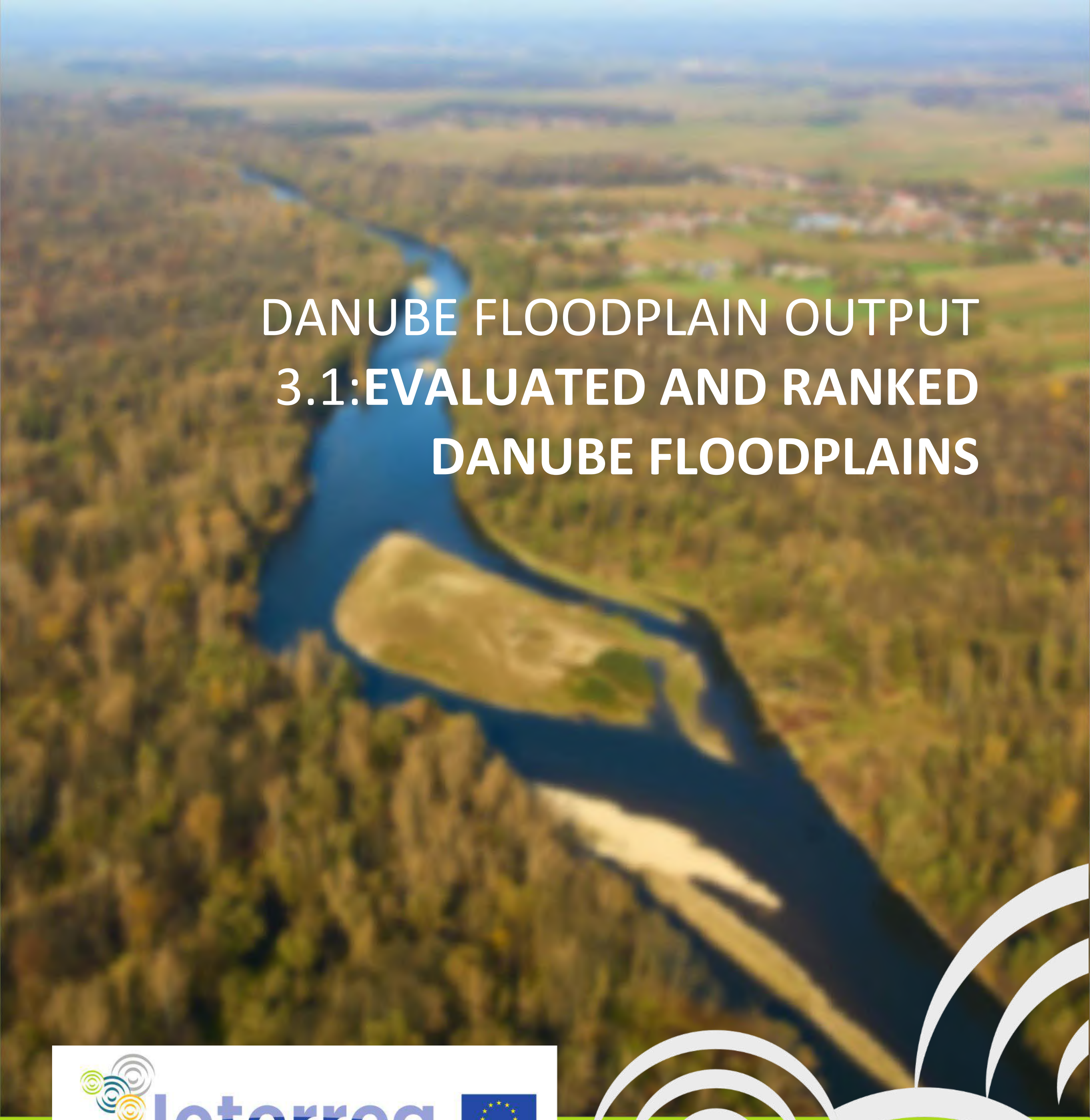

DANUBE FLOODPLAIN OUTPUT 3.1: **EVALUATED AND RANKED DANUBE FLOODPLAINS**

Interreg
EUROPEAN UNION
Danube Transnational Programme
Danube Floodplain

Project co-funded by European Union funds (ERDF, IPA)

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I. Activity 3.1: Mapping based on GIS and evaluation of floodplains along the Danube River

