a glandular, thornless shrub that can reach a height of 5 or 6 metres and twice that width. The leaves are pinnate and consist of ovate leaflets. It is native to North America and was introduced to Europe in the 18th century for its ornamental qualities, its value as a honey plant and its protective properties against soil erosion. Today it is registered amongst the most damaging invasive species in Europe.* A. fruticosa *can tolerate dry soils, but is most found along riverbanks, roads and the edges of flooded forests. The plant tolerates occasional flooding and grows well in full sun to light shade in medium to moist, well-drained soils. Thickets can be formed by suckers or self-seeding. Outside its natural range,* A. fruticosa *exhibits aggressive invasive behaviour due to its strong spreading ability and tolerance to a wide range of environmental conditions. Although it invades natural plant communities and successfully colonises damaged environments, it also successfully competes with native vegetation. The common name "false indigo bush" comes from the fact that the plants do contain indigo pigments, but in too small quantities for commercial use.*

Table 2-12 Presence of the species along the critical sections (1. – 17.)

Species name	Batina	Siga	Apatin	Zidovski rukavac	Usce_Drave	Aljmas	Staklar	Erdut	Bogojevo	Dalj	Borovo_1	Borovo_2	Vukovar	Sotin	Opatovac	Mohovo	Ilok
Amorpha fruticosa	x	x	x	x			x	x	x	x	x	x	x			x	x

Figure 2-84: Amorpha fruticosa (photo: Oikon)

2.2.3. Bird inventory

Overview

Preparation was carried out and a preparatory meeting was held with the Beneficiary (1February, 2023), where the approach to bird inventory was presented to the Beneficiary (locations of research, timing and overall dynamics of research, conditions of research), and some open questions were discussed (definition of recording locations and recording methods, occasional use of the Beneficiary's ship during its regular activities).

During February, the boundaries of 17 field research locations were delivered by the Beneficiary in kml format. Based on these, access routes from the mainland were determined to reach locations within the floodplains.

All available sources related to bird fauna studies in this part of the Danube have been collected, especially related to the protected areas such as the Kopački rit Nature Park or the Gonje Podunavlje Special Reserve. A number of scientific and professional studies dealing with the entire bird fauna of the area or individual species have been collected, and in particular the following references:

- Monitoring protocols:

1. Croatian national biodiversity monitoring protocols: https://www.haop.hr/hr/tematska-podrucja/prirodne-vrijednosti-stanje-i-ocuvanje/pracenje-stanja-prirode/provedba-pracenja
2. JNNC (2004) Common standards monitoring guidelines for birds. Version August 2004. https://data.jncc.gov.uk/data/dc33b514-d571-44b3-8936-08d2d7a1e1b1/CSM-Birds-2004.pdf
3. Mikuska T., Fenyosi L., Tomik A., Eichner K., Mikuska A. & Šalić V. (2007) Monitoring protocol for birds (Aves) in alluvial floodplains of Continetal parts of Croatia. Str. 189-202. U: Purger J.J. (Ur.) Manual for the investigation of biodiversity along the river Drava. University in Pecs, Pecs.
4. Martinović, M., Kralj, J., Tome, D., Basle, T., Božić, L. i Ječmenica, B. (2019) Cross-border monitoring protocol of the red-billed tern (Sterna hirundo) in the Sava and Drava basins. INTERREG V-A Si-HR ČIGRA project. ZZO HAZU, NIB, DOPPS, Biom, Zagreb, Ljubljana, Maribor. 17 str. http://info.hazu.hr/upload/Image/interreg_cigra/protokol/%C4%8CIGRA_protokol_HR.pdf

- Bird studies in the project area

1. Mikuska J. i Mikuska T. (1994) Birds of the Danube valley in Croatia. Anali Zavoda za znanstveni rad u Osijeku, 10: 109-175.
2. Mihaljević, M. Getz, D., Tadić, Z., Živanović, B., Gucunski, D.,Topić, J., Kalinović, I. & Mikuska, J. (1999) Kopački rit – pregled istraživanja i bibliografija. HAZU Zavod za znanstveni rad Osijek, Osijek.
3. Puzović, S., Grubač, B., Ham, I., Marinković, S. & Rašajski, J. (2000) Atlas ptica grabljivica Srbije. Zavod za zaštitu prirode Srbije. Beograd.
4. Radović, D., Kralj, J., tutiš, V., Radović J. & Topić, R. (2005) Nacionalna ekološka mreža. Važna područja za ptice u Hrvatskoj. Državni zavod za zaštitu prirode. Zagreb.
5. Puzović, S., Sekulić, G., Stojnić, N., Grubač, B. & Tucakov, M. (2009) Značajna područja za ptice u Srbiji. Ministarstvo životne sredine i prostornog planiranja, Zavod za zaštitu prirode Srbije, Pokrajinski sekretarijat za zaštitu životne sredine i održivi razvoj. Beograd.
6. Tutiš, V., Kralj, J., Radović, D., Ćiković, D. & Barišić, S. (2013) Crvena knjiga ptica Hrvatske. Ministarstvo zaštite okoliša i prirode. Državni zavod za zaštitu prirode. Zagreb.
7. Puzović, S., Radišić, D., Ružić, M., Rajković, D., Radaković, M., Pantović, U., Janković, M., Stojnić, N., Šćiban, M., Tucakov, M., Gergelj, J., Sekulić, G., Agošton, A. i Raković, M. (2015). Ptice Srbije: procena veličina populacija i trendova gnezdarica 2008–2013. Društvo za zaštitu i proučavanje ptica Srbije i Prirodno–matematički fakultet, Novi Sad, pp. 160.
8. Šćiban, M., Rajković, D., Radišić, D., Vasić, V. & Pantović, U. (2015) Birds of Serbia – critical list of species. Institute for Nature Conservation of Vojvodina Province and Bird Protection and Study Society of Serbia. Novi Sad.
9. Radišić, D., Vasić, V., Puzović, S., Ružić, M., Šćiban, M., Grubač, B. & Vujić, A. (Eds) (2018) Red book of fauna of Serbia 3, Birds. Zavod za zaštitu ptica Srbije. Beograd.
10. Podgorelec, M., Božič L., Grlica D., Radišić D., Cigan A., Kur U., Törnar T., Španiček B., Tucakov M. (2022). First joint census of selected riverbed breeding birds in 5-country biosphere reserve Mura-Drava-Danube; Deliverable report for EU-Interreg DTP project DTP3-308-2.3 "lifelineMDD", IRSNC, Ljubljana.
11. Radišić, D. (2022). River bird survey on Danube in Serbia (1298-1433 river kilometer). Deliverable report for EU-Interreg DTP project DTP3-308-2.3 "lifelineMDD", University of Novi Sad, Faculty of Science, Department for Biology and Ecology, Novi Sad.

12. Grlica, I. (2022). Final river birds breeding report for Croatia. Deliverable report for EU-Interreg DTP project DTP3-308-2.3 "lifelineMDD", Natural History Society "Drava", Virovitica.
13. Mikuska T., Tomik A., Ledinšćak J. (2023) Projekt NATURAVITA – Monitoring staništa, flore i faune – ponovljeni postupak – Grupa 5: Monitoring ptica. Konačno izvješće. Hrvatsko društvo za zaštitu ptica i prirode, Osijek. 85 str.

The procedures for obtaining the necessary permits for research in the border area have been carried out. The status of the procedures is shown below in Chapter 3, Table 3-1.

For the purpose of safe access to the area, a map of mine-suspected areas for the entire Republic of Croatia was obtained from the Ministry of Interior, Directorate of Civil Protection (received on 26 April 2023).

On the basis of the project terms of references and the agreement from the preparatory meeting, the methodology for the implementation of the inventory was elaborated. The methodology for field research is presented below.

Text box 2-8 Field research methodology for bird inventory

Bird inventory methodology for field research

Bird inventory was carried out in the project area during the 18 months of project implementation at 17 predetermined sub-sites, which are defined as critical sections from Batina to Ilok. Surveys were conducted throughout the year to cover all four seasons in the birds' lives (wintering, spring and autumn migration and nesting). Through monthly field trips on the Danube River, bird research was carried out from bank to bank in order to determine the bird fauna related to the river itself, its banks, sand bars and islands, as well as important parts of the river that serve as feeding and resting places for birds during migration and wintering. During the nesting period, sandbank nesters, steep bank nesters, raptors and wading birds were especially monitored. Special importance was given to NATURA 2000 and endangered species. For each species, established standard species monitoring protocols were followed in detail (e.g. Mikuška et al. 2007; Croatian national biodiversity monitoring protocols, etc.). The following bird surveys were carried out:

- Sand bar and sand island breeding species

All sands bars and sand islands were visited within the entire length of the HR-SR section of the river and species nesting on them and their abundance was recorded. Inventory was carried out twice during the season (from May to June), twice during the 18 months of project implementation, ideally in the middle of the month. The minimum interval between tours was 20 days.

Each recorded sand bank or sand island was observed from a distance with binoculars, without disturbing the birds, and the present species was determined, and an initial estimate of their abundance was made. Locations of the sand bars were displayed within the interactive map of the study area within the framework of geoinformation system establishment. Landing on the sand bar and counting active nests was carried out only if it was necessary to establish the exact number of breeding pairs in order to minimise disturbance and avoid the danger of stepping on cryptically coloured eggs and birds. In order to not interrupt the incubation of the eggs or the care of the birds for too long, no more than 30 minutes was spent on the islanat once d. Research was conducted in weather without wind and precipitation and not above 27°C during sunny weather. For each field visit, the smallest, average and largest number of nesting pairs present above the current water level were estimated, and to data from the CMHS on the water level at the nearest measuring station on the day of the survey was added. Habitat and the pressures and threats to the species that nest on the bank, such as island submergence, disturbance by humans, woody vegetation overgrowth , presence of predators (tracks, droppings, feeding remains), etc. were described and whether the threat was high, moderate, or low was assessed.

- Riverbank nesting species

Danube Riverbanks was visited within the entire length of the HR-SR section of the river and species nesting on them and their abundance was recorded. Inventory was carried out twice during the season (from May to June), twice during the 18 months of project implementation, ideally mid-month. The minimum interval between trips was 20 days.

This research was carried out from the boat and the following was recorded:

• the location of steep banks suitable for nesting using GPS devices. Locations of the steep banks were displayed within the interactive map of the study area within the framework of the establishment of a geoinformation system.

• the length and surface of the steep bank

• number of holes for each nesting species.

For each field visit, the smallest, average and largest number of nesting pairs present above the current water level were estimated, and to data from the CHMS on the water level at the nearest measuring station on the day of the survey was added. Habitat and the pressures and threats to the species that nest on the steep banks, such as sinkholes, coastal erosion, construction or forestry works, the presence of predators (tracks, droppings, feeding remains) etc. was described and whether the threat was high, moderate or low was assessed.

- Marshland breeding birds

Marshes, oxbows and side channels within the Danube floodplain were covered in order to establish the breeding water bird fauna (including wetland related song birds such as warblers). Inventory was carried out once during the season (from May to July), twice during the 18 months of project implementation, ideally in the mid-month. Marshes, oxbows and side channels were explored either from the bank or from the boat using the linear transect method. The number of singing males (for songbirds) and the number of adults and families with chicks were recorded. For each locality, the smallest, average and largest number of nesting pairs present were estimated, and data from the CMHS on the water level at the nearest measuring station on the day of the survey was attached. Habitats and the pressures and threats to the species that nest in marshes, such as such as submergence of nests, overgrowth of reeds with woody vegetation, construction or forestry works, burning of reeds, presence of predators (tracks, droppings, feeding remains), etc. was described and whether the threat was high, moderate, or low was assessed.

- Passage and wintering bird fauna

Through monthly field trips on the Danube River, bird research was carried out from bank to bank in order to determine the bird fauna during spring and autumn migration as well as wintering, that they use the area for feeding, resting and wintering. Species composition and their abundance was recorded. The goal was also to determine and map significant localities and important parts of the river that serve as feeding and resting places for birds during these periods.

Surveys of spring migration were carried out in the period March-May, at least once a month, during the 18 months of project implementation. Surveys of autumn migration were carried out in the period September-November, at least once a month. Wintering surveys were carried out in the period December-February, at least once a month during the 18 months of project implementation. It was particularly significant that the surveys in January coincided with the international waterbird winter count. The collected data was registered in one of the available databases (e.g. www.observado.org) in order to be permanently preserved and accessible to a wide range of people and the public.

According to this methodology, a research protocol was prepared - recording of field results, according to the standard monitoring protocols for individual species (including line transects and point counts protocols) (e.g., JNNC, 2004), as well as a plan for the implementation of field trips was prepared (approaches, locations of entries by daily sections, checking the locations of mine-suspected areas along the right bank of the Danube), instructions were prepared for the protection of researches during work and in emergency situations (general measures and safety measures related to the use of associated equipment) and equipment for field work was prepared.

Figure 2-85: Examples of locations along the Danube covered by bird inventarisation

All necessary equipment for field research was collected (binoculars, telescopes, GPS devices) and team members were appointed to carry out field work. A boat and a motor were also acquired for research along the banks of the Danube River and its side-channels.

Since the hydrological situation on the Danube from February to April 2023 was favorable (at low and medium-low water levels), it was possible to access and research the floodplain of the Danube. During May and June, research implementation was significantly affected by two natural phenomena: precipitation (during May there were 12 rainy days, and during June an additional 5 days with a total amount of precipitation higher than average values), and the rise in the water level of the Danube. While the rainy days significantly reduced the possibility of going out into the field, the rise in the water level of the Danube and the resulting floods made it impossible to access and move around a large part of the flooded area. Therefore, the research was primarily done in available locations. During July, the water level of the Danube once again dropped to medium and low water levels, which made it possible to research the shoals and banks. In mid-August, there was a second sharp rise in the water level caused by heavy rainfall in the upstream parts of the Danube and Drava basins, and there were repeated floods, both in the shoals and low banks along the river, as well as in the floodplain along the Danube. During September, October and November, the water level of the Danube was at medium-low and low water levels, which made it possible to research the banks on the river itself, as well as the availability of the flooded area. During December, water levels rose again and reached their culmination in early January 2024, with water levels higher than all of 2023. The high water level remained until the end of February. During March and April 2004, the water level of the Danube was at the medium-low water levels, which made it possible to investigate part of the shoals on the river itself, as well as the availability of the flood area. During May 2024, the water level was at the medium-low water levels, which made it possible to investigate the steep banks. At the end of May, the water level rose with a significant flood wave that submerged most of the flood area.

Thus, during February-April period, regular monthly counts of wintering and migrating birds were carried out on the Danube River (from bank to bank) from Batina to Ilok. Also, as part of the international mid-winter counts, a count of wintering birds was carried out in January, i.e., outside the period of this report, and the results will be used in further data processing. Dates of the field works are shown in Table 2-13 below.

Table 2-13: Field work dates during Janaury-Decenber 2023 and January-May 2024 period

Date	Site	Bird group	Sub-area
12/01/2023	Dunav Batina-Vukovar	Wintering birds	1-12
17/01/2023	Dunav Vukovar-Ilok	Wintering birds	13-17
08/02/2023	Dunav Batina-Vukovar	Wintering birds	1-12
16/02/2023	Dunav Vukovar-Ilok	Wintering birds	13-17
21/02/2023	Porić	Raptors	7
04/03/2023	Erdutski dunavac	Raptors	9
08/03/2023	Dunav Batina-Vukovar	Spring migration	1-12
17/03/2023	Mačkaluk,Vrblje	Raptors	1
23/03/2023	Tikvara, Ilok, Mohovo	Raptors	16-17
25/04/2023	Dunav Batina-Vukovar	Spring migration	1-12
02/05/2023	Savuljica, Borovska ada	Breeding birds	11-12
09/05/2023	Orlovnjak-Sotinska ada	Breeding birds	13-14
17/05/2023	Erdutski dunavac	Breeding birds	9
20/05/2023	Mačkaluk,Vrblje, Batina, Zmajevacki dunavac	Breeding birds	1-2
24/05/2023	Tikvara, Ilok, Mohovo	Waterbirds	16-17
26/05/2023	Savuljica, Borovska ada	Breeding birds	11-12
03/06/2023	Bezdan, Siga, Šmaguc	Breeding birds	1-2
09/06/2023	Zmajevački i Monjoroški dunavac, Siga	Breeding birds	2
10/06/2023	Mačkaluk,Vrblje, Batina	Breeding birds	1
14/06/2023	Aljmaš, Porić, Erdutski dunavac	Breeding birds	7,9
17/06/2023	Ašovanj, Monjoroški dunavac	Breeding birds	2-3
18/06/2023	Savuljica, Borovska ada	Breeding birds	11-12

03/07/2023	Savuljica, Borovska ada	Breeding birds	11-12
04/07/2023	Dunav Aljmaš-Borovo desna obala	Riverbanks and sand island breeding birds	6-12
06/07/2023	Aljmaš, Porić	Breeding birds	6-7
07/07/2023	Erdutski dunavac	Breeding birds	8-9
08/07/2023	Tikvara, Ilok, Mohovo	Waterbirds	16-17
10/07/2023	Dunav Batina-Aljmaš desna obala	Riverbanks and sand island breeding birds	1-6
11/07/2023	Dunav Batina-Aljmaš lijeva obala	Riverbanks and sand island breeding birds	1-6
13/07/2023	Dunav Borovo-Ilok lijeva obala	Riverbanks and sand island breeding birds	12-17
14/07/2023	Dunav Vukovar-Ilok desna obala	Riverbanks and sand island breeding birds	14-17
20/07/2023	Dunav Aljmaš-Borovo lijeva obala	Riverbanks and sand island breeding birds	6-12
26/07/2023	Tikvara, Ilok, Mohovo	Waterbirds	16-17
01/09/2023	Dunav Batina-Borovo	Waterbirds	1-12
02/09/2023	Dunav Borovo-Ilok	Waterbirds	12-17
20/09/2023	Dunav Zmajevac-Vukovar, Monjoroški dunavac	Fall migration	2-12
22/10/2023	Dunav Batina-Aljmaš	Fall migration	1-6
24/10/2023	Dunav Vukovar-Ilok	Fall migration	14-17
09/11/2023	Apatinski rit	Fall migration	3-4
23/11/2023	Monoštorski rit	Fall migration	2
20/12/2023	Dunav Aljmaš-Vukovar	wintering	6-12
21/12/2023	Mačkaluk,Vrblje, Batina	wintering	1
30/12/2023	Vukovar, Borovo, Savuljica, Aljmaš	wintering	6-12
03/01/2024	Kopački rit Posebni zoološki rezervat	wintering	5
04/01/2024	Kopački rit Petreš Ulnaci	wintering	3-4
05/01/2024	Vukovar, Borovo, Savuljica, Aljmaš	wintering	6-12
09/01/2024	Dunav Batina-Vukovar	wintering	1-12
10/01/2024	Dunav Vukovar-Ilok	wintering	14-17
24/01/2024	Mačkaluk,Vrblje, Batina	wintering	1
26/01/2024	Dunav Vukovar-Erdut	wintering	7-17
13/02/2024	Dunav Batina-Vukovar	wintering	1-12
15/03/2024	Siga	wintering	2
20/03/2024	Dunav Batina-Vukovar	wintering	1-12
06/04/2024	Borovska ada	raptor, močvarice	11
10/04/2024	Erdutski dunavac	raptor, močvarice	9
13/04/2024	Plavna Bačka Palanka	marsh birds	13-17
24/04/2024	Ilok-Aljmaš	marsh birds	7-17
25/04/2024	Siga	spring migration, raptor	2
10/05/2024	Dunav Batina-Aljmaš	nesting	1-6
11/05/2024	Dunav Aljmaš-Borovo	nesting	6-12

These surveys were supplemented during the winter and spring of 2024. To date, 118 nesting territories have been identified (of which 47 are within critical areas) and an additional 17 potential territories along the Danube from the Croatian-Hungarian border to Ilok (Table 2-14, Figure 2-86).

Table 2-14: Number of nesting pairs of White-tailed eagles along the flood valley of the Danube from 1433-1296 rkm

Critical area	Rkm	within critical area	Active flood valley outside the critical area	Outside the active flood valley	Potential pairs	**Total number of pairs**
1 Batina	1433-1424	2	1	4	1	**8**
2 Siga	1424-1412	**5**	1	2	4	**12**
3 Apatin	1412-1399	**4**	**14**	2	1	**21**
4 Židovski dunavac	1399-1389	**11**	**20**	1	4	**36**
5 Ušće Drave	1389-1382	**11**	**18**	0	4	**33**
6 Aljmaš	1382-1378	2	0	0	1	**3**
7 Staklara	1378-1370	1	2	0	1	**4**
8 Erdut	1370-1366	**4**	0	0	0	**4**
9 Bogojevo	1366-1360	1	0	0	1	**2**
10 Dalj	1360-1351	0	1	0	0	**1**
11 Borovo 1	1351-1340	2	0	0	0	**2**
12 Borovo 2	1340-1334	0	0	0	0	**0**
13 Vukovar	1334-1322	1	2	0	0	**3**
14 Sotin	1322-1319	0	0	0	0	**0**
15 Opatovac	1319-1313	0	1	0	0	**1**
16 Mohovo	1313-1307	2	2	0	0	**4**
17 Ilok	1307-1296	1	0	0	0	**1**
Total		**47**	**62**	**9**	**17**	**135**

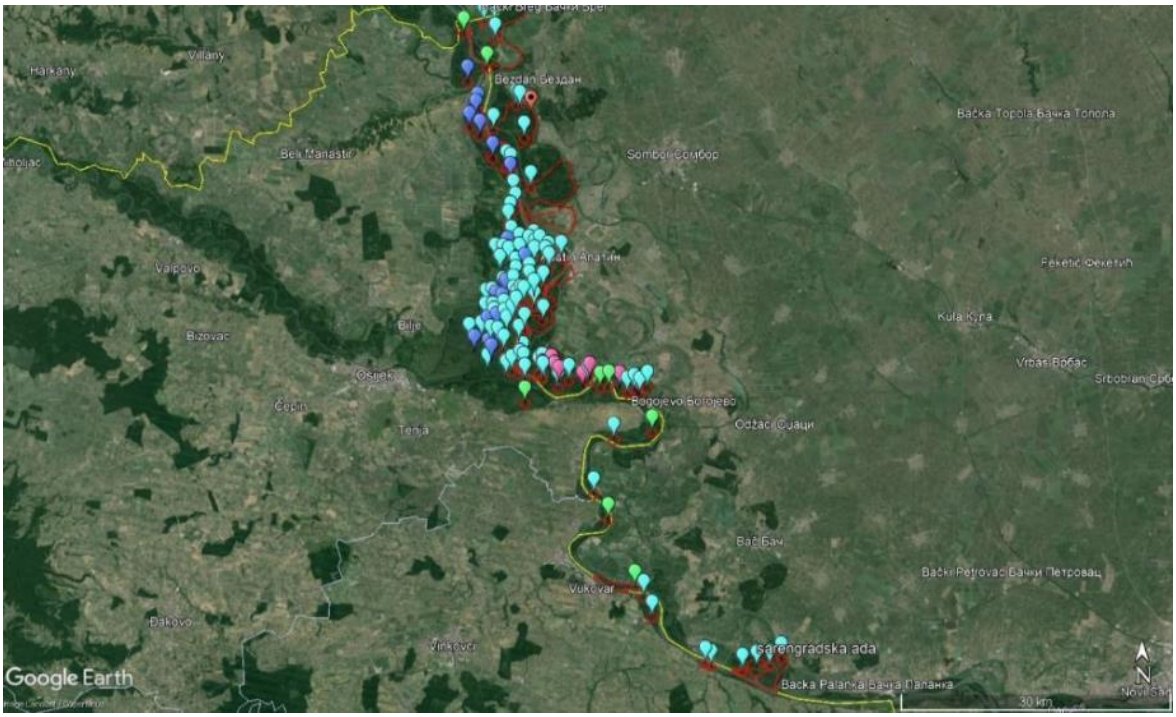


Figure 2-86: Layout of the nesting territories of the White-tailed eagle Haliaeetus albicilla along the Danube

During the 2023 nesting season, 31 potential nesting territories of black kites *Milvus migrans* were identified, 16 of which were located within critical sectors.

During April-June, the raptors inventory was supplemented by a survey of nesting birds, including the wetlands of the Danube floodplain. Along the Danube on both sides of the river, 16 colonies of herons and cormorants are known, which are primarily located outside the floodplain, but from which the birds regularly go to feed in the floodplain. Known colonies of herons and great cormorants along the right bank were visited and photographed with a drone, and the number of nesting pairs was determined by counting the nests from the photographs.

Despite all difficulties, the implementation of the ornithofauna inventory field work related to shoals and steep shores, as well as ponds and swamps, was completely finalized, although the nesting results were very modest due to this year's hydrological conditions. The high water levels of the Danube and the consequent floods caused the flooding of all available shoals, so that the species associated with these habitats had no nesting conditions. The high water levels of the Danube also caused flooding of the banks in the area upstream of the mouth of the Drava, making it impossible for species associated with steep banks to nest. Thus, colonies of terns (Sternidae) were not recorded at all, while the *Charadrius dubius* tern was recorded at only 8 locations (shoals), six of which are located within critical sectors. These surveys were repeated in May 2024.

During September, research on marsh birds during the autumn migration began, which continued until November. They are primarily related to bird surveys along the river itself in order to map the most important resting and feeding grounds. At this moment, most of our migratory nesting birds have left the Danube area for their wintering grounds in the Mediterranean or Africa. However, due to the extremely warm weather (which is still present), migrants from the northern regions, especially various species of ducks, loons and mergansers, arrived in our region only in mid-November.

The winter of 2023/2024 was characterized by a high water level so that the flood area was completely flooded, and a very mild and warm winter. As a result of these conditions, marsh birds were dispersed throughout the floodplain where they had plenty of food and resting places, while extremely few birds were recorded on the river itself.

During these investigations, all encountered species of wild birds were recorded.

A total of 17 monthly trips cycles were conducted.

Results

Based on observations during the project and literature data, the bird fauna of the common sector of the Danube (river + active flood valley) consists of a total of 245 bird species. If we include data from the former flood valley (today's protected area), then the total number of species rises to 301 species. Out of 245 species, the largest number – 122 species – belong to nesting birds. Of these, 32 species are resident nestlings (which are present in the area throughout the year and do not migrate), and an additional 90 species belong to migratory nestlings (which after nesting regularly move to their wintering grounds in the Mediterranean or sub-Saharan Africa). Furthermore, 61 species of birds belong to the regular migrants of this area. They can be seen during the spring and autumn migration, and they nest in the northern parts of Europe. There are 25 species of true hibernation species that spend the winter period in this area from November to February. The last category consists of rare species - 37 of them - that appear rarely or by chance, and their presence is not significant from a ecological functioning point of view of the area.

A Final Report on the inventory of birds was prepared as part of the "Catalogue of Biodiversity Components on the Joint Croatian-Serbian Sector of the Danube River" (see: **ANNEX 3**). Analysis, i.e. counting species from photos, could be done later with the help of a photo processing program (for example, Photoshop) or specially designed programs for this purpose (for example, https://biodiversityinformatics.amnh.org/open_source/dotdotgoose/).

The collected data was also displayed in the space within the interactive map of the subject area (within geoinformation system establishment), which also included the collected photo documentation (photos of stations, species, equipment, etc.).

2.2.4. River benthos type inventory

Overview

Preparation was carried out and a preparatory meeting was held with the Beneficiary (1 February, 2023), at which the Beneficiary was exposed to the river benthos types inventory approach (the project task defined 17 critical locations as the research area and, accordingly, the number of macrozoobenthos samples, the research period and possible sampling limitations in terms of hydrological conditions).

The collection and review of documents on earlier benthos research on the Croatian-Serbian section of the Danube was carried out, as well as the review of documents published on the Project Forum

(link: https://www.plovput.gov.rs/forum-zainteresovanih-strana).

Procedures have been initiated and the necessary permits for research in protected areas and in the border area have been obtained. Necessary permits have been obtained. The status of the procedures is shown below in Chapter 3, Table 3-1.

Based on the project task and the agreement from the preparatory meeting the inventory implementation methodology was elaborated. The methodology for field sampling is presented below.

Text box 2-9 Methodology for field sampling

Methodology for field sampling

Sampling is carried out in accordance with the Decision of Hrvatske vode from 2016 on adopting the Methodology of sampling, laboratory analyses and determining the ratio of ecological quality of biological quality elements, point 3. Biological quality elements in rivers, point 3.4. Biological quality element of macrozoobenthos.

In doing so, each selected sampling location should meet the criteria established in accordance with the sampling standard for benthic invertebrates (HR EN 16150:2012).

According to the methodology, sampling is carried out in accordance with the Decision of Hrvatske vode from 2016.

As part of the technical preparation and planning of the field work, tentative sampling locations were determined, taking into account the availability of the location (from land or river, the possibility of access to the coast and the location where sampling will be done with a manual benthos net), as well as other factors that may influence locations selection (e.g. mine-suspected areas).

On the basis of these conditions and the prepared baseline documentation, a plan for the implementation of field trips was prepared (approaches, locations of entrances and exits to the coast according to daily sections, checking the locations of mine-suspected areas along the right bank of the Danube (as of 14 April 2023)), instructions for protection were prepared for research team safety during the works (general measures and safety measures related to the use of the associated equipment) and in emergency situations, and the equipment for field work adapted to the special conditions of work on large rivers, including a boat with a reinforced bottom and a spare engine, as well as protective equipment for team members (life belts, fluorescent vests, head protection, gloves and boots, flares and a loaded signal gun). The members of the field work implementation team have been determined.

An inventory protocol (recording of field results) has been prepared, in accordance with the Croatian national protocols for monitoring benthic invertebrates in streams:

https://www.voda.hr/sites/default/files/metodologija_uzorkovanja_laboratorijskih_analiza_i_odredivanja_omjera_ekoloske_kakvoce_bioloskih_elemenata_i_odluka.pdf

As the conditions on the Danube are important for sampling, the hydrological situation on the Danube is continuously monitored.

Field work has been carried completely on all 17 critical sections during summer 2023.

Sampling was carried out in the period between May and September in accordance with the project assignment. On the basis of the determined hydrological state of the Danube in the first part of June (stagnation and a slight drop in the water level on the stretch from Batina to Aljmaš), a decision was made to carry out the first part of sampling on the Danube at locations from the border with Hungary to Aljmaš (Staklar) (at 7 locations, in the period from June 8 to 11, 2023). At the end of July, the hydrological conditions were favourable for sampling, and sampling was carried out on the remaining part of the Danube (10 locations, from Erdut to Ilok, in the period from July 24 to 27, 2023).

Sampling was carried out in accordance with the proposed methodology so that all available microhabitats are sampled ("multi-habitat sampling") at a particular sampling location. Macrozoobenthos was sampled with a manual benthos net with mesh diameter of 500 μm and frame dimensions of 25 × 25 cm. At each measuring station, 20 replicate subsamples were collected, distributed in proportion to the share of microhabitat types. The microhabitat type represents a combination of inorganic and organic substrate. Individual sub-samples were sampled by lifting the substrate consisting of the substrate with the associated animals from an area of 25 × 25 cm (0.0625 m^2). The sum of 20 subsamples represents a composite sample from a sampled area of 1.25 m^2. The depth of the sampled layer was adjusted to collect all species present, depending on the substrate type.

Given that the length of the sampled section depends on the area of the watershed, for the Danube River, whose catchment area is more than 10,000 km^2 (very large river), the length of the sampled section was 250 m.

Sampling was carried out with a lot of difficulties (extremely large swarms of mosquitoes in the investigation area), especially at 7 locations sampled during June 2023.

Data were recorded on the sampled sections during macrozoobenthos sampling in field forms, in accordance with the project task and the prescribed methodology:

- basic data about the sampled section: cause code, name of the critical section, sampling date, name of the watercourse and the nearest settlement, code and name of the stream, water body code, coordinates of the starting point of the sampled section, catchment area and altitude of the location of the cause, length of the sampled section, description of sampling location, sampling method, proportions of sampled microhabitats
- features of the watercourse at the sampling location: bank (left, right, middle), part of the watercourse, shape of the river valley, shading, water flow velocity, representation of natural microhabitats, water level, estimated flow, estimated turbidity, water temperature and air temperature, dissolved oxygen, oxygen saturation, electrical conductivity, pH
- features at the sampling location that point to pressures and threats: colour, smell, foam, visible waste, visible signs of the reduction process, pollution, physical disturbances.

Using the prescribed method of sampling all available habitats ("multi-habitat sampling"), macrozoobenthos was sampled at 17 locations, that is, at one location per critical section. At each sampling location, the length of the sampled section (transect) was 250 m. At 14 locations, samples were taken on the right bank of the Danube, while at the remaining critical sections, sampled transects were selected in the central part of the watercourse (river islands). According to the proportion of microhabitats, in 9 locations in the sample natural substrate types, pelal (particles < 6 μm) prevailed, in 5 locations psamopelal prevailed, in 1 location microlithal (2-6 cm, i.e. medium and coarse pebbles up to the size of a hand) and in 2 locations argillaceous (< 6 μm, inorganic silt and clay). Technolital was also present at 4 locations. It was sampled mostly (9 locations) in the depth range from 5 to 130 cm, in the remaining locations in the range from 10 to 150 cm (7 locations) and in one location in the depth range from 20 to 150 cm. Physical and chemical parameters were also measured on the field: the water temperature ranged from 21 to 28 degrees Celsius, the pH value ranged between 7.4 and 8.1, the oxygen saturation at all locations was at least 100%, while the electrical conductivity ranged from 329 to 383 μS/cm.

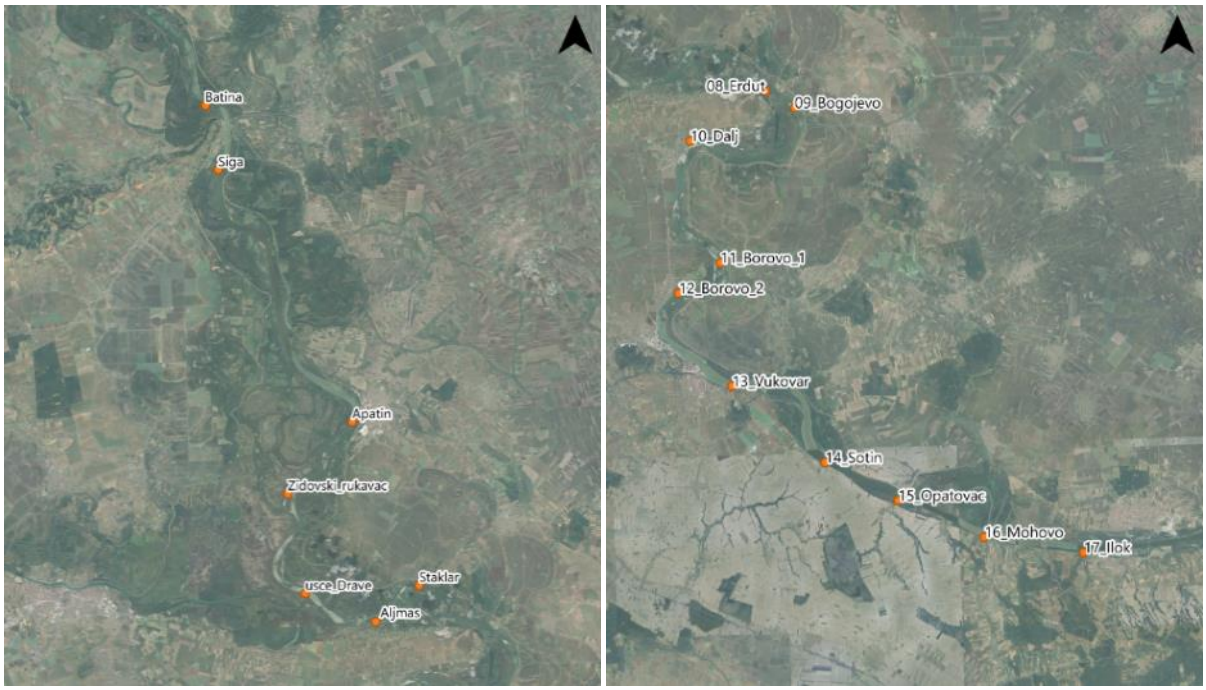


Figure 2-87: Sampling location (left: June 2023; right July 2023)

During sampling, all relevant data were recorded according to the protocol, photo documentation was taken for each sampling location (Figures 2-87, 2-88, 2-89, 2-90), and the samples were stored and sent for further laboratory analysis according to the protocol. Large and rare organisms that are easy to determine in the field were recorded in the field form and returned to the watercourse (large bivalves from the family Unionidae, large decapod crustaceans, Figure 2-91).

Figure 2-88: Sampling at Batina location

Figure 2-89: Sampled section at location Staklar (along the right riverbank)

Figure 2-90: Sampled section at location Bogojevo (along the central part of the watercourse – on river island)

Figure 2-91: Large bivalves and large decapod crustaceans are determined in field and returned to the watercourse

Laboratory analyses began in September 2023. The laboratory procedure of sample analysis includes the isolation of animals from the samples and then the determination of taxa. Isolation of animals from samples and further determination of taxa are the most time-consuming activities. The isolation of animals from the samples was completed by the end of January 2024. The determination of animals is done at the lowest possible level, but at least at the prescribed level according to the Methodology of sampling, laboratory analyses and determination of the relationship of ecological quality of biological elements of water quality. Taxa determination was completed by the end of May 2024.

Figure 2-92: Laboratory work (isolation and determination of animals)

Results

Upon the completion of the laboratory processing, the data were processed in accordance with the methodological guidelines of Croatian Waters, and all data were delivered and integrated into the GIS and database. The obtained results after processing for each individual sampling location (watercourse section of 250 m) are shown as point locations in the space within the interactive map of the subject area.

Using the method of sampling all available habitats ("multi-habitat sampling"), a total of 91 taxa (17.468 individuals) were isolated and determined from the samples on all critical sections (see tha table below for the complete list). In 16 samples, a minimum of 700 animals were isolated from the appropriate number of isolation units (minimum 5), while in one sample, all animals present in the composite sample were completely isolated (critical section Bogojevo). The number of individuals of a particular taxon was recalculated for the entire sample and for an area of 1 m^2, and then this parameter (the number of individuals of a particular taxon per m^2) was used for further calculations.

Table 2-15: The list of sampled taxa

Systematic group	Family	Taxon
Bivalvia	Corbiculidae	*Corbicula fluminea*
Bivalvia	Corbiculidae	*Corbicula* sp.
Bivalvia	Dreissenidae	*Dreissena polymorpha*
Bivalvia	Sphaeriidae	*Pisidium* sp.
Bivalvia	Sphaeriidae	*Sphaerium* sp.
Bivalvia	Sphaeriidae	*Sphaerium corneum*
Bivalvia	Sphaeriidae	*Sphaerium ovale*
Bivalvia	Unionidae	*Anodonta anatina*
Bivalvia	Unionidae	*Anodonta* sp.
Bivalvia	Unionidae	*Unio pictorum*
Bivalvia	Unionidae	*Unio tumidus*
Bivalvia	Unionidae	*Sinanodonta woodiana*
Coelenterata	Hydridae	*Hydra* sp.
Collembola	[Ord:Collembola]	Collembola Gen. sp.
Crustacea	Asellidae	*Asellus aquaticus*
Crustacea	Cambaridae	*Orconectes limosus*
Crustacea	Corophiidae	*Corophium curvispinum*
Crustacea	Corophiidae	*Corophium robustum*
Crustacea	Corophiidae	*Corophium* sp.
Crustacea	Crangonyctidae	*Synurella ambulans*
Crustacea	Gammaridae	*Dikerogammarus villosus*
Crustacea	Gammaridae	*Dikerogammarus haemobaphes*
Crustacea	Gammaridae	*Dikerogammarus bispinosus*
Crustacea	Gammaridae	*Dikerogammarus* sp.
Crustacea	Gammaridae	*Echinogammarus* sp.
Crustacea	Gammaridae	*Obesogammarus* obesus
Crustacea	Gammaridae	*Gammaridae* Gen. sp.
Crustacea	Gammaridae	*Niphargus* sp.
Crustacea	Janiridae	*Jaera* istri
Crustacea	[Ord:Mysidacea]	*Mysidacea* Gen. sp.
Crustacea	Mysidae	*Hemimysis anomala*
Crustacea	Mysidae	*Limnomysis benedeni*
Crustacea	[Kl:Ostracoda]	Ostracoda Gen. sp.
Crustacea	[Kl:Cladocera]	Cladocera Gen. sp.
Crustacea	[Kl:Copepoda]	Copepoda Gen. sp.
Diptera	Chironomidae	Chironomini Gen. sp.
Diptera	Chironomidae	Chironomidae Gen. sp.
Diptera	Chironomidae	*Orthocladiinae* Gen. sp.
Diptera	Chironomidae	*Tanytarsini* Gen. sp.
Diptera	Chironomidae	*Tanypodinae* Gen. sp.
Diptera	Ceratopogonidae	*Atrichopogon* sp.
Diptera	Ceratopogonidae	Ceratopogonidae Gen. sp.
Diptera	Empididae	Empididae Gen. sp.
Diptera	Muscidae	Muscidae Gen. sp.
Diptera	Psychodidae	Psychodidae Gen. sp.
Diptera	Simuliidae	*Simulium* sp.
Diptera	Stratiomyiidae	Stratiomyiidae Gen. sp.
Diptera	Tabanidae	Tabanidae Gen. sp.
Diptera	Tipulidae	Tipulidae Gen. sp.
Diptera	[Kl:Diptera]	Diptera Gen. sp.
Ephemeroptera	Baetidae	*Cloeon dipterum*
Ephemeroptera	Baetidae	*Centroptilum luteolum*
Ephemeroptera	Caenidae	*Caenis* sp.

Systematic group	Family	Taxon
Ephemeroptera	Heptageniidae	*Heptagenia sulphurea*
Ephemeroptera	Heptageniidae	*Heptagenia flava*
Ephemeroptera	Heptageniidae	*Heptagenia* sp.
Ephemeroptera	Heptageniidae	Heptageniidae Gen. sp.
Ephemeroptera	Polymitarcyidae	*Ephoron virgo*
Gastropoda	Physidae	*Physella* sp.
Gastropoda	Hydrobiidae	*Lithoglyphus naticoides*
Gastropoda	Hydrobiidae	Hydrobiidae (incl. Bithyniidae) Gen. sp.
Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*
Gastropoda	Valvatidae	*Borysthenia naticina*
Gastropoda	Valvatidae	*Valvata piscinalis* ssp.
Gastropoda	Valvatidae	*Valvata* sp.
Gastropoda	Melanopsidae	*Esperiana esperi*
Gastropoda	Neritidae	*Theodoxus fluviatilis* ssp.
Gastropoda	Neritidae	*Theodoxus* sp.
Gastropoda	Viviparidae	*Viviparus* sp.
Gastropoda	[Kl:Gastropoda]	*Gastropoda* Gen. sp.
Heteroptera	Micronectidae	*Micronecta* sp.
Hydrachnidia	[Ph:Hydrachnidia]	Hydrachnidia Gen. sp.
Nematoda	[Kl:Nematoda]	Nematoda Gen. sp.
Odonata	Calopterygidae	*Calopteryx* sp.
Odonata	Gomphidae	*Gomphus vulgatissimus*
Odonata	Gomphidae	*Gomphus flavipes*
Odonata	Gomphidae	*Gomphus* sp.
Odonata	Gomphidae	Gomphidae Gen. sp.
Oligochaeta	Enchytraeidae	Enchytraeidae Gen. sp.
Oligochaeta	Haplotaxidae	Haplotaxidae Gen. sp.
Oligochaeta	Lumbricidae	Lumbricidae Gen. sp.
Oligochaeta	Lumbriculidae	Lumbriculidae Gen. sp.
Oligochaeta	Naididae	Naididae Gen. sp.
Oligochaeta	Naididae	*Stylaria lacustris*
Oligochaeta	Tubificidae	Tubificidae juv without setae
Oligochaeta	Tubificidae	Tubificidae juv with setae
Oligochaeta	[Kl:Oligochaeta]	Oligochaeta Gen. sp.
Polychaeta	Ampharetidae	*Hypania invalida*
Trichoptera	Ecnomidae	*Ecnomus tenellus*
Trichoptera	Hydropsychidae	*Hydropsyche contubernalis*
Trichoptera	Hydropsychidae	*Hydropsyche* sp.

Indicators (indices) and modules for the assessment of the ecological state based on macrozoobenthos used for the type of watercourse to which the Danube River belongs (HR-R_5D; Lowland very large streams-Danube, 5D) are as follows:

1) to determine the modulus of saprobity and general degradation based on macrozoobenthos:

1.1) Croatian saprobic index (SIHR) – biological index that indicates the load with easily degradable organic substances, i.e. saprobic load

1.2) Extended biotic index (PBI) (IBE Aqem) – biological index whose value depends on the presence of representatives of individual groups of invertebrates with different sensitivity to organic pollution, starting from the most sensitive to tolerant ones and on the number of taxa in the sample.

2) to determine the general degradation module:

2.1) Shannon-Wiener diversity index (H) – is a mathematical expression used to measure the community structure, based on the number and uniformity of species. As a rule, the values of this index are lower in the case of various types of degradation and pollution, although with extremely clean spring waters, the values

of the diversity index are also low, but this is not a consequence of the poor condition of the water, but of the natural characteristics of the source (stable relatively low temperature, less dissolved oxygen).

2.2) Proportion of taxa that prefer gravel, littoral and sandy substrate type Akal+Lit+Psa (ALP%) ([%] Type Aka+Lit+Psa (scored taxa = 100%)) – an index indicating the general degradation of streams, which also includes certain organic pollution. The values of the index (i.e. the share of representatives of groups that prefer such habitat types) regularly decrease with the deterioration of the water condition.

2.3) Index of Biocoenotic Region (IBR) – the index is a collective indicator of the preference of a particular species for a particular zone of the river/watercourse (biocoenotic region) along the longitudinal profile – crenal, ritral, potamal, littoral and profundal. Lower values of the index indicate a higher proportion of species that prefer crenal and rhytral, and higher values of the index indicate that the community is dominated by indifferent species or species that prefer lower streams and potamal areas.

All the above indexes, except for the Croatian saprobity index (SIHR), are calculated using the computer program Asterics 4.0.4. Microsoft Excel was used in numerical and graphical data processing.