Introduction

Among all natural disasters, floods have the greatest damage potential worldwide (UNISDR 2015).In recent years, awareness was raised, leading to the development of new approaches in integrated flood risk management as demanded by the EU Floods Directive (2007/60/EC) by integrating non-structural and structural measures for flood protection. Such new methods of flood mitigation should especially focus on preserving and/or restoring floodplains (Habersack, Schober & Hauer 2015). Therefore, WP3 of the Danube Floodplain project has the purpose to review and update active and potential floodplain areas including data collection and analyses ofthese data using GIS. The aim is to provide a spatial reference framework with accompanied database based on comprehensive inventory of floodplain areas and their multicriteria analysis along the Danube River and selected tributaries. The resulting actual and potential floodplain areas inventory will provide the main spatial reference base (geodatabase), where other hydrological, hydraulic, ecological and socio-economic parameters will be analysed (Activity 3.1).

In the first step for this approach, active and potential floodplains were identified. The floodplains will be displayed in the Danube GIS and the Danube Floodplain GIS (DFGIS). Active floodplains were originally defined as all areas which are still flooded during an HQ_{100} but have beenextensively edited and potential floodplains are areas which are currently not flooded, but have the theoretical potential to be reconnected to the river system again. The definition of the activeand potential floodplains was a joint effort of all partners in the framework of Activity 3.2.

In the next step, both floodplain types were evaluated with the Floodplain Evaluation Matrix (FEM), which is a holistic, integrative tool for the assessment of hydrological, hydraulic, ecologicaland socio-economic effects of a floodplain (Activity 3.2).

In the last step, based on the FEM parameters, all active and potential floodplains along the Danube and selected tributaries were ranked to identify priority areas for preservation and/or restoration (“restoration demand”). The results of the ranking are stored in a spatial database, the DFGIS and are published on a public web map and in the Danube GIS. A summary of the ratingsand restoration demand is published as the Danube Floodplain inventory (DFInv) (Activity 3.1).

Activity 3.1 is responsible for the following deliverables:

D 3.1.1. List of jointly accepted data sources and criteria to build up DFGIS and DFInv

D 3.1.2. Geodatabase and Danube Floodplain GIS for active and potentially restorable floodplains

D 3.1.3. Danube Floodplain inventory for active and potentially restorable floodplains

Deliverable D 3.1.1. List of jointly accepted data sources and criteria to build up DFGIS and DFInv

For the geodatabase, each FEM parameter is defined with a fieldname, data type and unit. Table 1 provides the structure used to store the parameters in attribute tables of shape files of the active and potential floodplains of the Danube and selected tributaries. A detailed description of each parameter is given in "Report on data included within database" (D 3.2.2). The attribute table of eachfloodplain polygon is filled with the results of the FEM calculations and evaluations and the shapefilesare uploaded in the DFGIS.

Table 1: Parameter structure for geodatabase of active and potential floodplains (blue colouring indicates minimum, green colouring medium, yellow colouring extended FEM-parameters)

Name of field	data type/length	Full name of the parameter	Unit
DFGIS_ID	text/50	ID of the floodplains	
FP_Type	text/50	Floodplain type	
Location	text/50	Location of the Floodplain	
Transbound	text/10	Does the Floodplain cross country boundary	Yes/no
HQ100	numeric, integer	HQ100	m^3/s
Km_from	numeric, double	Starting river kilometer	km
Km_to	numeric, double	End river kilometer	km
PDF	text/254	Link to the DFInv PDF file	
SHP	text/254	Link to the zip file with the shape files	
Area	numeric, double	Area (ha)	ha
FPlength	numeric, double	Length of the floodplain	km
Chan_width	numeric, integer	Width of the channel	m
R_delta_Q	numeric, integer	FEM Rating of peak reduction ΔQ	1, 3 or 5
R_delta_t	numeric, integer	FEM Rating of flood wave translation Δt	1, 3 or 5
R_delta_h	numeric, integer	FEM Rating of water level change Δh	1, 3 or 5
R_C_fp_wb	numeric, integer	FEM Rating of Connectivity	1, 3 or 5
R_Prot_spp	numeric, integer	FEM Rating of Existence of protected species	1, 3 or 5
R_Building	numeric, integer	FEM Rating of potentially affected buildings	1, 3 or 5
R_Land_use	numeric, integer	FEM of Rating of Land use	1, 3 or 5
R_Hyd_eff	numeric, integer	FEM Rating of effects in case of extreme discharge	1, 3 or 5
R_delta_v	numeric, integer	FEM Rating of flow velocity Δv	1, 3 or 5
R_prot_hab	numeric, integer	FEM Rating of Existence of protected habitats	1, 3 or 5
R_veg_nat	numeric, integer	FEM Rating of Vegetation naturalness	1, 3 or 5
R_WL_dyn	numeric, integer	FEM Rating of water level dynamics	1, 3 or 5
R_pl_int	numeric, integer	FEM Rating of Presence of documented planning interests	1, 3 or 5
R_delt_Tau	numeric, integer	FEM Rating of bottom shear stress Δτ	1, 3 or 5
R_p_tp_hab	numeric, integer	FEM Rating of potential for typical habitats	1, 3 or 5