Table 2-16: Values of the calculated indices at sampled locations along the Danube

Index	Batina	Siga	Apatin	Zidovski rukavac	Usce_Drave	Aljmas	Staklar	Erdut	Bogojevo	Dalj	Borovo_1	Borovo_2	Vukovar	Sotin	Opatovac	Mohovo	Ilok
Number of taxa	39	40	35	35	34	42	29	22	19	17	9	24	30	34	19	30	28
Shannon-Wiener diversity index (H')	2,8	2,2	2,3	2,6	2,2	2,6	1,1	1,6	1,3	1,7	0,9	1,5	2,3	2,6	1,3	1,7	2,4
Extended biotic index (PBI)	6,6	7,4	6,0	5,6	6,0	7,6	5,6	5,4	2,4	3,4	2,0	5,0	5,0	6,0	5,0	6,0	5,4
Proportion of taxa that prefer gravel, littoral and sandy substrate type (ALP%)	56,8	40,7	50,4	61,6	50,3	48,2	35,6	36,5	43,1	30,0	24,9	35,5	59,0	74,4	49,5	51,3	40,7
Index of Biocoenotic Region (IBR)	7,1	7,0	7,2	7,2	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,1	7,4	7,1	7,4	7,2
Croatian saprobic index	2,2	2,2	2,3	2,2	2,2	2,3	2,2	2,4	2,2	2,8	2,2	2,5	2,8	2,6	2,3	2,5	2,8

The figure below shows the values of the total number of taxa and the values of the Shannon-Wiener diversity index at each sampled location.

The Shannon-Wiener diversity index values were between 0,92 and 2,76. The highest values (above 2,5) were determined in four locations (Batina, Židovski rukavac, Aljmaš and Sotin). The lowest values were determined at the locations Staklar, Bogojevo, Borovo 1, Borovo 2 and Opatovac. The low diversity at the mentioned locations can be explained by the pronounced dominance of one species at each location, namely at the Staklar and Borovo 2 locations, the invasive alien snail species *Lithoglyphus naticoides* predominates in number of individuals, while at the other three, the invasive alien bivalve *Corbicula* sp. dominates.

After calculating the index value, the ecological quality ratio (OEK) is calculated, whereby the index values are previously transformed (normalized) into a range from 0 (very bad) to 1 (very good), so that all indices are mutually comparable. The OEK values of each index are then used to calculate the ecological quality ratio of the saprobity module and the general degradation module for the sampled type of watercourse

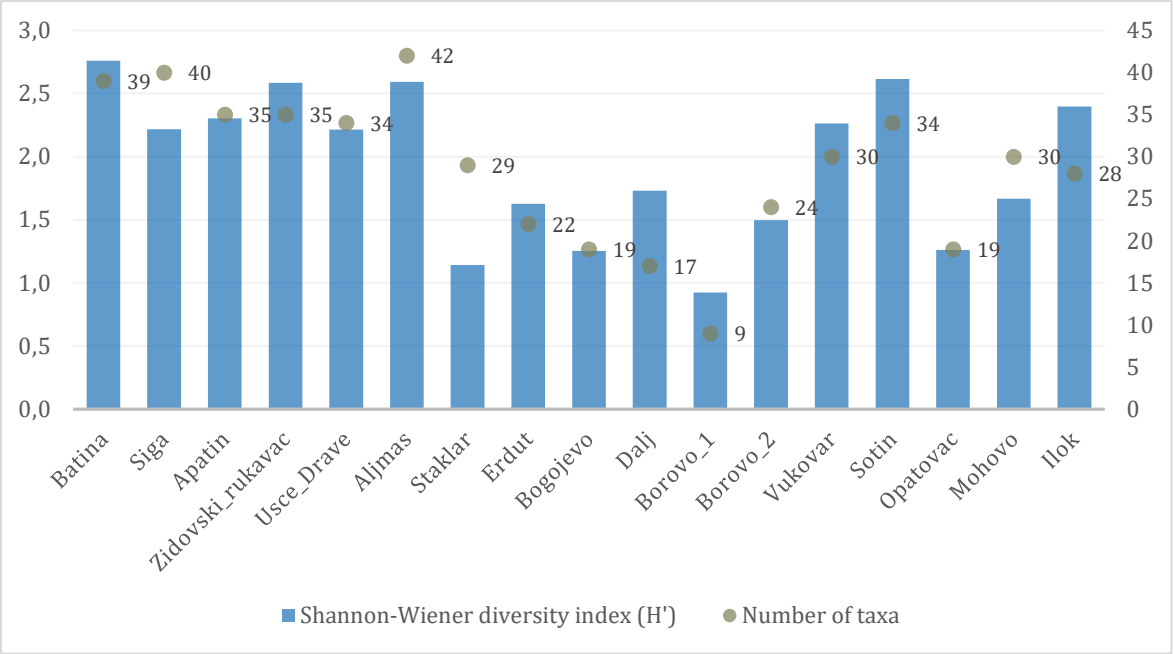


Figure 2-93: Number of taxa and Shannon-Wiener diversity index on sampled locations along the Danube

The ecological quality ratio is calculated separately for the saprobity module, and separately for the general degradation module, while the overall evaluation of the ecological state based on the biological quality element of macrozoobenthos is the worse OEK value of these two modules Categories of ecological status and limit values of categories of ecological status, expressed as a ratio of ecological quality, are determined on the basis of the Regulation on water quality standards.

At the end of the research, the data and results of the research are presented in the "Catalogue of Biodiversity Components on the Common Croatian-Serbian Sector of the Danube River" (see: **ANNEX 3**) and in the form of a final spatial representation within an interactive map of the subject area (within the establishment of a geoinformation system), which also includes collected photo documentation.

2.3. Geoinformation System (GIS) Establishment

Overview

Preparation was carried out and a preparatory meeting was held with the Beneficiary (1 February, 2023), where the approach to the establishment of GIS according to the project task was presented to the Beneficiary (division into work tasks, deadlines and dynamics of execution, conditions for the execution of tasks), and some open questions were discussed (delivery of the necessary background and available data in spatial form, definition of mandatory entries, referencing to existing web databases).

All available previous documentation and data of the monitoring carried out so far (in written and spatial form) were requested and downloaded from the Beneficiary, which will need to be stored in the database. Also, part of the existing web databases and online platforms that will need to be referenced in the GIS database have been submitted.

Familiarization with the Beneficiary's existing WebGIS system, which was created in 2018 and financed through EU funds, and which is available as a DRAWA application on the links:

- iOS: https://apps.apple.com/us/app/drawa/id1448374025
- Android: https://play.google.com/store/apps/details?id=com.codecons.drawa

Based on the project task and based on the agreement from the preparatory meeting, the approach to the establishment of the GIS database was elaborated. The approach was as follows:

Text box 2-10 Approach to GIS database establishment

Approach to GIS database establishment

The WebGIS system will consist of three main components: a static and dynamic part, a web interface, and a server component that will send information to the web interface. The graphical interface will be web-based and used for accessing, visualizing, managing, and exporting data. Administrators will have access to the data and the ability to modify and add to it. The main goal is to enable the review and download of scanned reports for each monitoring component, as well as displaying monitoring results spatially with references to segments from the reports.

The dynamic part of the WebGIS system will enable an interactive map of the shared Croatian-Serbian sector of the Danube River with real-time navigation. Static data will be inputted through the web interface. Web visualization will involve displaying tables, graphs, maps, and other data related to biodiversity. Data management will include the ability to input, modify, and add new data. Data export will cover exporting tables, graphs, printing maps, as well as exporting reports/catalogues in PDF or Word format. All previously conducted monitoring activities will be stored in the database, including tracking morphological changes at specific locations during specified periods.

The web interface will also include links to existing web databases/online biodiversity platforms such as GBIF, INaturalist, and Biofresh. The local administrator will have the ability to add and modify these links. The Contractor will only store the data in the database without processing it.

The interface is expected to be used by a minimum of 5 and a maximum of 15 users simultaneously. It is important that the system operates without errors or difficulties during standard operations. Access to the application will be secured with a username and password, with the ability to change the password. Consideration can also be given to alternative forms of authentication, such as government officials' ID cards. The user interface will be located on the MMPI's LAN network but will also be accessible publicly through assigned access data or preparation for access outside the local network. Additional security checks will be conducted before opening it to the public. The Contractor should provide training for selected MMPI employees for a minimum of two working days at the MMPI's location.

The Contractor should provide a user manual, system administrator instructions, system management and control instructions, and user training documentation. All documentation should be available in printed and electronic form in the Croatian language. The Contractor is obligated to deliver program documentation that includes the system's source code, as well as any modifications made during the system development. The MMPI has the right to freely modify, supplement, exchange, and integrate the

source code with other software solutions, acquiring full ownership, usage, and transfer rights of the program code.

The geoinformation system must be developed, tested, and functional according to the project duration. System maintenance must be ensured for five years after the completion of the service according to the contract. The Contractor is responsible for correcting errors, providing software support, and assisting with system operations within 30 days of receiving notification from the MMPI.

The next relevant activity that was carried out wasanalysis of the quality and usability of the submitted data, foundations, and databases. The Beneficiary was informed of the conclusions of the analysis at the meeting held on 21 April, 2023, at which the Beneficiary was asked some additional questions, for example related to the harmonization of the project's web database with other georeferenced databases related to the project area.

The Beneficiary answered all the questions and gave additional clarifications, about which a record was drawn up, and some explanations were included in the adopted approach to the establishment of the GIS database. With this step, the beneficiary's user requests were analysed and accepted.

In the process of preparing the fieldwork, a GIS project was created (an example of overlaying spatial information in Figure 2-94), which includes all available spatial databases that contain the data that is essential for planning and implementing project activities.

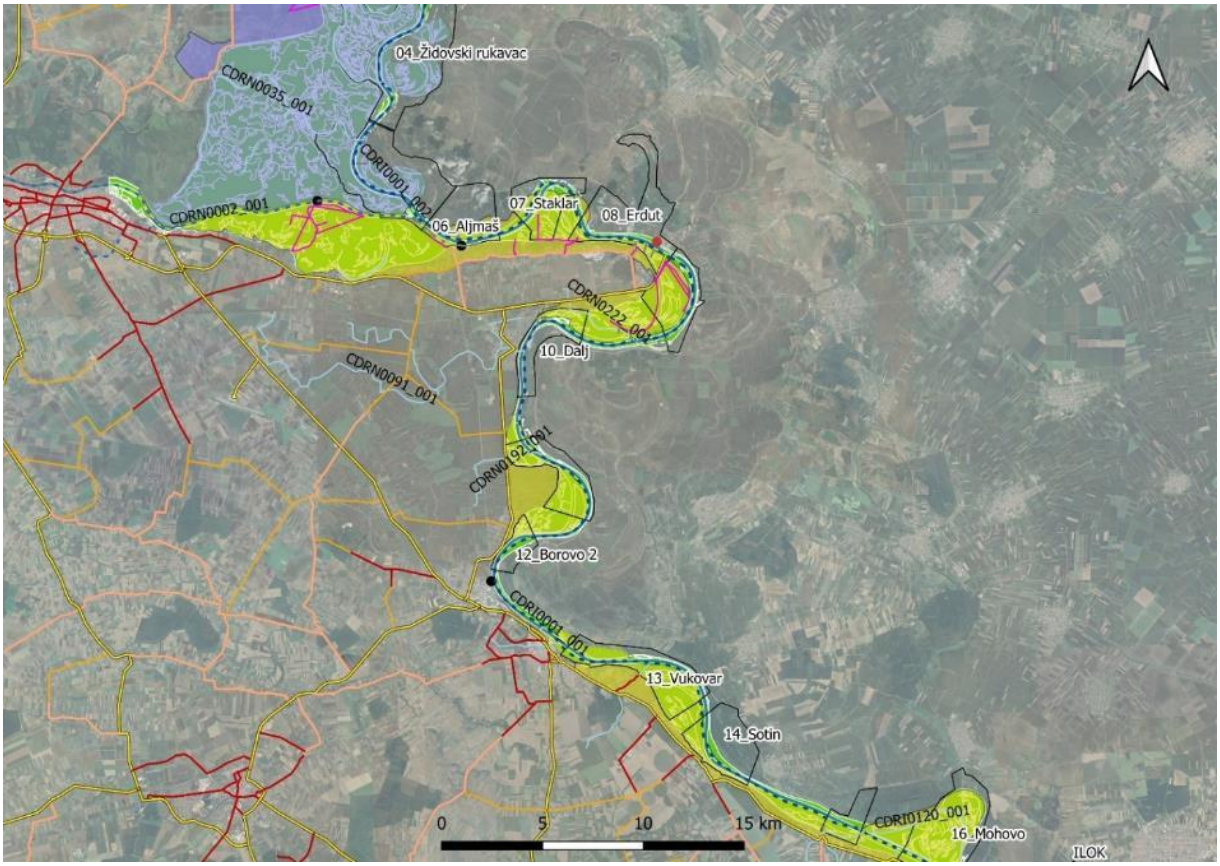


Figure 2-94: An example of overlapping spatial information essential for fieldwork planning

Furthermore, the technical conditions for the procurement of equipment for the Beneficiary were defined (a local server with at least 5 TB of disk space (upgradable) that will be able to meet the interface requirements, with at least 128 GB of RAM and with a minimum of 2xIntel Xeon processors, and must support Raid systems 0 ,1,3,5,6 and 10). The procurement of local server components has been done, and the server with all aforementioned components and technical characteristics were installed and tested at the Beneficiary's location (Figure 2-95).

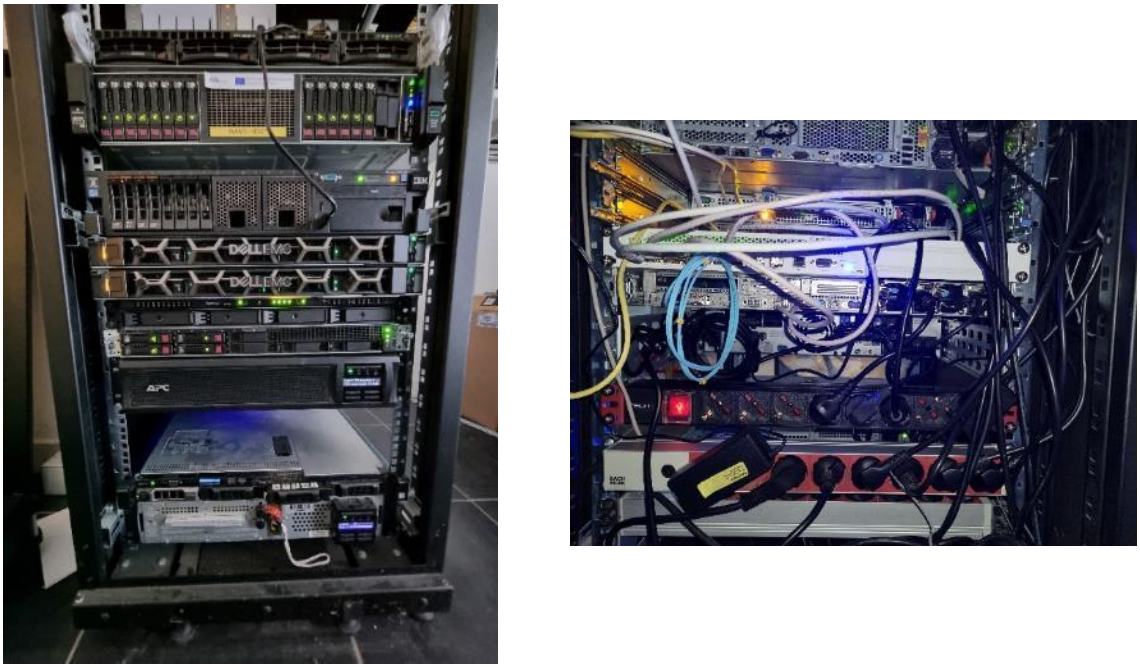


Figure 2-95: The server installed at the Beneficiary's location, left image front, right image back

In the current phase, we are remotely testing the server and advancements have been achieved in developing a database based on earlier field research. The database structure is nearing finalization, positioning it for effortless integration with the developed application directly from the installed local server.

The creation of the architecture of the overall system is prepared and the draft version of application (Figure 2-96) with the test data was demonstrated at the Stakeholder Forum for common Croatian-Serbian Danube section, organized in Kopački Rit, on 27 September.

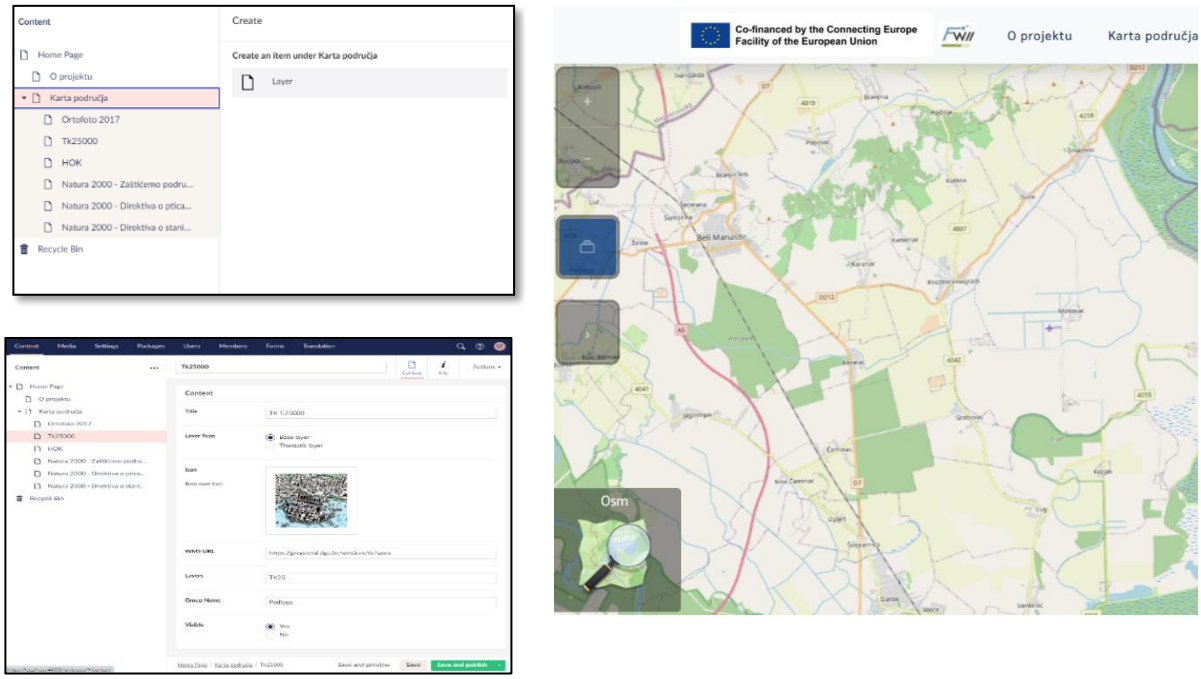


Figure 2-96: An example of the tested application interface

The GIS team then prepared data for the creation of a biodiversity inventory catalog, which includes the implementation of GIS analyzes and the creation of preliminary maps.

During the preparation period, the GIS team held several internal meetings to define the final items of the mounted server at the MMPI's location. The necessary items have been installed so as to start setting up the application without any difficulties.

There was also continuous work on processing and collecting layers for the database. In the last period, the GIS team has been actively working on the WebGIS application and data processing, as well as on the creation of documentation (User Manual, Instructions for use for system administrators, Instructions for system management and control, Documentation for user training).

Results

As a result of the geoinformation system establishment, a WEBGIS application and database was established. The WEBGis application includes all delivered data relevant to the overview of the subject area, which includes:

- Collected and processed data on parameters relevant to the maintenance of the waterway: regulatory structures, hydrographic measurements, recorded speeds and flows and measured transport of suspended and towed sediment, locations of piezometers
- Collected and processed inventory data of biodiversity components: data on fish, habitats, birds and types of river benthos

For easier use and further application updating, the Contractor developed the following documentation:

- User manual
- User instructions for the system administrator
- Instructions for system management and control
- User training documentation

Furthermore, in addition to the mentioned WEBGis application, a database was also created, which, in addition to the application data, includes field data, photographs, tabular representations, previously created studies submitted by the MMPI and all created documents as part of this Project.

Forum members can access GIS database on the following link:

https://fairway2.oikon.hr/

Username: **Forum_member_Danube**
Password: **dUn@Vukovar**

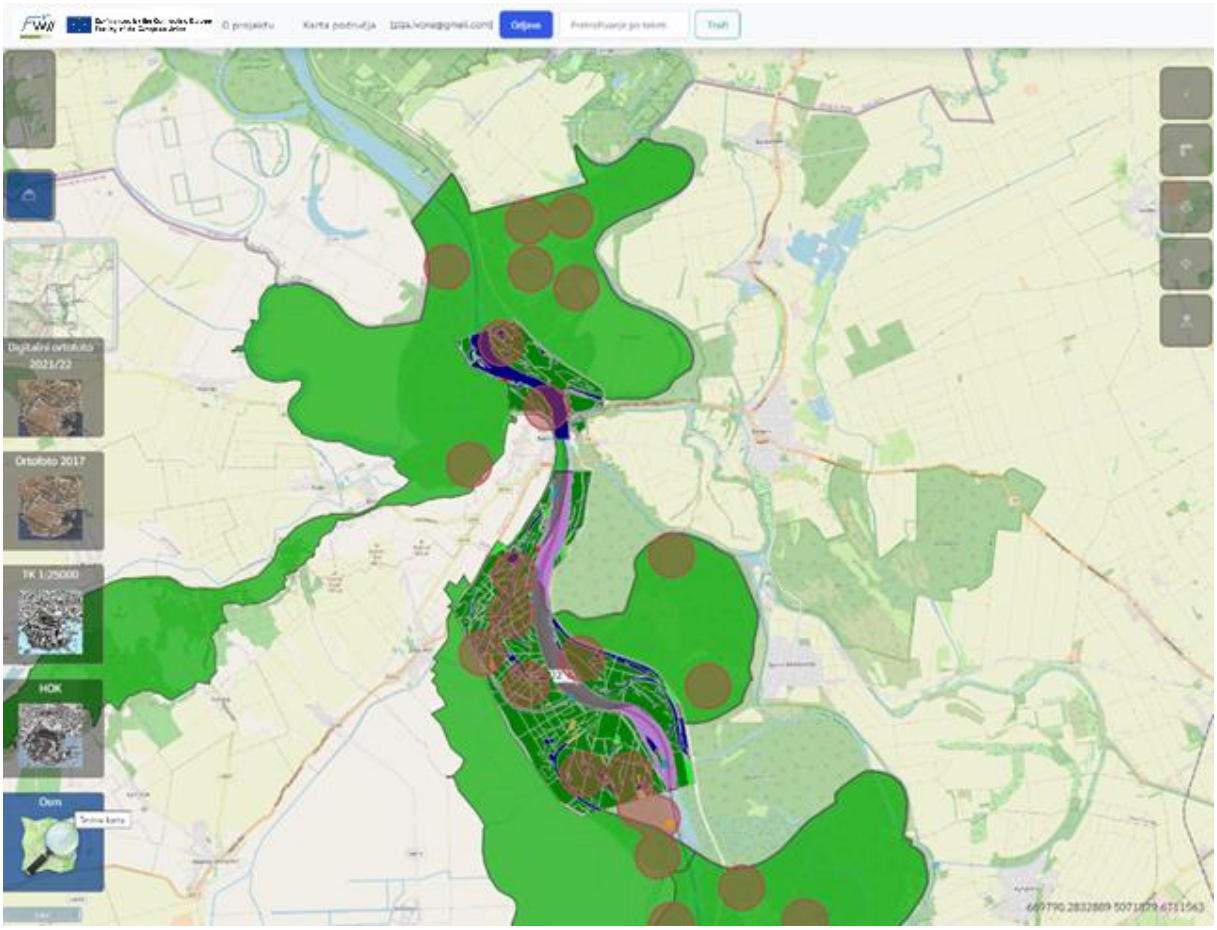


Figure 2-97: The visual of the WEB gis application interface (magnified area of Batina and Sig critical sections)

Maintenance

Maintenance of the geoinformation system will be provided for five years, starting from the date of end of the service, all in accordance with the contract.