R_wb_stat	numeric, integer	FEM Rating of ecological water body status	1, 3 or 5
Restoratio	text/25	Restoration demand	lower, medium, higher

Deliverable 3.1.2 Geodatabase and Danube Floodplain GIS for active and potentially restorable floodplains

The outlines of all identified active and potentially restorable floodplains of the Danube and selected tributaries are available in the DFGIS and the parameters are stored as attributes. The DFGIS is stored as ESRI Geodatabase. All geographic data is stored in EPSG:3035 – ETRS89- extended / LAEA Europe (European Terrestrial Reference System) (Figure 1). The geodatabase serves to create output maps and the FPInv. Results related to the Danube will be shared with theDanube GIS (https://www.danubegis.org/).

The structure of the geodatabase allows for easy update. This provides the opportunity to incorporate new data for storage and publications in the future.

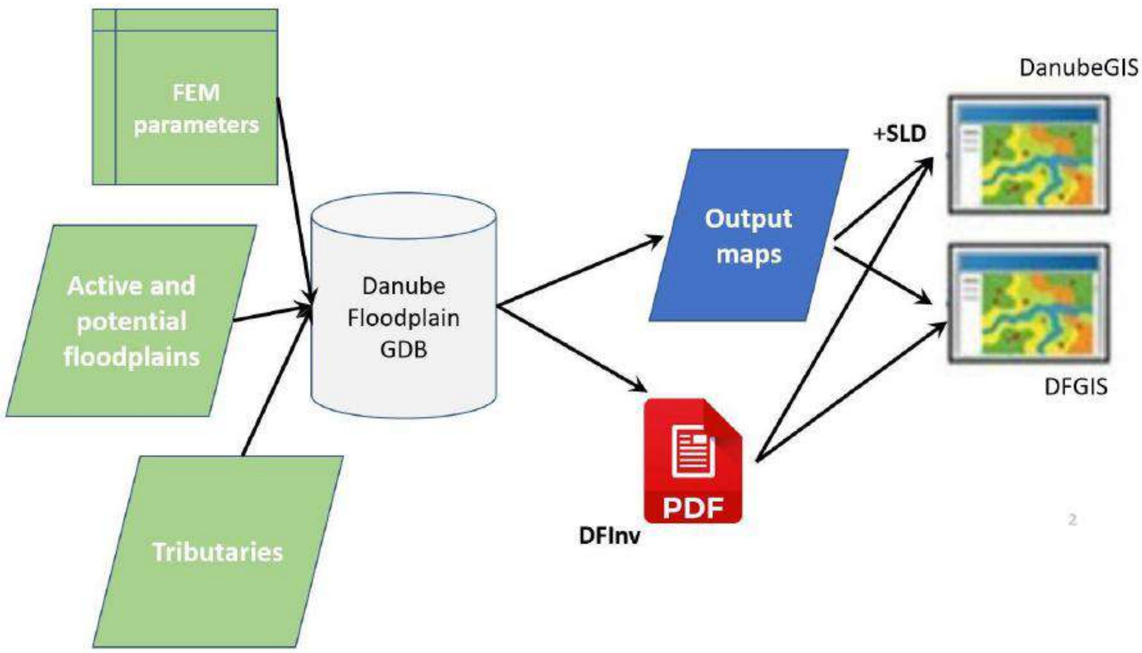


Figure 1: Danube Floodplain data flow

Fifty active floodplains with attribute data along the Danube are stored in the DFGIS.