3. PROJECT MANAGEMENT WITH REPORTING AND MEETINGS

In the "Danube Monitoring" project, the terms of communication with the Beneficiary (through regular status reports and regular meetings) and delivery of project results are directly determined with Terms of Reference (ToR). Management conditions are indirectly determined in terms of the organization of field work (obtaining permits and conditions for the implementation of monitoring, risk management) and in terms of the collection, processing and storage of data collected by monitoring and the organization of their spatial presentation. In addition to the mentioned mandatory management elements, these activities also include other usual manager activities, such as, managing and ensuring the quality of all deliverables that are defined by the contract, solving unplanned/unexpected difficulties, and providing various advisory services to the Beneficiary regarding all future ways of using the results of this project.

Overview

All necessary permits for research in the project area are obtained (Table 3-1).

Table 3-1: Obtained permits/conditions

Permit/conditions	Authorized institution	Status	Comment
Permit for hydrographic surveys and measurement of flow and sediment	MSTI, Border police, Port authority	Obtained 23.03.2023.	
Permission to research in the border area for biodiversity monitoring and for river regulation infrastructure inventory	Border police HR	General permission obtained 27.04.2023.	announcement (via e-mail) before each field trip
Permit and special conditions for biodiversity inventory in the HR	MESD, Nature Protection Directorate	Obtained 04.05.2023.	
Permit fish fauna inventory in the HR	Ministry of Agriculture	Obtained 10.03.2023	
Permit and special conditions for biodiversity inventory in the RS	Ministry of Environmental Protection of the RS	Obtained	
Confirmation about the locations of mine-suspected areas	Ministry of Internal Affairs, Directorate of Civil Protection	Obtained 26.04.2023.	
Permission to conduct research in the forest areas of the HR	Hrvatske šume (Croatian Forests), Forest Management Unit Osijek	Obtained 13.04.2023.	
Permission to conduct research in NP Kopački rit	MESD, Nature Protection Directorate	Obtained 04.05.2023.	
Permission to research in the border area - Biodiversity monitoring	Border police RS	General permission obtained 12.05.2023.	announcement (via e-mail) before each field trip
Permission to conduct research in PA Gornje Podunavlje	"Vojvodina šume" Public Company (Vojvodina Forests)	Obtained	
Permission to conduct research in SRP Karađorđevo	"Karađorđevo" military institution	Obtained	
Permission to conduct research in the forest areas of the RS	"Vojvodina šume" Public Company (Vojvodina Forests)	Obtained	

Authorized institutions in the neighbouring country were selected for cooperation, cooperation was agreed especially for the research of ichthyofauna and especially for the research of floodplain habitats area, and the necessary approvals, i.e. permits are obtained.

4. PROJECT CHALLENGES

Anticipating the difficulties and risks in Project implementation was crucial for managing the project in terms of achieving the set goals. Thus, at its beginning, two key units were singled out from the overall project task, each of which was exposed to difficulties and risks and which may lead to contract execution outside the established framework. These units are:

- implementation of all field research/monitoring/inventory
- delivery of the results of conducted field research/monitoring/inventory for further analysis

Preliminarily, in the Introductory Report at the beginning of project implementation, the difficulties and risks associated with the implementation of field works, which had to be managed at the Contractor team level, and especially the difficulties and risks related to the delivery of the results of the field works, which should be managed, were specially presented and analyzed both at the level of the Contractor and MMPI teams, but also at the Project partners level.

In the First project progress Report, the key difficulties and risks for each type of research were singled out, and the procedures for managing these risks were presented until the beginning of May 2023. In further two-monthly reports (First to Seventh Report) on the project progress reports, the actual realized risks, the responses to the risks and their impact on the implementation of the Project are clearly presented.

Difficulties/risks in field work implementation

According to the carried out risk assessment in the implementation of field works, two conditions were immediately identified in the Introductory Report that require priority actions in terms of Project management:

- hydrological and meteorological conditions that can complicate or prevent field work,
- conditions for obtaining permits for access to the work area.

The first of these two risks appeared during the summer period of 2023, through unusual hydrological extremes on the Danube and through unusual meteorological conditions in the research area, which threatened to significantly disrupt the dynamics of the works. Unusual extreme hydrological and meteorological phenomena during May and June 2023 (duration of high waters of the Danube and a large number of days with unusually high precipitation) and then again in early August and early September 2023 postponed or slowed down certain field activities (inventories of water structures, ichthyofauna, ornithofauna, habitats of floodplains, hydrographic surveys), which caused a delay in their implementation, but still not to a level that would jeopardize the deadlines and quality of the works. The same thing happened again in January and February 2024, which is why the second cycle of hydrographic surveys was moved to March-April 2024. Due to hydrological conditions and the difficult availability of some habitats in the spring and summer of 2023, the period of ornitofauna inventory in these habitats was extended to May 2024. All other field investigations have been completed, and from this aspect it can be concluded that this risk for the execution of the set tasks was successfully controlled.

Risks related to the conditions for obtaining permits for access to the border monitoring area appeared at the very beginning of the Project. They included obligations to obtain recording and measuring approvals on the Danube itself, as well as field work approvals in floodplains on the territory of the Republic of Croatia and the Republic of Serbia. Since all conditions and necessary approvals were considered in time, including obtaining special approvals for field work on the territory of the Republic of Serbia (according to the legal conditions, such research is allowed only to authorized institutions in the RS, which was resolved by engaging their institutions as subcontractors on this Project) , the obtaining of permits was fully resolved for all research and inventories, and from that aspect as well, the risk was controlled and did not affect Contract execution.

Difficulties/risks in the delivery of field work results

The risk related to field work results delivery was recognized at the beginning of Project implementation and through preparatory meetings with the MMPI and then with possible partners of the MMPI in the use of collected data (priority Hrvatske vode and Plovput), additional conditions were determined for the implementation of some key research (inventory of water structures, construction of piezometers and

measurement of groundwater levels, inventory of benthos and ichthyofauna, hydrographic surveys and processing). During the initial reporting periods, this aspect of risk was controlled by the implementation of additional meetings and agreements with all Project stakeholders, and it can be considered that this aspect of risk was also reduced to the minimum possible extent.

5. RECOMMENDATIONS FOR FURTHER ACTIVITIES

All activities: field work, processing of results and analysis, as well as reporting and meeting activities foreseen and planned have been carried out and finished in contracting time (June-July 2024).

Given recommendations for the future activities on individual topics of Monitoring on the Danube can be used in order to use the obtained results in the best possible way for the needs of future adaptive management of the Danube in the border zone between Croatia and Serbia, i.e. for the purpose of continuous maintenance of the international waterway with the ensured protection of biological diversity and with the maintenance of the services of natural flood ecosystems on both sides of the river.

Nature conservation and water protection are subject of international regulations (WFD, Natura 2000 based upon Birds and Habitat Directives, Emerald Net- work of Areas of Special Conservation Interest, etc.) and national laws. General requirement is that the status of water bodies, habitats and biological quality elements must not be degraded, but to remain or be developed to achieve a good status.

In accordance with the meetings held with the stakeholders, some general recommendations on which we all agreed are presented here. This primarily refers to the recommendations given by Umweltbundesamt GmbH (UBA) and World Wide Fund for Nature Austria (WWF Austria).

General recommendations

First of all is the recommendation (UBA) to use the opportunity that the availability of the newly collected monitoring data offers to secure the compliance with the mentioned regulations and to look for synergies between fairway development and necessary nature conservation and/or restauration measures.

Second is to observe (UBA) the Do-no-significant-harm Principle (Common Provisions 2021/1060) related to the EU Taxonomy Regulation (2020/852a), which facilitates sustainable financing and defines environmental objectives for planning economic activities, notably public infrastructures. This is being observed and applied e.g. in Croatia by the Ministry of Regional Development.

It has also been highly recommended (UBA & WWF) that the current monitoring results will still be subject of an interpretation step and that by the exploration of any future development measures not only their impact on the Danube in its role as a fairway for navigation is considered, but also their potential to address the negative effects of sinking water levels due to riverbed incision (for which, for example, the data that will be collected on piezometers along the Danube, which were instaled within this EU project, will be very useful) and of reduced flows due to climate change.

It is recommended (WWF) that the ecological status of every 17 proposed bottlenecks should be assessed (according to Water Framework Directive or similar standard) and improvements for hydrological connectivity, sediment transport and nature protection should be recommended so that responsible administrations can use this as a basis for potential future actions.

As part of preparatory analysis for improvement suggestions the initial (baseline) situation (historical situation, before human influence) needs to be assessed so that any potential measures can then be discussed/compared as well as identification of change trends in the hydromorphological and ecological status of waters which are crucial for the assessment of the current state of the Danube section and for the assessment of the impact of possible interventions on the change in the hydromorphological and ecological status of the river, as well as for the analysis of any possible measures.

In accordance with WWF recommendation it is recommended the extension of research in the future to other suitable habitats in the Danube River floodplain, primarily standing water bodies, which are crucial for certain target species of amphibians and invertebrates (e.g., *Graphoderus bilineatus*, dragonfly species). Prepared habitat maps shows the current diversity, state, and distribution of natural habitats in the project area will be useful source of data for future research, including a preliminary assessment of the availability of suitable habitats for other target species.

Bearing in mind the feedback from WWF on the overall results, the general recommendation is to do additional interpretation of newly collected data on biodiversity that would put these data into ecological context and offer valuable input during future planning of activities and infrastructure related to the fairway maintenance.

Specific recommendations

Specific recommendations of the expert team that are aiming on monitoring of hidrological, hydraulic and morphological characteristics and inventory of biodiversity components are as follows:

- Inventory of all river regulation infrastructure
    - Inform Hrvatske vode about the results of the conducted inventory and about the established GIS database of water structures in order to harmonize data and connect information systems.
- Riverbed hydrographic surveying
    - Inform Hrvatske vode about the results of the conducted surveys.
- Sediment velocity and flow measurement
    - Inform Hrvatske vode about the results of the measurements.
- Piezometer installation
    - Inform Hrvatske vode about the instaled piezometers and the implementation of measurements for the possible inclusion of these piezometers in the network on which monitoring is carried out by Hrvatske vode.
    - MSTI to continue to gather metered data (water levels, temperature) at piezometer locations to enable further analysis with long-term data.
- Fish inventory
    - Inform Hrvatske vode and the Ministry of Environmental Protection and Green Transition about the results of the inventory and the established database in order to harmonize data and connect information systems
    - Establish regular monitoring of fish populations with the emphasis on endangered fish species and Natura 2000 fish species present along the joint Croatian-Serbian sector of the Danube. Extend the electrofishing and sonar monitoring on the Danube and its tributaries, possibly in areas identified as potential habitats for rare or endangered species, which would help build a more comprehensive understanding of fish populations across the river system and allow trends to be assessed.
    - The assessment of the local mitigation measures, which provides important information for further assessments, must be harmonized for each individual researched sector between the Croatian and Serbian sides.
    - At these critical points along the Danube a long term monitoring stations could be established to track changes in fish populations and their habitat conditions over time, which would provide valuable data on trends and help in understanding the impacts of climate change, pollution, and human activities on the river ecosystem.
    - Develop the targeted management strategies to control invasive species identified during the research. Regular monitoring and removal of invasive species should be implemented to prevent them from outcompeting native fish and disrupting the ecosystem balance.
- Habitat inventory
    - The assessment of the local "Degree of Conservations", which provides important information for further assessments of the impact on Natura 2000 areas, needs to be harmonized for each individual researched sector between the Croatian and Serbian sides, and in accordance with the information provided in the "Standard Data Forms (SDF)". for Natura 2000 areas.
    - The assessment of the local mitigation measures, which provides important information for further assessments, must be harmonized for each individual researched sector between the Croatian and Serbian sides.
    - Additional research could be carried out in order to prepare connectivity map of alluvial habitats on critical sections with the aim of creating a more comprehensive basis for future planning of waterway maintenance works in synergy with restoration or conservation measures.

  - Establish regular monitoring of Natura 2000 habitat types that are water-dependent and sensitive to changes in the water level and natural hydromorphological dynamics of the river (primarily Natura 2000 habitat types: 3130, 3150, 3270, 6440, 91E0*, 91F0). The methodology should follow the national monitoring programmes for these habitats. Recommendation is also that the locations where national monitoring of these habitats is carried out or planned be to be included within future Danube monitoring which would enable more reliable assessment of trends in the future.

- Bird inventory
  - Establish regular monitoring of bird fauna related to sand bars and riverbanks, as well as floodplains and wetlands after the completion of the project. Extend the regular monitoring to the whole active floodplain of the Danube in the joint Croatian-Serbian sector and harmonise the data collection, storage and exchange with other running monitoring activites in Kopački rit Nature Park, Gornje Podunavlje Special reserve and Tikvara Nature park.
  - Inform the Ministry of Environmental Protection and Green Transition about the results of the inventory and about the established database in order to harmonize data and connect information systems.
  - The assessment of the local mitigation measures, which provides important information for further assessments, must be harmonized for each individual researched sector between the Croatian and Serbian sides.
  - Enter the data obtained from subsequent observations into one of the available databases (www.observado.org) so they are available to a wide range of people and the public.

- River benthos type inventory
  - Inform Hrvatske vode about the results of the conducted inventory and about the established database in order to include these data in the database of Hrvatske vode.
  - Establish monitoring of ecological status according to benthic macroinvertebrate communities, following the national methodology for stream and river assessment to allow trends to be assessed along the joint Croatian-Serbian sector of the Danube River.
  - Expansion of the spatial scope of the research could be planned in the future with the adaptation of the methodological approach to include stagnant water bodies and side arms in the floodplain and to survey the distribution of Natura 2000 freshwater invertebrate species that are ecologically bound to those habitats.

6. TIME PLAN TABLE & GANTT CHART

No.	Activity	Planned beginning/end of activities	Actual /expected beginning/end of activities	Comment
3.2.1	**Monitoring of relevant waterway maintenance parameters**	**01.02.2023.-31.03.2024.**	**01.02.2023.-30.04.2024.**	
3.2.1.1	**Inventory of all river regulation infrastructure**	**01.03.-31.10.2023.**	**10.02.-31.10.2023.**	
1.a	Permit issuance	01.03.-31.03.2023.	10.02.-12.05.2023.	**completed**
1.b	Introductory study of planned activities with digitalization of existing baseline documentation	01.04.-30.04.2023.	01.04.-30.04.2023.	**completed**
1.c	Inventory field work	01.04.-31.10.2023.	01.08.-30.11.2023.	**completed**
1.d	Results processing, completed inventory study development	01.04.-31.10.2023.	01.09.-29.02.2024.	**completed**
3.2.1.2	**Riverbed hydrographic surveying**	**01.02.-31.03.2024.**	**10.02.-30.04.2024.**	
1.a	Preparatory works and permit issuance	01.02.-31.03.2023.	10.02.-27.04.2023.	**completed**
1.b	Riverbed hydrographic surveying	01.03.-31.05.2023.	10.05.-15.07.2023.	**completed**
1.b1	Riverbed hydrographic surveying	01.01.-31.03.2024.	01.02.-30.06.2024.	**completed**
1.c	Data processing	01.05.-30.06.2023.	01.08.-30.11.2023.	**completed**
1.c1	Data processing	01.03.-31.03.2024.	01.03.-30.04.2024.	**completed**
3.2.1.3	**Velocity and flow recording and measurement of suspended and dragged sediment**	**01.03.-31.10.2023.**	**10.02.-30.11.2023.**	
1.	**Batina**	01.03.-31.10.2023.	10.02.-30.11.2023.	
1.a	Permit issuance	01.03.-31.03.2023.	10.02.-27.04.2023.	**completed**
1.b	Velocity and flow measurement	01.04.-30.04.2023.	10.05.-30.06.2023.	**completed**
1.b1	Velocity and flow measurement	01.07.-31.07.2023.	01.07.-31.07.2023.	**completed**
1.b2	Velocity and flow measurement	01.10.-31.10.2023.	01.10.-31.10.2023.	**completed**
1.c	Measurement of suspended and dragged sediment flow	01.04.-30.04.2023.	10.05.-30.06.2023.	**completed**
1.c1	Measurement of suspended and dragged sediment flow	01.07.-31.07.2023.	01.07.-31.07.2023.	**completed**
1.c2	Measurement of suspended and dragged sediment flow	01.10.-31.10.2023.	01.10.-31.10.2023.	**completed**
1.d	Results processing, Development of Study for suspended and dragged sediment and velocity and flow monitoring	01.04.-31.10.2023.	01.07.-30.11.2023.	**completed**
2.	**Danube River mouth**	01.03.-31.10.2023.	10.02.-30.11.2023.	
2.a	Permit issuance	01.03.-31.03.2023.	10.02.-27.04.2023.	**completed**
2.b	Measurement of suspended and dragged sediment flow	01.04.-31.10.2023.	10.05.-30.06.2023.	**completed**
2.b1	Measurement of suspended and dragged sediment flow	01.07.-31.07.2023.	01.07.-31.07.2023.	**completed**
2.b2	Measurement of suspended and dragged sediment flow	01.10.-31.10.2023.	01.10.-31.10.2023.	**completed**
2.c	Results processing, sediment monitoring study development	01.04.-31.10.2023.	01.07.-30.11.2023.	**completed**
3.	**Vukovar**	01.03.-31.10.2023.	10.02.-30.11.2023.	
3.a	Permit issuance	01.03.-31.03.2023.	10.02.-27.04.2023.	**completed**
3.b	Velocity and flow measurement	01.04.-30.04.2023.	10.05.-30.06.2023.	**completed**
3.b1	Velocity and flow measurement	01.07.-31.07.2023.	01.07.-31.07.2023.	**completed**
3.b2	Velocity and flow measurement	01.10.-31.10.2023.	01.10.-31.10.2023.	**completed**
3.c	Results processing, velocity, and flow monitoring study development	01.04.-31.10.2023.	01.07.-30.11.2023.	**completed**
4.	**Ilok**	01.03.-31.10.2023.	10.02.-30.11.2023.	
4.a	Permit issuance	01.03.-31.03.2023.	10.02.-27.04.2023.	**completed**
4.b	Velocity and flow measurement	01.04.-30.04.2023.	10.05.-30.06.2023.	**completed**

4.b1	Velocity and flow measurement	01.07.-31.07.2023.	01.07.-31.07.2023.	**completed**
4.b2	Velocity and flow measurement	01.10.-31.10.2023.	01.10.-31.10.2023.	**completed**
4.c	Measurement of suspended and dragged sediment flow	01.04.-30.04.2023.	10.05.-30.06.2023.	**completed**
4.c1	Measurement of suspended and dragged sediment flow	01.07.-31.07.2023.	01.07.-31.07.2023.	**completed**
4.c2	Measurement of suspended and dragged sediment flow	01.10.-31.10.2023.	01.10.-31.10.2023.	**completed**
4.d	Results processing, velocity/flow/sediment monitoring study development	01.04.-31.10.2023.	01.07.-30.11.2023.	**completed**
3.2.1.4	**Piezometer installation**	**01.02.-31.05.2023.**	**01.02.-31.01.2024.**	
1.a	Preliminary piezometer locations proposal	01.02.-28.02.2023.	01.02.-28.02.2023.	**completed**
1.b	Beneficiary locations confirmation	01.02.-28.02.2023.	01.02.-28.02.2023.	**completed**
1.c	Work programme development, HV Water management conditions issuance	01.03.-31.03.2023.	01.03.-02.05.2023.	**completed**
1.d	Installation of 3 piezometers at a depth of 15 m	01.03.-31.03.2023.	01.05.-26.06.2023.	**completed**
1.e	Installation of automatic meters (water level, temperature)	01.04.-30.04.2023.	01.07.-31.01.2024.	**completed**
1.f	Study development „Piezometers on joint Croatian-Serbian sector of the Danube River"	01.04.-31.05.2023.	01.07.-31.08.2023.	**completed**
3.2.2	**Biodiversity inventory**	**01.02.2023.-30.06.2024.**	**01.02.2023.-30.06.2024.**	
3.2.2.1	**Fish inventory**	**01.02.2023.-28.02.2024.**	**10.02.2023.-30.04.2024.**	
3.2.2.1.0	Permit issuance	01.02.-31.03.2023.	10.02.-30.09.2023.	**completed**
3.2.2.1.1	Electrofishing	01.04.-30.09.2023.	01.07.-30.09.2023.	**completed**
1.a	Electrofishing (1. - 6. critical area)	01.04.-31.05.2023.	01.07.-31.07.2023.	**completed**
1.a1	Electrofishing (7. - 12. critical area)	01.06.-31.07.2023.	01.07.-31.08.2023.	**completed**
1.a2	Electrofishing (13. - 17. critical area)	01.07.-30.09.2023.	01.07.-30.09.2023.	**completed**
3.2.2.1.2	Electric dredger	01.06.-30.09.2023.	01.07.-31.03.2024.	**completed**
2.a	Electric dredger (1. - 9. critical area)	01.06.-31.07.2023.	01.07.- 31.03.2024.	**completed**
2.a1	Electric dredger (10. - 17. critical area)	01.08.-30.09.2023.	01.07.- 31.03.2024.	**completed**
3.2.2.1.3	Winter sampling (sonar)	01.12.2023.-28.02.2024.	01.12.2023.-28.02.2024.	**completed**
3.a	Winter sampling (sonar) (1. - 9. critical area)	01.12.2023.-31.01.2024.	01.12.2023.-28.02.2024.	**completed**
3.a1	Winter sampling (sonar) (10. - 17. critical area)	01.01.2024.-28.02.2024.	01.01.-28.02.2024.	**completed**
3.2.2.1.4	Data collection during research	01.02.2023.-28.02.2024.	01.02.2023.-28.02.2024.	**completed**
4.a	Data collection of previous research	01.02.-31.03.2023.	01.02.-31.03.2023.	**completed**
4.b	Cooperation with ichthyologists from Serbia	01.04.2023.-28.02.2024.	01.04.2023.-28.02.2024.	**completed**
4.c	Communication and cooperation with fishing societies	01.04.2023.-28.02.2024.	01.04.2023.-31.03.2024.	**completed**
3.2.2.2	**Habitat inventory**	**01.02.2023.-31.05.2024.**	**01.02.2023.-31.05.2024.**	
3.2.2.2.1	Preparatory activities	01.02.-31.05.2023.	01.02.-31.05.2023.	**completed**
1.a	Permit issuance for field sampling	01.02.-30.04.2023.	01.02.2023.-1.08.2023.	**completed**
1.b	Collection of existing (literary) data and baseline documentation for the project area	01.02.-30.04.2023.	01.02.-30.04.2023.	**completed**
1.c	Development of a GIS based preliminary habitat map of the monitoring area scope based on existing data and habitat map	01.02.-31.05.2023.	01.03.-31.05.2023.	**completed**
1.d	Technical preparation (fieldwork planning)	01.03.-30.04.2023.	01.04.-30.04.2023.	**completed**
3.2.2.2.2	Field sampling - habitat mapping	01.05.-31.10.2023.	01.07.-31.10.2023.	**completed**
2.a	Mapping priority habitat types of Natura 2000 floodplains (91E0*)	01.05.-31.10.2023.	01.07.-31.10.2023.	**completed**

2.b	Mapping of endangered and rare habitat types listed in Annex I of the Habitats Directive (3130, 3150, 3270, 6440, 91E0*)	01.05.-31.10.2023.	01.07.-31.10.2023.	**completed**
3.2.2.2.3	Habitat map development	01.08.2023.-31.05.2024.	01.08.2023.-30.06.2024.	**completed**
3.a	Plant species determination (herbal material)	01.08.2023.-30.04.2024.	01.08.2023.-31.05.2024.	**completed**
3.b	Habitat map development (NHC, Natura 2000 classification) for the monitoring area scope	01.12.2023.-31.05.2024.	01.12.2023.-30.06.2024.	**completed**
3.c	Data preparation (habitat map, point locations) for GIS input	01.12.2023.-31.05.2024.	01.12.2023.-30.06.2024.	**completed**
3.2.2.3	**Bird inventory**	**01.02.2023.-30.06.2024.**	**01.02.2023.-30.06.2024.**	
3.2.2.3.1	Shoal research	01.05.2023.-30.06.2024.	01.05.2023. -30.06.2024.	**completed**
1.a	Shoal research	01.05.2023. -31.07.2023.	01.05.2023. -31.07.2023.	**completed**
1.a1	Shoal research	01.05.2024. -30.06.2024.	01.05.2024. -30.06.2024.	**completed**
3.2.2.3.2	Research of steep bank sections	01.05.2023. -30.06.2024.	01.05.2023. -30.06.2024.	**completed**
2.a	Research of steep bank sections	01.05.2023. -31.07.2023.	01.05.2023. -31.07.2023.	**completed**
2.a1	Research of steep bank sections	01.05.2024. -30.06.2024.	01.05.2024. -30.06.2024.	**completed**
3.2.2.3.3	Research of ponds and marshes	01.02.2023. -30.06.2024.	01.02.2023. -30.06.2024.	**completed**
3.a	Research of ponds and marshes – colonial nesting birds	01.04.2023. -31.07.2023.	01.04.2023. -31.07.2023.	**completed**
3.a1	Research of ponds and marshes – colonial nesting birds	01.04.2024. -30.06.2024.	01.04.2024. -30.06.2024.	**completed**
3.b	Research of ponds and marshes – birds of prey	01.02.2023. -30.06.2023.	01.02.2023. -30.06.2023.	**completed**
3.b1	Research of ponds and marshes – birds of prey	01.01.2024. -30.06.2024.	01.01.2024. -30.06.2024	**completed**
3.c	Research of ponds and marshes – marsh nesting birds	01.04.2023. -31.07.2023.	01.04.2023. -31.07.2023.	**completed**
3.c1	Research of ponds and marshes – marsh nesting birds	01.04.2024. -30.06.2024.	01.04.2024. -30.06.2024.	**completed**
3.2.2.3.4	Bird monitoring during spring and autumn migration and wintering	01.02.2023. -30.06.2024.	01.02.2023. -30.06.2024.	**completed**
4.a	Bird monitoring during spring and autumn migration and wintering	01.02.2023. -30.04.2023.	01.02.2023. -30.04.2023.	**completed**
4.b	Bird monitoring during spring and autumn migration and wintering	01.08.2023. -30.04.2024.	01.08.2023. -30.04.2024.	**completed**
3.2.2.3.5	Additional non-systematic and incidental field tours	01.02.2023. -30.06.2024.	01.02.2023. -30.06.2024.	**completed**
3.2.2.4	**Macrozoobenthos field sampling**	**01.02.2023.-31.05.2024.**	**01.02.2023.-31.05.2024.**	
3.2.2.4.1	Preparatory activities	01.02.2023. -30.04.2023.	01.02.2023 -12.05.2023.	**completed**
1.a	Permit issuance for field sampling	01.02.2023. -30.04.2023.	10.02.2023. -12.05.2023.	**completed**
1.b	Collection of existing (literary) data and baseline documentation for the project area	01.02.2023. -30.04.2023.	01.02.2023. -30.04.2023.	**completed**
1.c	Technical preparation (fieldwork planning)	01.03.2023 -30.04.2023.	01.03.2023 -30.04.2023.	**completed**
3.2.2.4.2	Macrozoobenthos field sampling at locations designated as monitoring area scope (17 samples) in accordance with prescribed methodology	01.05.2023. -31.10.2023.	01.05.2023. -31.10.2023.	**completed**
3.2.2.4.3	Processing of Macrozoobenthos samples processing	01.08.2023. -31.05.2024.	01.08.2023. -30.06.2024.	**completed**

3.a	Isolation of individuals and determination of macrozoobenthos taxa from samples in accordance with prescribed methodology	01.08.2023. - 31.05.2024.	01.08.2023. - 30.06.2024.	**completed**
3.b	Data processing in accordance with prescribed methodology	01.09.2023. - 31.05.2024.	01.09.2023. - 30.06.2024.	**completed**
3.c	Data preparation (macrozoobenthos) for GIS input	01.09.2023. - 31.05.2024.	01.09.2023. - 30.06.2024.	**completed**
3.2.3	**Establishment of GIS system**			
3.2.3.1	Local server delivery	01.02.2023. - 30.06.2024.	01.02.2023. - 30.06.2024.	**completed**
	Equipment procurement	01.02.2023. - 30.06.2023.	01.02.2023. - 30.11.2023.	**completed**
	Setting up server and user installation	01.07.2023. – 29.02.2024.	01.07.2023. – 29.02.2024.	**completed**
	Functionality testing	01.01.2024. - 30.06.2024.	01.01.2024. - 30.06.2024.	**completed**
3.2.3.2	Implementation of a simple webGIS system	01.02.2023. - 30.06.2024.	01.02.2023. - 30.06.2024.	**completed**
	Analysis of user requirements	01.02.2023. - 31.03.2023.	01.02.2023. - 31.03.2023.	**completed**
	System architecture creation and technology selection	01.03.2023. – 30.04.2023.	01.03.2023. – 30.10.2023.	**completed**
	Application development in a development environment	01.05.2023. – 31.10.2023.	01.05.2023. – 30.11.2023.	**completed**
	Application testing in a test environment and bug correction	01.11.2023. – 29.02.2024.	01.11.2023. – 29.02.2024.	**completed**
	Application implementation and confirmation of functionality by the user	01.03.2024. – 30.06.2024.	01.03.2024. – 30.06.2024.	**completed**
3.2.3.3	Processed data collection and GIS database development	01.02.2023. - 30.06.2024.	01.02.2023. - 30.06.2024.	**completed**
	Defining input data format	01.02.2023. – 30.04.2023.	01.02.2023. – 30.04.2023.	**completed**
	Collection of all baseline documentation and data collected during monitoring and collection of historical baseline documentation and data	01.03.2023. – 30.04.2024.	01.03.2023. – 30.04.2024.	**completed**
	Data cataloguing by components	01.03.2023. – 30.04.2024.	01.03.2023. – 30.04.2024.	**completed**
	Data entry and GIS layers creation by components	01.03.2023. – 30.04.2024.	01.03.2023. – 30.04.2024.	**completed**
	Data consolidation and preparation for entry into the webGIS system	01.03.2024. – 30.06.2024.	01.03.2024. – 30.06.2024.	**completed**
3.2.3.4	Documentation delivery and user training	01.01.2024. – 30.06.2024.	01.01.2024. – 30.06.2024.	**completed**
	User manuals development, system administrators' usage instructions, system management and control manual, and documentation for user training	01.01.2024. – 30.06.2024.	01.01.2024. – 30.06.2024.	**completed**
	Training of selected MSTI employees	01.05.2024. – 30.06.2024.	01.05.2024. – 30.06.2024.	**completed**
3.2.3.5	Geoinformation system maintenance	30.06.2024. – 30.06.2029.	30.06.2024. – 30.06.2029.	**ongoing 5 years after the end of the project**

Monitoring of the hydrological, hydraulic and morphological charac+A1:U88teristics of the Danube River and inventory of biodiversity components on the joint Croatian-Serbian sector of the Danube River																				
R. br.			2023.											2024.						
3.2.1	**Monitoring of relevant waterway maintenance parameters**																			
3.2.1.1	**Inventory of all river regulation infrastructure**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0.a	Permit issuance	4																		
0.b	Introductory study of planned activities with digitalization of existing baseline documentation	1																		
0.c	Inventory field work	4																		
0.d	Results processing, completed inventory study development	6																		
3.2.1.2	**Riverbed hydrographic surveying**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.a	Preparatory works	5																		
1.b	Riverbed hydrographic surveying	6																		
1.c	Data processing	6																		
3.2.1.3	**Velocity and flow recording and measurement of suspended and dragged sediment**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	**Batina**	**10**																		
1.a	Permit issuance	3																		
1.b	Velocity and flow measurement	4																		
1.c	Measurement of suspended and dragged sediment flow	4																		
1.d	Results processing, Development of Study for suspended and dragged sediment and velocity and flow monitoring	5																		
2.	**Danube River mouth**	**10**																		
2.a	Permit issuance	3																		
2.b	Measurement of suspended and dragged sediment flow	4																		
2.c	Results processing, sediment monitoring study development	5																		
3.	**Vukovar**	**10**																		
3.a	Permit issuance	3																		
3.b	Velocity and flow measurement	4																		
3.c	Results processing, velocity and flow monitoring study development	5																		
4.	**Ilok**	**10**																		
4.a	Permit issuance	3																		
4.b	Velocity and flow measurement	4																		
4.c	Measurement of suspended and dragged sediment flow	4																		
4.d	Results processing, Development of Study for suspended and dragged sediment and velocity and flow monitoring	5																		
3.2.1.4	**Piezometer installation**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
5.a	Preliminary piezometer locations proposal	1																		
5.b	Client locations confirmation	1																		
5.c	Work programme development, HV Water management conditions issuance	3																		
5.d	Installation of 3 piezometers at a depth of 15 m	1																		
5.e	Installation of automatic meters (water level, temperature)	4																		
5.f	Study development „Piezometers on joint Croatian-Serbian sector of the Danube River"	7																		

Monitoring of the hydrological, hydraulic and morphological characteristics of the Danube River and inventory of biodiversity components on the joint Croatian-Serbian sector of the Danube River																				
R. br.			2023.											2024.						
3.2.2	**BIODIVERSITY INVENTORY**																			
3.2.2.1	**Fish inventory**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3.2.2.1.1	**Electrofishing**	**3**																		
	Electrofishing (1. - 6. critical area)	1																		
	Electrofishing (7. - 12. critical area)	2																		
	Electrofishing (13. - 17. critical area)	3																		
3.2.2.1.2	**Electric dredger**	**3**																		
	Electric dredger (1. - 9. critical area)	3																		
	Electric dredger (10. - 17. critical area)	3																		
3.2.2.1.3	**Winter sampling (sonar)**	**3**																		
	Winter sampling (sonar) (1. - 9. critical area)	3																		
	Winter sampling (sonar) (10. - 17. critical area)	3																		
3.2.2.1.3	**Data collection during research**	**11**																		
	Data collection of previous research	**2**																		
	Cooperation with ichthyologists from Serbia	**9**																		
	Communication and cooperation with fishing societies	**10**																		
3.2.2.2	**Habitat inventory**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3.2.2.2.1	**Preparatory activities**	**4**																		
	Permit issuance for field sampling	7																		
	Collection of existing (literary) data and baseline documentation for the project area	3																		
	Development of a GIS based preliminary habitat map of the monitoring area scope based on existing data and habitat map	3																		
	Technical preparation (fieldwork planning)	1																		
3.2.2.2.2	**Field sampling - habitat mapping**	**4**																		
	Mapping priority habitat types of Natura 2000 floodplains (91E0*)	4																		
	Mapping of endangered and rare habitat types listed in Annex I of the Habitats Directive (3130, 3150, 3270, 6440, 91E0*)	4																		
3.2.2.2.3	**Habitat map development**	**10**																		
	Plant species determination (herbal material)	9																		
	Habitat map development (NHC, Natura 2000 classification) for the monitoring area scope	7																		
	Data preparation (habitat map, point locations) for GIS input	7																		
3.2.2.3	**Bird inventory**	**Estimated duration**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3.2.2.3.1	**Shoal research**	**5**																		
3.2.2.3.2	**Research of steep bank sections**	**5**																		
3.2.2.3.3	**Research of ponds and marshes**	**12**																		
	Research of ponds and marshes – colonial nesting birds	7																		
	Research of ponds and marshes – birds of prey	9																		
	Research of ponds and marshes – marsh nesting birds	7																		
3.2.2.3.4	**Bird monitoring during spring and autumn migration and wintering**	**12**																		
3.2.2.3.5	**Additional non-systematic and incidental field tours**	**17**																		

Monitoring of the hydrological, hydraulic and morphological characteristics of the Danube River and inventory of biodiversity components on the joint Croatian-Serbian sector of the Danube River																				
R. br.			2023.											2024.						
3.2.2.4	River benthos type inventory	Estimated duration	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3.2.2.4.1	**Preparatory activities**	**4**																		
	Permit issuance for field sampling	4																		
	Collection of existing (literary) data and baseline documentation for the project area	3																		
	Technical preparation (fieldwork planning)	2																		
3.2.2.4.2	**Macrozoobenthos field sampling**	**6**																		
	Macrozoobenthos field sampling at locations designated as monitoring area scope (17 samples) in accordance with prescribed methodology	6																		
3.2.2.4.3	**Processing of Macrozoobenthos samples processing**	**11**																		
	Isolation of individuals and determination of macrozoobenthos taxa from samples in accordance with prescribed methodology	11																		
	Data processing in accordance with prescribed methodology	9																		
	Data preparation (macrozoobenthos) for GIS input	9																		
3.2.3	**ESTABLISHMENT OF A GEOINFORMATION SYSTEM (GIS)**																			
		Estimated duration	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
3.2.3.1	**Local server delivery**	**17**																		
	Equipment procurement	10																		
	Setting up server and user installation	8																		
	Functionality testing	6																		
3.2.3.2	**Implementation of a simple webGIS system**	**17**																		
	Analysis of user requirements	2																		
	System architecture creation and technology selection	8																		
	Application development in a development environment	6																		
	Application testing in a test environment and bug correction	4																		
	Application implementation and confirmation of functionality by the user	4																		
3.2.3.3	**Processed data collection and GIS database development**	**17**																		
	Defining input data format	3																		
	Collection of all baseline documentation and data collected during monitoring and collection of historical baseline documentation and data	14																		
	Data cataloguing by components	14																		
	Data entry and GIS layers creation by components	14																		
	Data consolidation and preparation for entry into the webGIS system	4																		
3.2.3.4	**Documentation delivery and user training**	**6**																		
	User manuals development, system administrators' usage instructions, system management and control manual, and documentation for user training	6																		
	Training of selected Ministry employees	2																		
3.2.3.5	**Geoinformation system maintenance**	5 years after the end of the project																		

7. EXECUTIVE SUMMARY

Monitoring on the Danube along the joint Croatian-Serbian sector of the river is an integral part of the international EU project "Preparation of FAIRway2 works on the Rhine-Danube Corridor" which has been conducted within the CEF 2014-2020 calls in the field of transport. The project partners in this EU project are the Austrian Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, the Serbian Ministry of Construction, Transport, and Infrastructure and the Croatian Ministry of the Sea, Transport and Infrastructure. Project coordinator is "viadonau" from Vienna.

The aim of this monitoring is to create the basis for a joint Croatian and Serbian strategy to maintain the Danube as an important international waterway. As part of the comprehensive EU project, the Croatian and Serbian partners will redefine priority critical sections for navigation on the shared stretch of the Danube and analyse their alternative solutions. All results will be presented within a comprehensive study which will be the basis for the future joint adaptive management of the Danube in the border zone between Croatia and Serbia. Implementation of the joint adaptive Croatian-Serbian management will at the same time enable maintenance of the waterway, ensure the protection of biodiversity and maintain ecosystem services of natural flood plains on both sides of the Danube.

This project has been implemented through realization of all monitoring and inventory activities with the establishment of GIS database. All project tasks were carried out by Contractor's team consisting of experts from Oikon Ltd. – Institute of Applied Ecology, Hidroing Ltd. Osijek, Vodoprivredno-projektni biro JSC and Croatian Society for the Protection of Birds and Nature (as the subcontractor of Oikon Ltd.). Oikon Ltd. was responsible for the project management and coordination of the project.

Monitoring on the Danube consisted of 3 components (with first two components comprising of 4 sub-components), as follows:

1) Monitoring of relevant waterway maintenance parameters

   a. Inventory of river regulation infrastructure (activities performed by Hidroing Ltd.)
   b. Riverbed hydrographic surveying (activities performed Vodoprivredno-projektni biro JSC (VPB) and MMPI)
   c. Velocity and flow recording and measurement of suspended and dragged sediment (activities performed by Hidroing Ltd.)
   d. Piezometer installation (activities performed by Hidroing Ltd.)

2) Inventory of biodiversity components

   a. Fish inventory (activities performed by Oikon Ltd.)
   b. Habitat inventory (activities performed by Oikon Ltd.)
   c. Bird inventory (activities performed by Croatian Society for the Protection of Birds and Nature, as the subcontractor of Oikon Ltd.)
   d. River benthos type inventory (activities performed by Oikon Ltd.)

3) Establishment of a geoinformation system (activities performed by Oikon Ltd.).

Monitoring of relevant waterway maintenance parameters

Inventorization of river regulation infrastructure

Field work activities have been conducted during October 2023 to ensure high(er)visibility of the structures. 78 existing objects on the right bank have been identified; 89 objects on the left bank.

Upon completion of all field works, the obtained data were processed and the following textual and graphic representations were given:

- Serial number of the structure on the left or right bank
- River regulation structure name (e.g., 1423 – river kilometre of the infrastructure, D5 - right bank, fifth object (L = left bank))
- Structure type: revetment, groyne, T-groyne, parallel structure, imported fills or barrier
- Chainage of the river regulation structure – exact river kilometre of the structure, for groynes and barriers in river kilometres, and for revetment, parallel structures and imported fills, the range from river kilometre to river kilometre

- Length of the river regulation structure in meters (for groynes length parallel with the fairway).
- Crown or toe elevation of river regulation structure in meters above sea level (m a.s.l.)
- Mark and page number in the "Cadastral Register"
- Location of the structure on an orthophoto image
- Foto-documentation (geo-located)
- Analysis of the condition of the structure (functionality, state and additional notes)

The condition of structures was evaluated in four categories:

- Bad condition
- Satisfactory condition
- Good condition
- Excellent condition

Out of 167 structures in total, 20% (33) is in excellent condition, 42% (70) in good condition, 20% (34) in satisfactory condition and 18% (30) in bad condition.

Riverbed hydrographic surveying

Surveying was carried out with a single-beam echosounder on 1376 control profiles (profile equidistance is 100 meters, from shore to shore), as well as with a single-beam echosounder surveying of 8 control profiles on the Drava River (from 0+000 to 0+800, profile equidistance is 100 meters, from coast to coast). During surveying, an integrated measurement system was applied as a combination of GPS-RTK and echosounder.

The data are delivered as text data files in 3 projections: HTRS96/TM HVRS71), HDKS (GK) 6 zones (HVRSTRST) and in UTM 34 (N) (HVRSTRST).

After processing the data, aligning the profile according to the lines of the cross profiles, a 3D models of the riverbed were created one for each measurement.

Upon completion of data processing, a profile comparison was made between the first measurement performed in 2023 and the second measurement performed in 2024.

By comparing the cross-section profiles between the first and second measurement, most of the points differ within +/- 50cm*. In some areas, there are more significant differences 1m+. Such systematic changes were observed near Sotin (Figure 36), Vukovar (Figure 37), Dalj (Figure 38) and the confluence of the Drava and the Danube.

In the case of Sotin, it was established that at the time of the first measurement, a so-called "parallel building" was constructed, which had an impact on the bed of the Danube River, especially due to the sequence of high waters from July 2023 to May 2024.

The differences in the cross-sections near Vukovar are possible consequences of excavations within the riverbed that occurred in the period between two measurements. In the case of digging the riverbed, changes in the riverbed are not only caused by digging, but also by the subsequent action of the river depending on the water regime.

In the curve at the entrance to the direction near Dalj from the direction of Erdut/Bogojevo, there are also height differences in the cross-section profiles upon exiting the curve itself. This is possible due to extremely depth change in short length and in just after the curve of the Danube River.

On the other side, number of profiles show an exceptional overlapping of profiles, despite sudden changes in the depths on the specific cross-section of the riverbed.

Monitoring and analysis of flow, velocity and sediment transport

As a precursor to field activities, initial engineering analysis was undertaken. Analysis of hydrological and hydraulic substrates, traffic substrates, analysis of the navigable water levels of the Danube and the analysis on the condition of the existing fairway was carried out.

Hydrological analysis concluded that there is a decrease in water levels and flows present at all analysed water meter stations (period 2002-2021). Sharper decrease of water levels was attributed to linear riverbed erosion – estimate of 2.2 cm/ann. for upstream section (Batina) to 1.6 cm/ann. for downstream section (Ilok).

The assessment of the state of the existing VI.c fairway for 17 critical sections was based on separately conducted analyses for different predetermined criteria. The results are as follows:

Fairway depth	partially satisfies (10/17)
Fairway width	partially satisfies (10/17)
Fairway curve radius	generally satisfies (16/17)
Width and height of the free fairway profile under the bridges	partially satisfies (3/4)
Sections where the fairway located adjacent to the bank potentially threatens the stability of the bank and the safety of navigation (side erosion of the banks).	partially satisfies (11/17)

In the current conditions, disturbances due to insufficient fairway depth and/or width and the small radius of bends do not cause substantial delays in navigation on any critical sections because the sections in question are short and one-way navigation is possible, for which there is sufficient width at any time if the navigation is conducted in prescribed compositions. The critical sections should be continually monitored in relation to highlighted criteria to ensured timely identification of possible further degradation of navigation conditions.

Velocity and flow measurements were performed at three locations: Batina, Vukovar, Ilok, while measurements of suspended and bedload sediment transport were performed at location: locations: Batina, Drava confluence, Ilok to account for inflow of sediment from Drava river. For each location a minimum of 2 profiles were analysed (downstream, upstream).

Measurements were carried out in 3 characteristic cases: high, medium, low water level. To define them, a hydrological analysis was carried out to define unique values (intervals) for these scenarios:

- Low water level < 100 cm, measurement campaign carried out in May 2023
- Average water level from 100 cm to 400 cm, , measurement campaign carried out in June 2023
- Large water level > 400 cm, measurement campaign carried out in September 2023

After the recording of sediment data, laboratory processing and numerical data processing have been conducted. Overall analysis included:

- Presentation of measurements of velocities, flow and morphology by ACDP in a wider subject area,
- Presentation of the results of the hydraulic-morphological analysis of the bed stability,
- Presentation of hydraulic analysis results,
- Multidimensional current distribution,
- Layout view of velocity distribution,
- Presentation of the detailed transfer of sediment along the transverse profiles and the spatial distribution of the intensity of sediment movement.

Recorded flow ranged from 1,350 m3/s up to 5,450 m3/s, depending on the location and hydrological scenario. Integrated velocities ranged from 0.72-1.17 m/s, maximum (mainstream) velocity of up to 2 m/s.

Bedload sediment accounted for 5-7% of the overall sediment: 6-14 kg/s for bedload sediment, 42-200 kg/s for suspended sediment. Median size (diameter D50) of the sediment particle is 0.3 mm in upstream section (Batina) decreasing to 0.2 mm in downstream section (Ilok).

Piezometer installation

Preliminary locations for piezometers on the upper, middle and lower sections of the Danube were defined, as follows:

1. Batina (rkm 1425+250)
2. Aljmas (rkm 1380+000)
3. Ilok (rkm 1299+100)

Piezometers were installed within a radius of up to 100 meters from the Danube bank, depth of up to 15 meters. Piezometer wells were sealed with a PVC construction made of full pipes and a filter layer, gravel backfill and clay-bentonite buffer.

Piezometers have been equipped with data-loggers, continuously measuring underground water levels and temperature. The loggers have an internal memory for 72,000 measurements.

Measurement of water level and temperature parameters started on March 29, 2024. The loggers continue to measure continuously after project completion.

Biodiversity inventory

Fish inventory

The comprehensive fish inventory of the Danube River employed a robust and multi-method approach to research fish populations and habitat conditions across 17 critical sections of the Danube river. Three advanced research methods were utilized during the field research: electrofishing, electrified benthic trawl (electrified dredging), and winter monitoring of fish wintering grounds using sonar technology.

Fieldwork related to electrofishing was conducted between July and October 2023. Research was focusing on 43 daytime transects, each with a minimum length of 500 meters, spanning 17 critical sections of the Danube from Batina to Ilok. Additionally, five transects were completed on the Serbian side of the Danube. Nighttime electrofishing was carried out on 13 of these transects, representing 30% of the total transect coverage.

Fish sampling with an electrified bottom trawl was conducted in March 2024, covering the same 17 critical sections. The electrified dredge, connected to a 10 kW power unit, was pulled upstream by a boat. At the end of each transect, the dredge was lifted out of the water, and the captured fish were processed before being returned to their original location, with the exception of invasive species, which were not returned to river.

In February 2024, monitoring of fish wintering habitats was carried out using sonar. Research locations were selected based on a 3D model generated from hydrographic measurements of the riverbed, supplemented by local fishing data, scientific research, and historical records. The research revealed that the highest fish densities were found in wintering areas near Apatin, Staklar, Dalj, and Borovo.

Overall, the research documented 39 fish species, totaling 3,443 individuals, using electrofishing and electrified dredging methods. The most abundant family was carp, found consistently across all 17 critical sections. Detailed data collection during sampling included transect specific information, habitat characteristics (such as shore and bottom type, aquatic and riparian vegetation, depth, and flow velocity), as well as pressures, threats, and habitat conservation status. Catch data recorded included the Croatian and scientific names of species, the number of individuals, age structure, species frequency in the sample, and age categories. This meticulous approach provided a comprehensive overview of the current state of fish populations in the Danube, contributing valuable insights into the health and diversity of the river's aquatic ecosystems.

Habitat inventory

The habitat inventory and the creation of the habitat map (scale 1:5000) covered the entire project area (17 critical sections along the joint Croatian-Serbian section of the Danube River with a buffer area covering the part of the natural floodplain, totalling almost 168.7 km2).

All available data on the project area were collected and a preliminary habitat map of the project area was created. On this basis, an intensive field sampling (mapping) of the habitats was carried out (383 sampling points in total), which included a survey of the distribution and condition assessment of Natura 2000 habitat types in the floodplain and along the Danube that are water-dependent and sensitive to changes in the water level and natural hydromorphological dynamics of the river (Natura 2000 habitats: 3130, 3150, 3270, 6440, 91E0*).

The final habitat map shows all existing natural terrestrial and freshwater habitat types (forests and shrubs, grassland habitats, macrophytes and aquatic habitats) mapped in accordance with the national habitat classification of the Republic of Croatia and the Natura 2000 habitat classification. During field sampling, flora data were collected at each sampling site, including macrophytes and invasive alien plant species. The field sampling methodology was in line with the national monitoring of Natura 2000 habitat types. It was carried out using methods based on determination and assessment of indicator species for each habitat type and indicator parameters that reflect the state of the habitat (structure and functions).

Habitat map of Natura 2000 habitats of the project area and collected monitoring data are presented in the "Catalogue of biodiversity components of the joint Croatian-Serbian sector of the Danube River", and in the

form of a spatial layer within an interactive map of the project area (as part of the established geo-information system (GIS)).

Bird inventory

The bird inventory was carried out in the project area during the 18 months of project implementation at 17 critical sections along joint Croatian-Serbian sector of the Danube River. Surveys were conducted throughout the year to cover all seasons of the birds' life cycle (wintering, spring and autumn migration and nesting).

During monthly field trips on the Danube River, bird research was carried out from bank to bank to determine the bird fauna related to the river itself, its banks, sand bars and islands, as well as important parts of the river that serve as feeding and resting places for birds during migration and wintering. During the nesting period, sandbank nesters, steep bank nesters, raptors and wading birds were especially monitored. Sand bar and sand island breeding (nesting) species as well as riverbank nesting species were surveyed within the entire length of the Croatian-Serbian sector of the river and their abundance was recorded. Inventory was carried out twice during the season (from May to June), twice during project implementation. Marshes, oxbows and side channels within the Danube floodplain were covered in order to survey the breeding water bird fauna (including wetland related songbirds). Inventory was carried out once during the season (from May to July), twice during project implementation. Marshes, oxbows and side channels were explored either from the bank or from the boat using the linear transect method. Habitats and the pressures and threats to the species that nest in marshes were recorded. During monthly field trips on the Danube River, bird research was carried out from bank to bank to determine the bird fauna during spring and autumn migration as well as wintering.

During field survey species composition and their abundance were recorded. The goal was also to determine and map significant sites and important parts of the river that serve as feeding and resting places for birds during these periods. Special importance was given to NATURA 2000 and endangered species. Established standard species monitoring protocols were followed in detail.

Monitoring data collected are presented in the "Catalogue of biodiversity components of the joint Croatian-Serbian sector of the Danube River", and in the form of a spatial layer within an interactive map of the project area (as part of the established geo-information system (GIS)).

River benthos type inventory

Sampling of macroinvertebrates and their habitats was carried out in 17 critical sections of the joint Croatian-Serbian section of the Danube. Sampling was carried out in accordance with the Croatian national methodology for sampling and monitoring of benthic macroinvertebrates as BQE for the assessment of the ecological status of rivers and streams (in accordance with the requirements of the Water Framework Directive (WFD)). Prior to the research, data was collected from earlier research on the macroinvertebrate communities of the project area.

The sampling of macrozoobenthos was carried out in such a way that all available microhabitats ("multi-habitat sampling") were sampled at a specific sampling site. The analysis of the samples included the isolation of animals from the samples and the determination of taxa (almost 17,500 individuals were separated and determined). Invasive alien species were determined.

Indices and modules for the assessment of ecological status based on macrozoobenthos as BQE were calculated according to the proposed methodology and the assessment of ecological status was carried out. The assessment follows the requirements of the WFD and considers macroinvertebrates as biological indicators, their species characteristics and autecological information to identify responses to saprobic and overall degradation of the sampling site. The ecological quality ratio (EQR) is calculated separately for the saprobity module, and separately for the overall degradation module, while the overall evaluation of the ecological state based on the BQE of macrozoobenthos is the worse EQR value of these two modules. Categories of ecological status and limit values for categories of ecological status, expressed as EQR, are determined on the basis of the Croatian national regulation covering water quality standards.

The data and results of the research are presented in the "Catalogue of biodiversity components of the joint Croatian-Serbian sector of the Danube River" and in the form of a final spatial layer within an interactive map of the project area (as part of the established geo-information system (GIS)).

Geoinformation System (GIS) Establishment

Establishment of a geo-information system (GIS) through the following main activities: (i) server setup and configuration (setting up the required infrastructure for the GIS system at the MMPI's site), (ii) WebGIS implementation (this includes user requirements analysis, WebGIS application development and database integration) and (iii) data collection and systematisation (collection and organisation of relevant waterway maintenance parameters and biodiversity monitoring data, followed by uploading all data to the WebGIS application and GIS database).

As the result of the geoinformation system establishment, the WebGIS application and database were developed. The WebGIS application includes all delivered data relevant to the overview of the subject area:

- Collected and processed data on parameters relevant to the maintenance of the waterway: regulatory structures, hydrographic measurements, recorded speeds and flows and measured transport of suspended and towed sediment, locations of piezometers
- Collected and processed inventory data of biodiversity components: data on fish, habitats, birds and river benthos communities.

For easier use and further application updating, the Contractor developed the following accompanying documentation (available only in Croatian): “User manual”, “User instructions for the system administrator”, “Instructions for system management and control” and “User training documentation”.

Furthermore, together with the mentioned WebGIS application, a database was also created, which, in addition to the application data, includes field data, photographs, tabular representations, all documentation prepared as part of this project, as well as previous studies and documentation made available by the Croatian Ministry of the Sea, Transport and Infrastructure.

Detailed data and all results from the project activities carried out are available in various formats at request at Croatian Ministry of the Sea, Transport and Infrastructure.

The activities related to GIS are planned to continue after the conclusion of other contractual obligations. This activities relate to the maintenance of the system and will be carried out according to the needs and requirements of the Croatian Ministry of the Sea, Transport and Infrastructure.

8. ANNEX 1: Map of the project area with marked 17 critical sections

(full image is given as a separate annex)

9. ANNEX 2: Locations of fish wintering habitats

1. LOCATION: Z_001

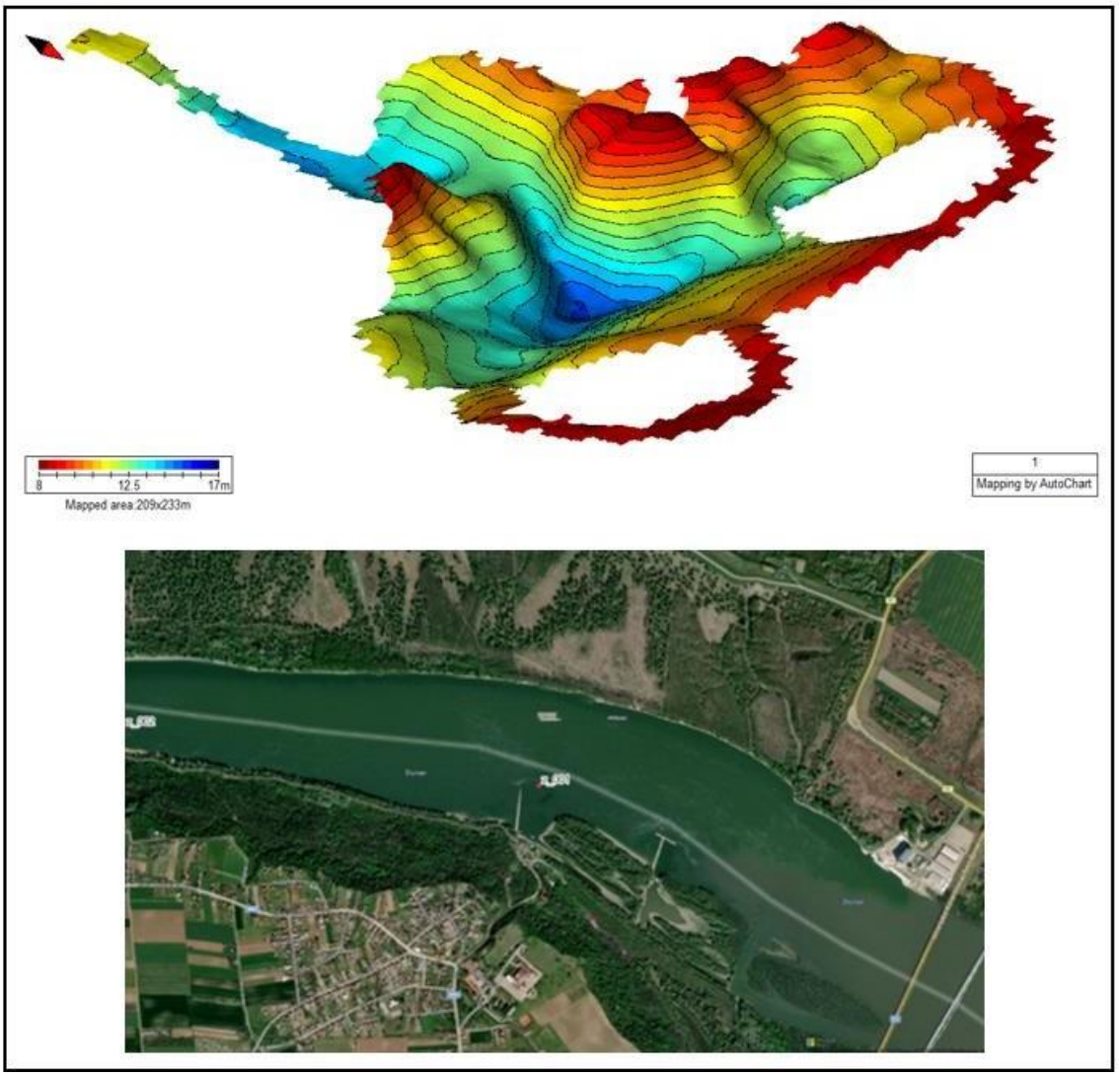


Figure 1. Map and 3D view of the site z_001

Table 2. Information about the site z_001

SITE:	z_001
LOCATION:	Erdut, a kilometre upstream from Velika Ada
LOCATION DESCRIPTION:	Right side of the riverbed
RECORDING DATE:	19.02.2024.
COORDINATES: X-	19.066344
Y-	45.530588
DEPTH RANGE (m):	4,2-15,4
NUMBER OF INDIVIDUALS:	15-20
DESCRIPTION OF THE SITE:	The recorded fish were not inside the wintering ground
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Fish recorded in the marginal area, but probably not a wintering ground

2. LOCATION: Z_002

Figure 2. Display of the position of the site z_002

Table 2. Information about the site z_002

SITE:	z_002
LOCATION:	Erdut, 800m downstream from Bakulja
LOCATION DESCRIPTION:	right side of the riverbed, the operation downstream of the meander and the backwater
RECORDING DATE:	19.02.2024.
COORDINATES: X- Y-	19.046477 45.532531
DEPTH RANGE (m):	8,8-18,8
NUMBER OF INDIVIDUALS:	4-8
DESCRIPTION OF THE SITE:	promising area, good depth range and morphology, recorded individuals outside the hollow
ASSESSMENT OF THE STATUS OF THE SITE:	Fish recorded in the marginal area, but probably not a wintering ground

3. LOCATION: Z_003

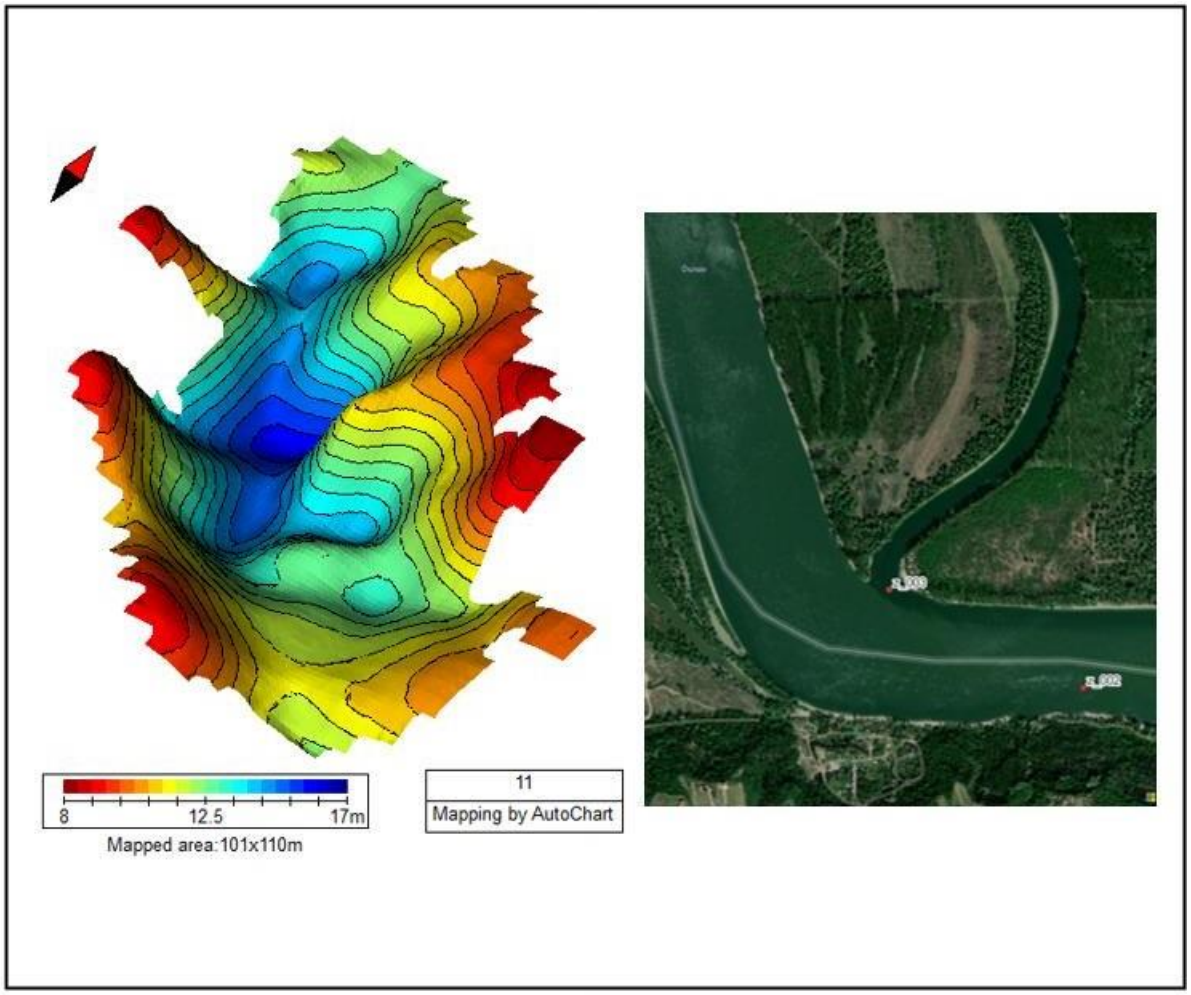


Figure 3. Map and 3D view of the site z_003

Table 3. Information about the site z_003

SITE:	z_003
LOCATION:	Erdut, next to Bakulja
LOCATION DESCRIPTION:	Connection of the sleeve and the main stream
RECORDING DATE:	19.02.2024.
COORDINATES: X- Y-	19.038550 45.535357
DEPTH RANGE (m):	4,8-16,5
NUMBER OF INDIVIDUALS:	10-20
DESCRIPTION OF THE SITE:	area recorded 2 times, distinguishing fish and branches difficult
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Active wintering ground

4. LOCATION: Z_004

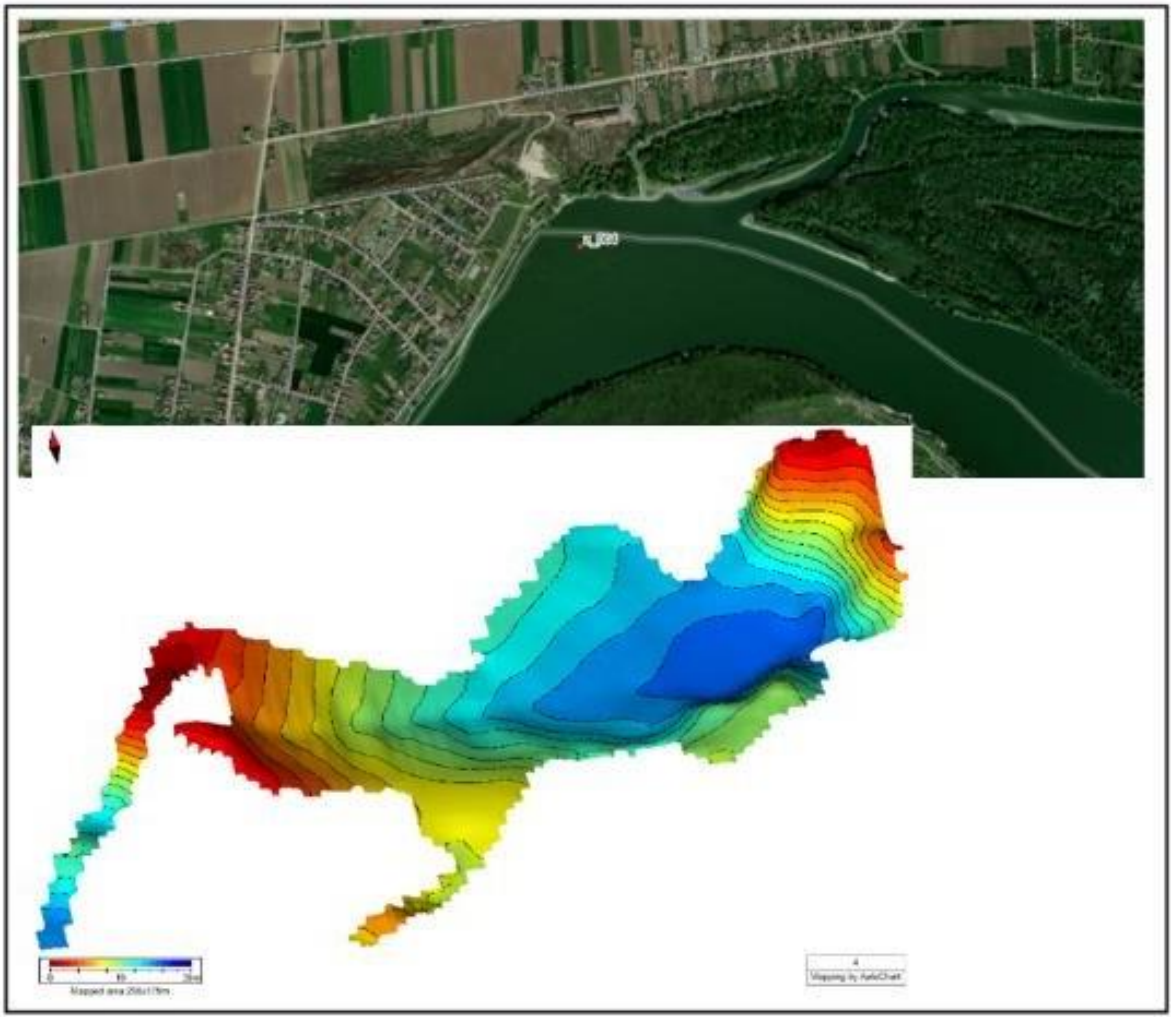


Figure 4. Map and 3D view of the site z_004

Table 4. Information about the site z_004

SITE:	z_004
LOCATION:	Dalj, half a kilometre downstream from the Island of Tanja
LOCATION DESCRIPTION:	right side of the riverbed, on a meander, downstream of the river island
RECORDING DATE:	20.02.2024.
COORDINATES: X-	19.003317
Y-	45.497380
DEPTH RANGE (m):	7,3-25,7
NUMBER OF INDIVIDUALS:	/
DESCRIPTION OF THE SITE:	A representative example of a wintering ground, the area is not well recorded
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Active wintering ground

5. LOCATION: Z_005

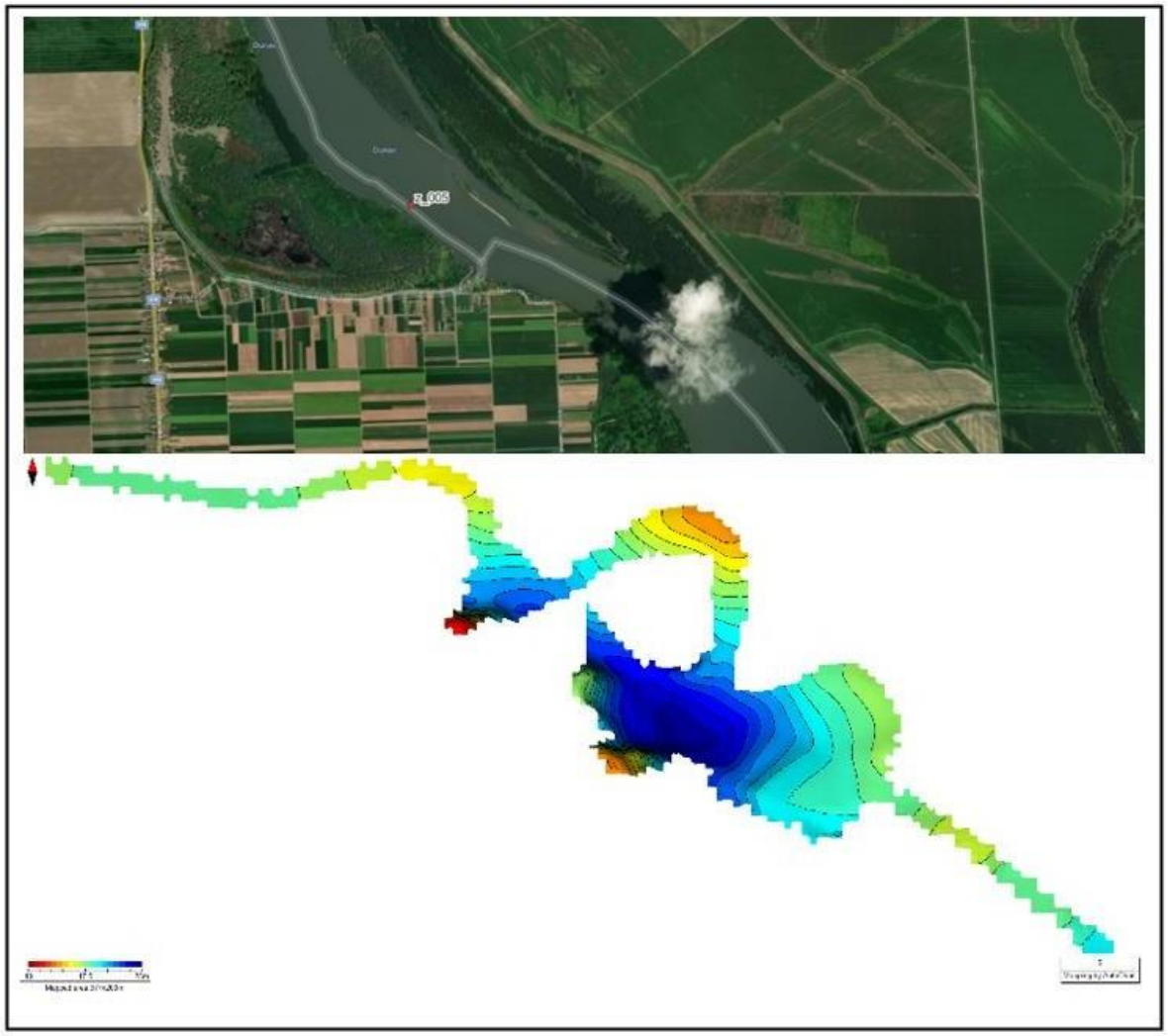


Figure 5. Map and 3D view of the site z_005

Table 5. Information about the site z_005

SITE:	z_005
LOCATION:	Savulja
LOCATION DESCRIPTION:	right side of the stream, upstream of the river island
RECORDING DATE:	20.02.2024.
COORDINATES: X-	18.998233
Y-	45.436304
DEPTH RANGE (m):	1,4-25
NUMBER OF INDIVIDUALS:	5-10
DESCRIPTION OF THE SITE:	promising depth and morphology, individuals outside the wintering grounds
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Fish recorded in the marginal area, but probably not a wintering ground

6. LOCATION: Z_006

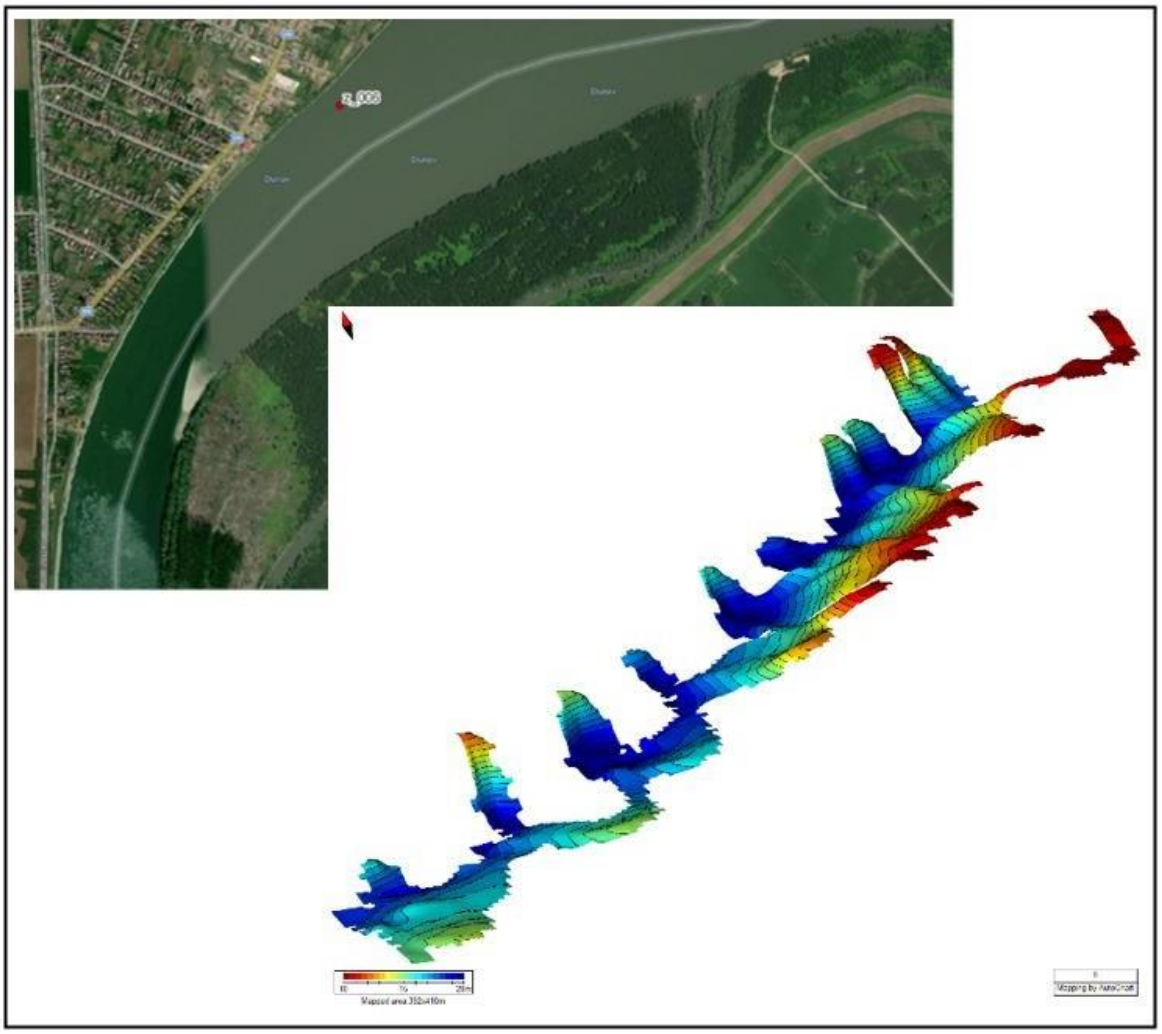


Figure 6. Map and 3D view of the site z_006

Table 6. Information about the site z_006

SITE:	z_006
LOCATION:	Borovo
LOCATION DESCRIPTION:	On the right side of the stream, a long furrow on the meander
RECORDING DATE:	20.02.2024.
COORDINATES: X-	18.978465
Y-	45.397630
DEPTH RANGE (m):	8,1-20,5
NUMBER OF INDIVIDUALS:	20-30
DESCRIPTION OF THE SITE:	The area is not fully recorded
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Active wintering ground

7. LOCATION: Z_007

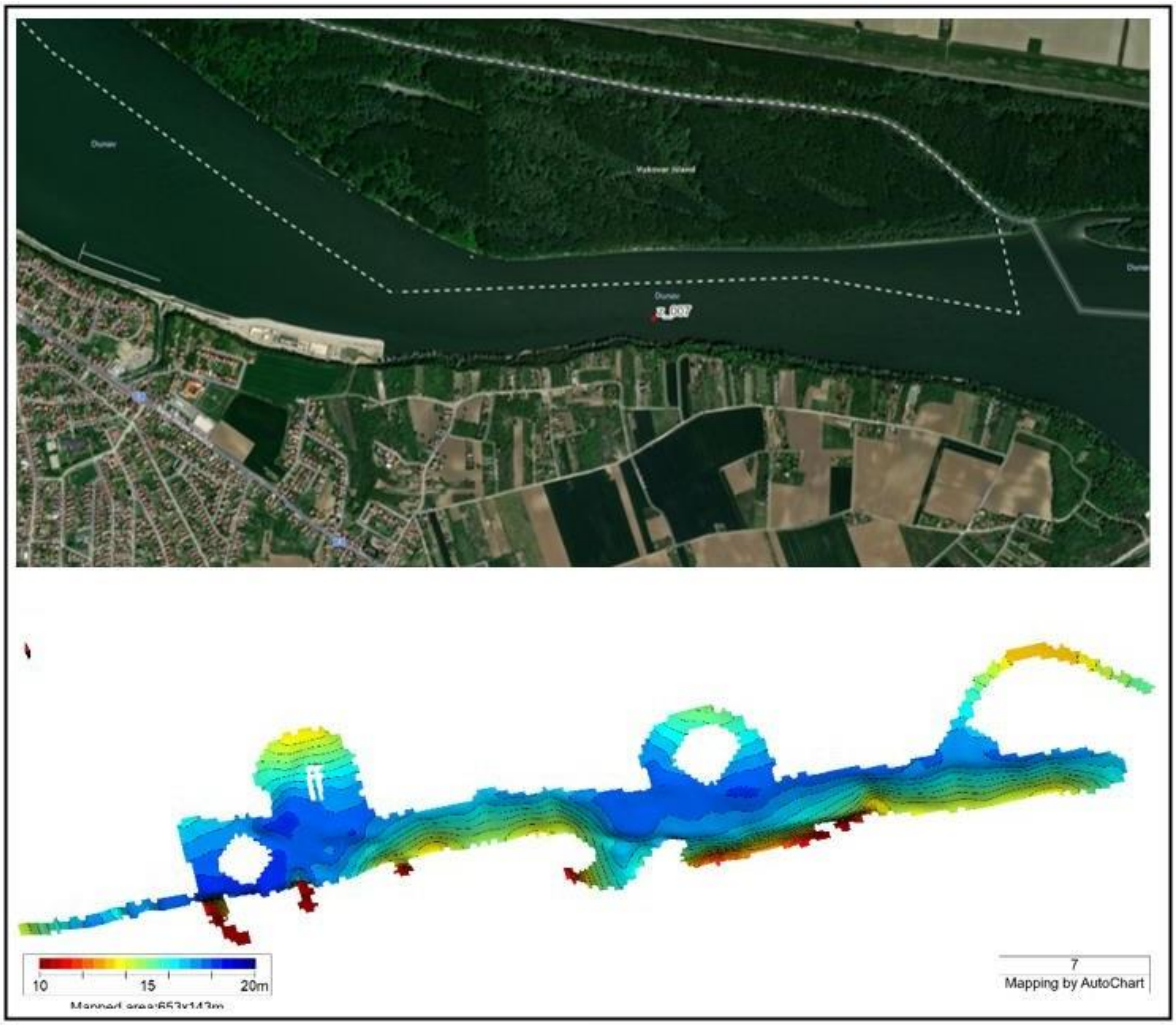


Figure 7. Map and 3D view of the site z_007

Table 7. Information about the site z_007

SITE:	z_007
LOCATION:	Vukovar, 2 kilometres upstream from Orlovnjak
LOCATION DESCRIPTION:	the right side of the stream
RECORDING DATE:	20.02.2024.
COORDINATES: X-	19.038740
Y-	45.342919
DEPTH RANGE (m):	3,3-19
NUMBER OF INDIVIDUALS:	10-20
DESCRIPTION OF THE SITE:	promising depth, individuals outside the wintering ground
ASSESSMENT OF THE STATUS OF THE SITE:	Fish recorded in the marginal area, but probably not a wintering ground

8. LOCATION: Z_008

Figure 8. Display of the position of the site z_008

Table 8. Information about the site z_008

SITE:	z_008
LOCATION:	Sotin, Plandiste
LOCATION DESCRIPTION:	the right side of the stream
RECORDING DATE:	20.02.2024.
COORDINATES: X-	19.1157473
Y-	45.2912929
DEPTH RANGE (m):	/
NUMBER OF INDIVIDUALS:	/
DESCRIPTION OF THE SITE:	The area is not well recorded
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Probably not a wintering ground

9. LOCATION: Z_009

Figure 9. Display of the position of the site z_009

Table 9. Information about the site z_009

SITE:	z_009
LOCATION:	Ilok, side bank
LOCATION DESCRIPTION:	The middle of the stream
RECORDING DATE:	20.02.2024.
COORDINATES: X-	19.371213
Y-	45.232174
DEPTH RANGE (m):	3,5-12,4
NUMBER OF INDIVIDUALS:	0
DESCRIPTION OF THE SITE:	lack of depth, the morphology of the riverbed does not show parts that would be suitable for a wintering ground, not recorded in detail.
ASSESSMENT OF THE STATUS OF THE SITE:	Probably not a wintering ground

10. LOCATION: Z_010

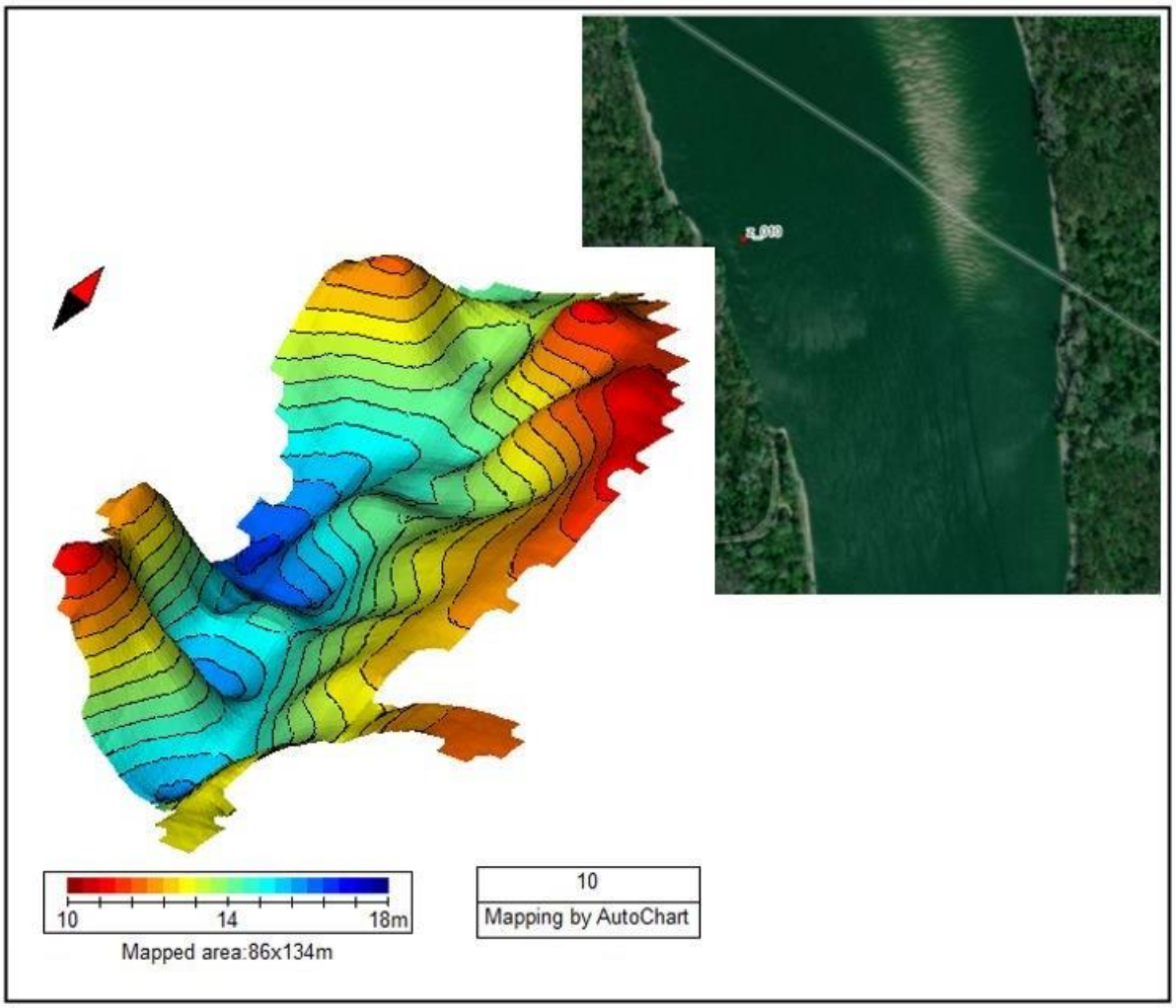


Figure 10. Map and 3D view of the site z_010

Table 10. Information about the site z_010

SITE:	z_010
LOCATION:	Kopački rit Nature Park, Donja Siga
LOCATION DESCRIPTION:	the right side of the stream
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.893909
Y-	45.748740
DEPTH RANGE (m):	9,6-17,8
NUMBER OF INDIVIDUALS:	0
DESCRIPTION OF THE SITE:	promising area, branching determined by processing the recording
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Potentially a wintering ground

11. LOCATION: Z_011

Figure 11. Display of the position of the site z_011

Table 11. Information about the site z_011

SITE:	z_011
LOCATION:	Kopački rit Nature Park, 1.5 km upstream from Apatin
LOCATION DESCRIPTION:	On the right side of the river, next to the river bank
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.94786
Y-	45.67900
DEPTH RANGE (m):	7,3-9,6
NUMBER OF INDIVIDUALS:	0
DESCRIPTION OF THE SITE:	the location does not meet any of the parameters required for the creation of the wintering ground, the AC file is not recorded
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Probably not a wintering ground

12. LOCATION: U_012

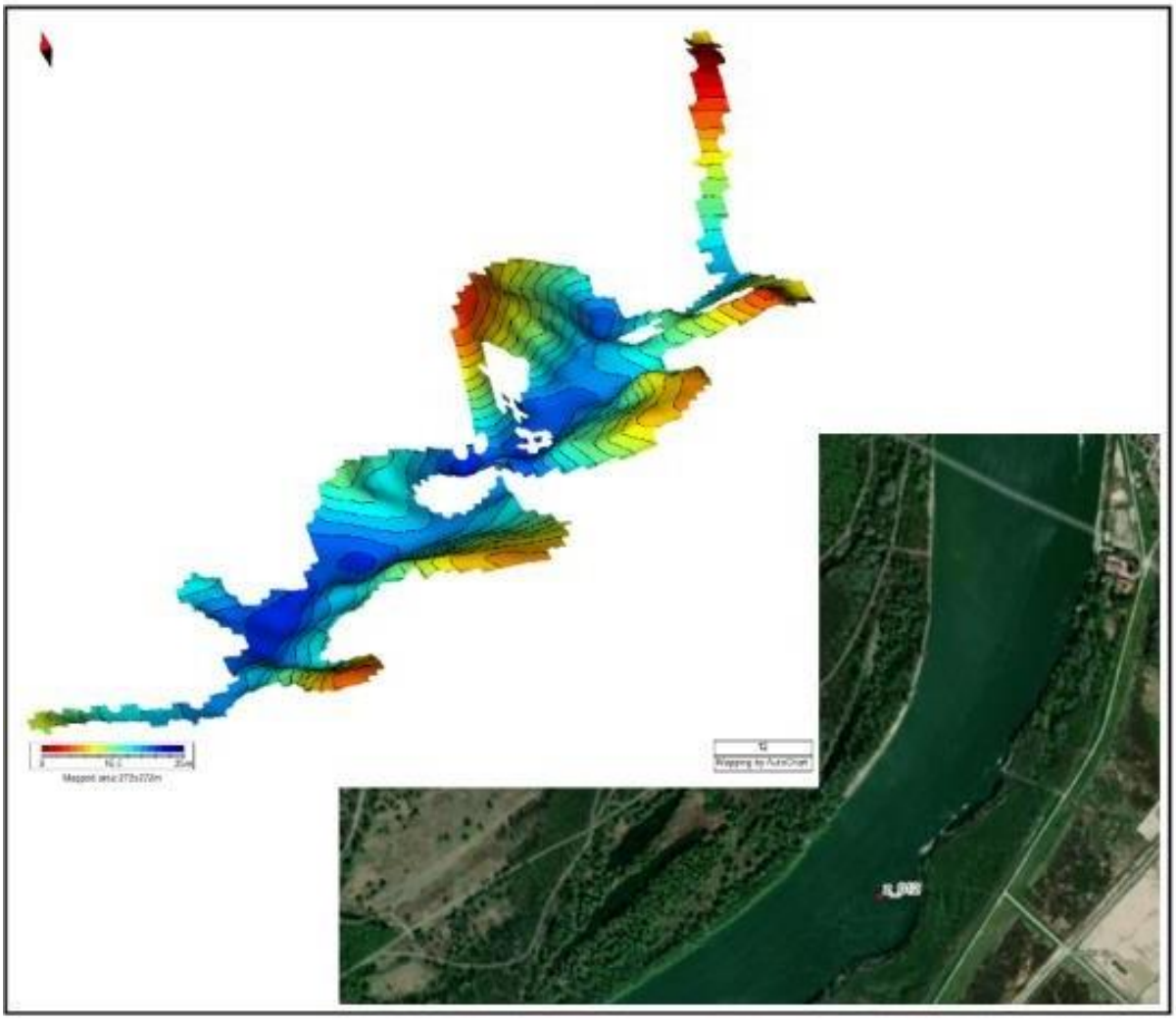


Figure 12. Map and 3D view of the site z_012

Table 12. Information about the site z_012

SITE:	z_012
LOCATION:	Kopački rit Nature Park, peninsula near Apatin
LOCATION DESCRIPTION:	left side of the stream, a slight depression in the bank
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.961099
Y-	45.656361
DEPTH RANGE (m):	7,4-23,2
NUMBER OF INDIVIDUALS:	30-60
DESCRIPTION OF THE SITE:	good depth range, a larger number of individuals recorded
ASSESSMENT OF THE STATUS OF THE SITE:	Active wintering ground

13. LOCATION: Z_013

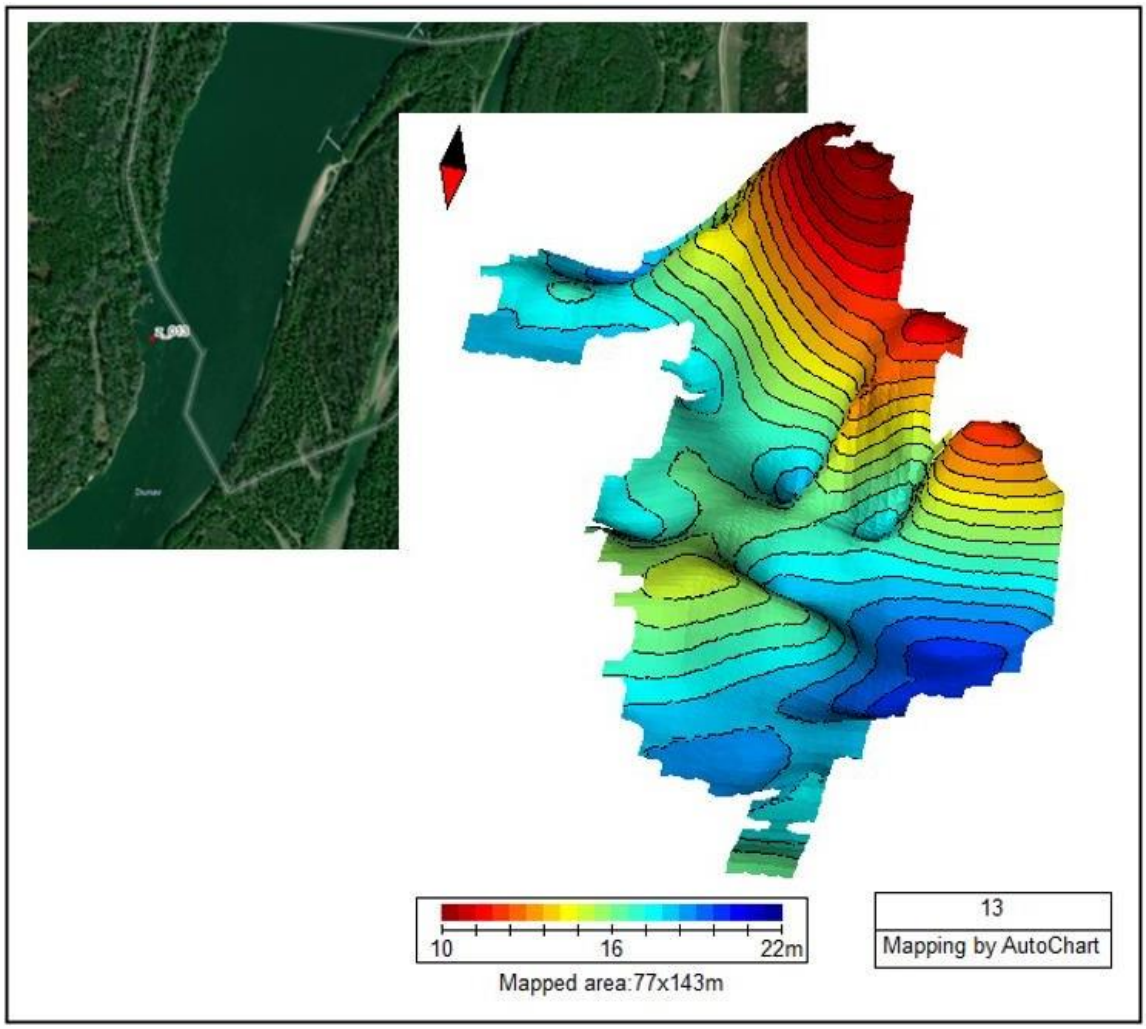


Figure 13. Map and 3D view of the site z_013

Table 13. Information about the location z_013

SITE:	z_013
LOCATION:	Kopački rit Nature Park, downstream of Čifutski Dunavac
LOCATION DESCRIPTION:	Right side of the flow in the area where the sleeve joins the main stream
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.966626
Y-	45.635312
DEPTH RANGE (m):	3,5-22,2
NUMBER OF INDIVIDUALS:	5-15
DESCRIPTION OF THE SITE:	Very promising parameters for habitat
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Active wintering ground

14. LOCATION: Z_014

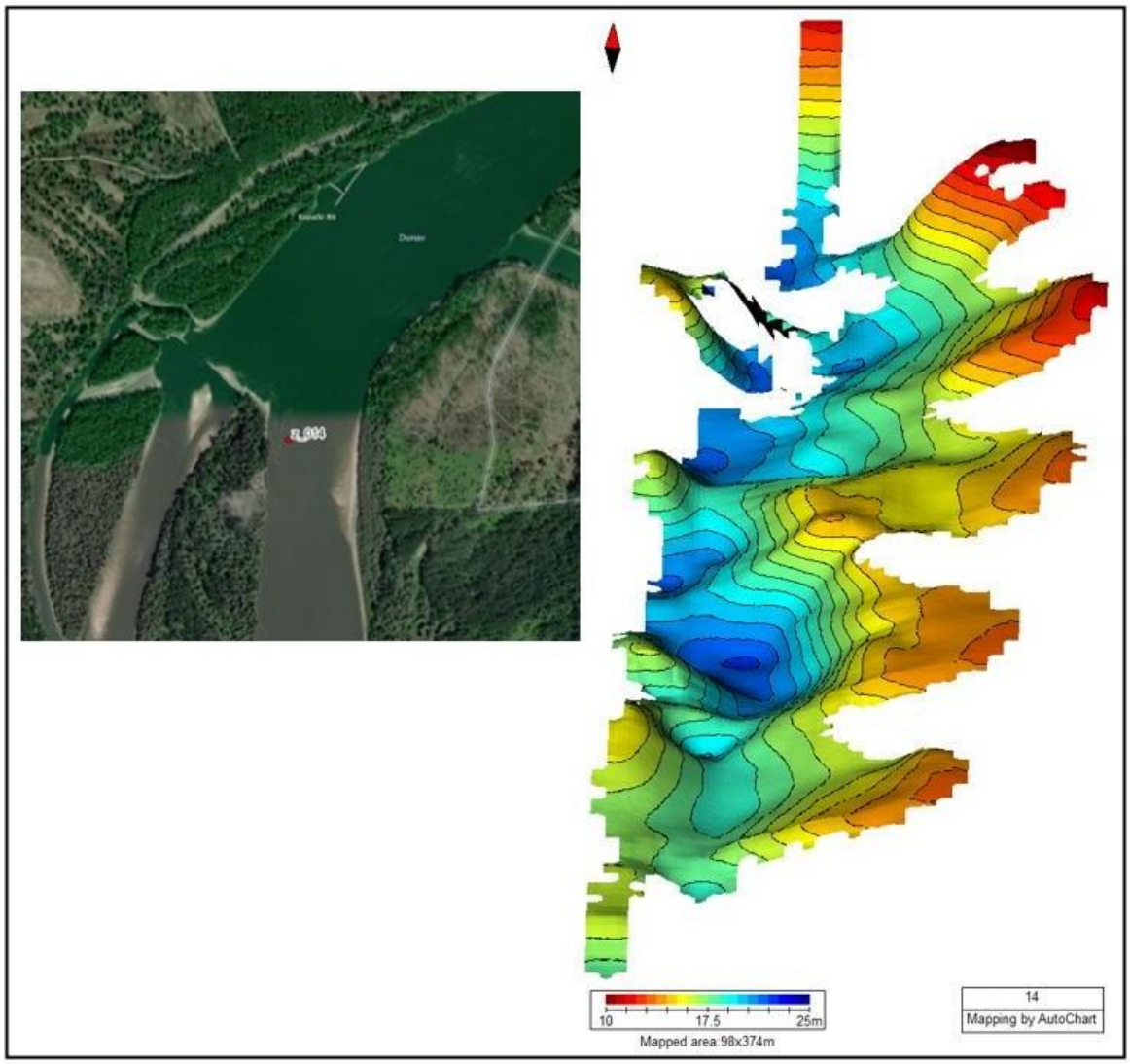


Figure 14. Map and 3D view of the site z_014

Table 14. Information about the site z_014

SITE:	z_014
LOCATION:	Kopački rit Nature Park, Mišval
LOCATION DESCRIPTION:	left side of the stream, lateral to the island
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.905159
Y-	45.616596
DEPTH RANGE (m):	6,3-27,1
NUMBER OF INDIVIDUALS:	2-3
DESCRIBE THE SITE:	very promising parameters for habitat formation
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Fish recorded in the marginal area, but probably not a wintering ground

15. LOCATION: Z_015

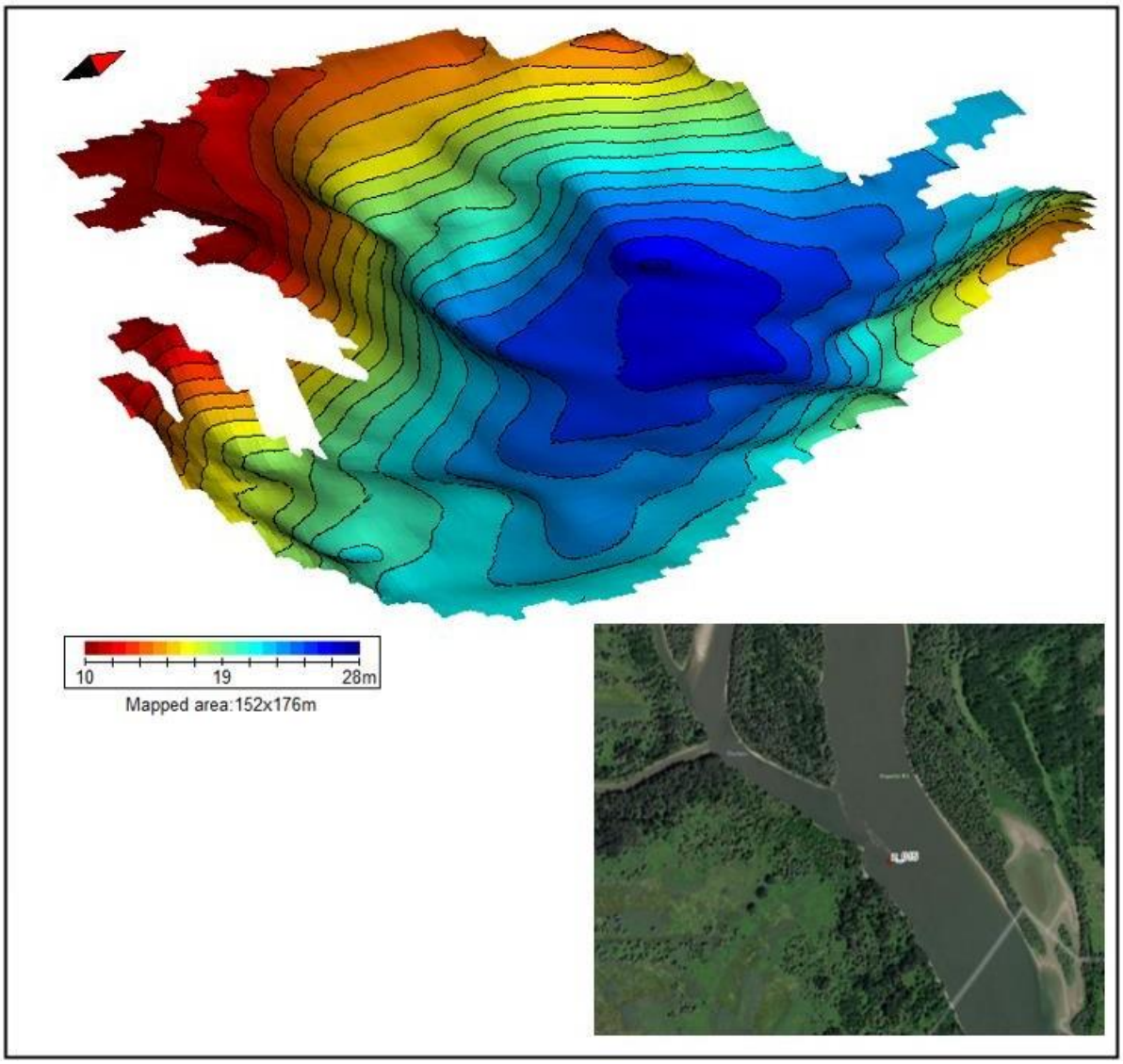


Figure 15. Map and 3D view of the site z_015

Table 15. Information about the site z_015

SITE:	z_015
LOCATION:	Kopački rit Nature Park, downstream from Mišval
LOCATION DESCRIPTION:	right side of the stream, downstream of the island and the oxbow
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.907170
Y-	45.603369
DEPTH RANGE (m):	6,5-26,2
NUMBER OF INDIVIDUALS:	15-30
DESCRIPTION OF THE SITE:	An excellent example of a wintering ground
ASSESSMENT OF THE STATUS OF THE SITE:	Active wintering ground

16. LOCATION: Z_016

Figure 16. Display of the position of the site z_016

Table 16. Information about the site z_016

SITE:	z_016
LOCATION:	Kopački rit Nature Park, Renovo
LOCATION DESCRIPTION:	Right side of the flow on the meander
RECORDING DATE:	21.02.2024
COORDINATES: X-	18.88810
Y-	45.56441
DEPTH RANGE (m):	6,1-17,6
NUMBER OF INDIVIDUALS:	2
DESCRIPTION OF THE SITE:	The site is not recorded in detail, lack of individuals
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Fish recorded in marginal areas, but probably not wintering

17. LOCATION: Z_017

Figure 17. Display of the position of the site z_017

Table 17. Information about the site z_017

SITE:	z_017
LOCATION:	Kopački Rit Nature Park, the confluence of the Drava and Danube rivers
LOCATION DESCRIPTION:	On the left side of the river, the confluence
RECORDING DATE:	21.02.2024.
COORDINATES: X-	18.92836
Y-	45.54661
DEPTH RANGE (m):	3,9-21,2
NUMBER OF INDIVIDUALS:	5-7
DESCRIPTION OF THE SITE:	Unsatisfactory parameters.
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Probably not a wintering ground

18. LOCATION: Z_018

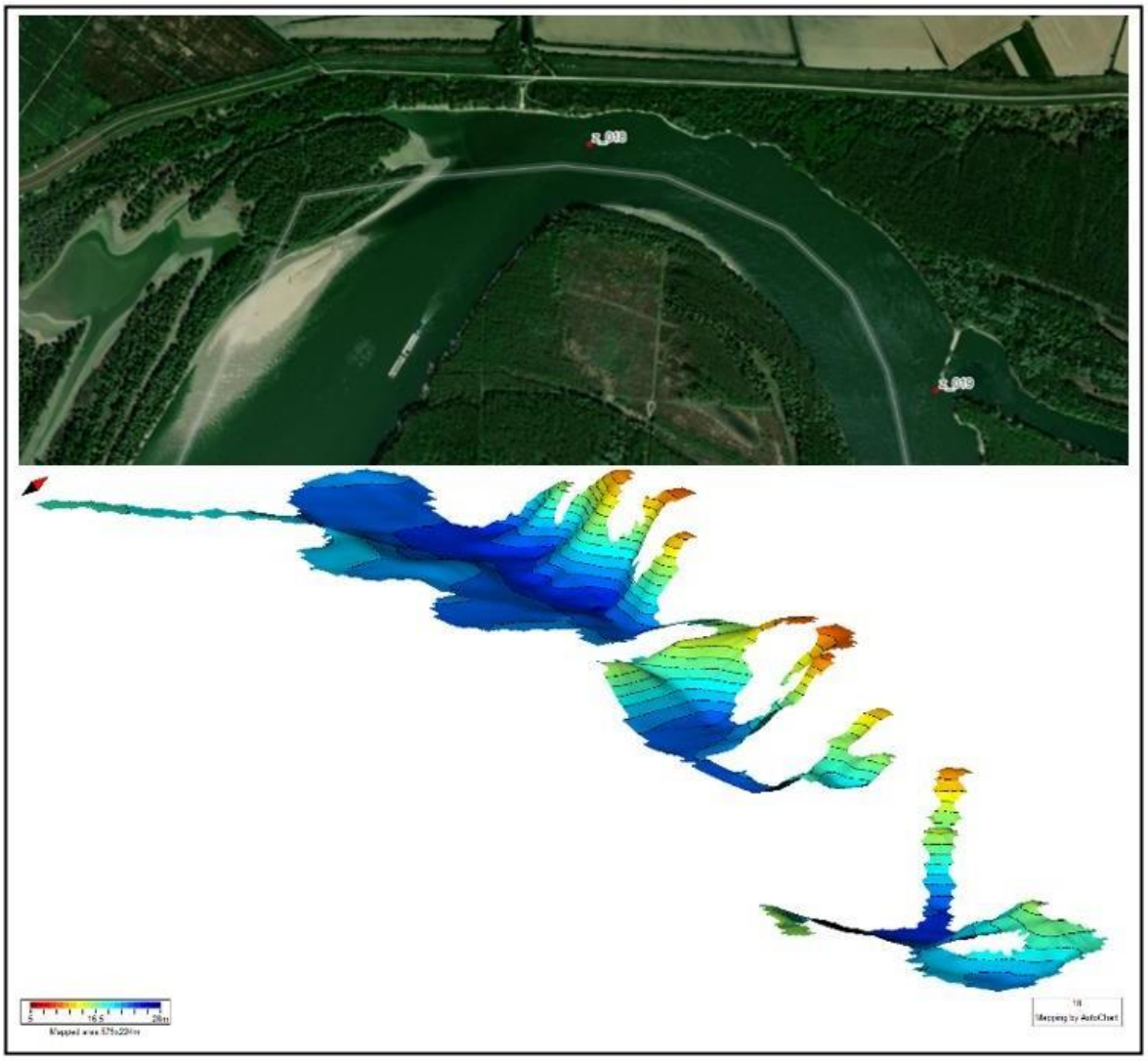


Figure 18. Map and 3D view of the site z_018

Table 18. Information about the site z_018

SITE:	z_018
LOCATION:	Downstream of Aljmaš, Porić
LOCATION DESCRIPTION:	On the left side of the river, the meander
RECORDING DATE:	21.02.2024
COORDINATES: X- Y-	19.015225 45.558316
DEPTH RANGE (m):	7,5-24,8
NUMBER OF INDIVIDUALS:	50-80
DESCRIPTION OF THE SITE:	appropriate depth and location, the largest recorded number of individuals
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Active wintering ground

19. LOCATION: Z_019

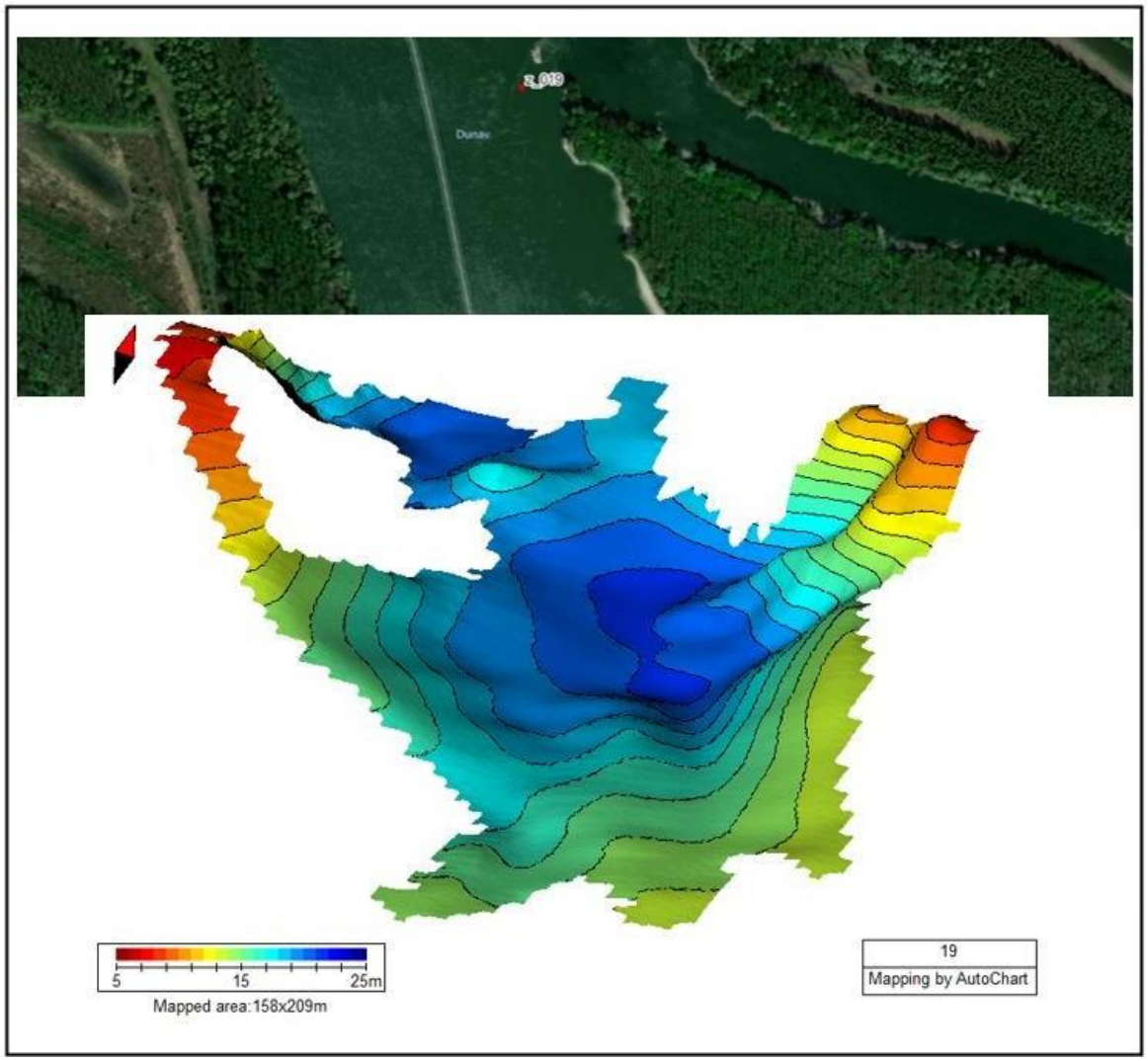


Figure 19. Map and 3D view of the site z_019

Table 19. Information about the site z_019

SITE:	z_019
LOCATION:	Upstream from Bakulja, near Erdut
LOCATION DESCRIPTION:	On the left side of the stream, at the fork
RECORDING DATE:	21.02.2024.
COORDINATES: X-	19.028493
Y-	45.551732
DEPTH RANGE (m):	/
NUMBER OF INDIVIDUALS:	/
DESCRIPTION OF THE SITE:	The track file is missing.
ASSESSMENT OF THE STATUS OF WINTERING GROUNDS:	Inadequately filmed