Table 2: Active Floodplains with their IDs in the Danube Floodplain GIS

Number	Floodplain Code	Country
1	DE_DU_AFP01	Germany
2	DE_DU_AFP02	Germany
3	DE_DU_AFP03	Germany
4	DE_DU_AFP04	Germany
5	DE_DU_AFP05	Germany
6	DE_DU_AFP06	Germany
7	DE_DU_AFP07	Germany
8	DE_DU_AFP08	Germany
9	DE_DU_AFP09	Germany
10	DE_DU_AFP10	Germany
11	AT_DU_AFP01	Austria
12	AT_DU_AFP02	Austria
13	AT_DU_AFP03	Austria
14	AT_DU_AFP04	Austria
15	AT_DU_AFP05	Austria
16	AT_SK_DU_AFP01	Austria/ Slovakia
17	HU_SK_DU_AFP01	Hungary / Slovakia
18	HU_SK _DU_AFP02	Hungary / Slovakia
19	HU_SK _DU_AFP03	Hungary / Slovakia
20	HU_SK _DU_AFP04	Hungary / Slovakia
21	HU_SK _DU_AFP05	Hungary / Slovakia
22	HU_DU_AFP01	Hungary
23	HU_DU_AFP02	Hungary
24	HU_DU_AFP03	Hungary
25	HU_DU_AFP04	Hungary
26	HU_DU_AFP05	Hungary
27	HU_DU_AFP06	Hungary
28	HU_DU_AFP07	Hungary
29	HU_DU_AFP08	Hungary
30	HR_HU_DU_AFP01	Croatia/ Hungary
31	HR_RS_DU_AFP01	Croatia/ Serbia
32	HR_RS _DU_AFP02	Croatia/ Serbia
33	HR_RS _DU_AFP03	Croatia/ Serbia
34	HR_RS _DU_AFP04	Croatia/ Serbia
35	HR_RS _DU_AFP05	Croatia/ Serbia
36	RS_DU_AFP01	Serbia
37	RS_DU_AFP02	Serbia

38	RS_DU_AFP03	Serbia
39	RS_DU_AFP04	Serbia
40	RS_DU_AFP05	Serbia
41	BG_RO_DU_AFP01	Bulgaria / Romania
42	BG_RO_DU_AFP02	Bulgaria / Romania
43	BG_RO_DU_AFP03	Bulgaria / Romania
44	BG_RO_DU_AFP04	Bulgaria / Romania
45	BG_RO_DU_AFP05	Bulgaria / Romania
46	BG_RO_DU_AFP06	Bulgaria / Romania
47	RO_DU_AFP01	Romania
48	RO_DU_AFP02	Romania
49	RO_DU_AFP03	Romania
50	RO_DU_AFP04	Romania

Twenty-four Potential floodplains along the Danube per country are stored in the DFGIS (Table 3).

Table 3: Potential Floodplains with their IDs in the Danube Floodplain GIS

Number	Floodplain Code	Country
1	AT_DU_PFP01	Austria
2	AT_DU_PFP02	Austria
3	BG_RO_DU_PFP01	Bulgaria, Romania
4	BG_RO_DU_PFP02	Bulgaria, Romania
5	BG_RO_DU_PFP03	Bulgaria, Romania
6	BG_RO_DU_PFP04	Bulgaria, Romania
7	BG_RO_DU_PFP05	Bulgaria, Romania
8	DE_DU_PFP01	Germany
9	DE_DU_PFP02	Germany
10	DE_DU_PFP03	Germany
11	DE_DU_PFP04	Germany
12	DE_DU_PFP05	Germany
13	HU_DU_PFP01	Hungary, Slovakia
14	HU_DU_PFP02	Hungary
15	HU_DU_PFP03	Hungary
16	HU_DU_PFP04	Hungary, Croatia
17	RO_DU_PFP01	Romania
18	RO_DU_PFP02	Romania
19	RO_DU_PFP03	Romania
20	RO_DU_PFP04	Romania
21	RO_DU_PFP05	Romania
22	RS_DU_PFP01	Serbia
23	RS_DU_PFP02	Serbia

24	RS_DU_PFP03	Serbia

The FEM evaluation results of active and potential floodplain along the tributaries will also be published via DFGIS.

Table 4: FEM evaluation results of the active floodplains of the tributaries in the Danube Floodplain GIS

Number	Floodplain Code	River	Country
1	RO_DE_AFP	Desnatui	Romania
2	SI_KR_AFP	Krka	Slovenia
3	SK_MR_AFP	Morava	Slovakia
4	HR_SA_AFP	Sava	Croatia
5	RS_SA_APF	Sava	Serbia
6	HU_TI_AFP	Tisza	Hungary
7	RS_TI_AFP	Tisza	Serbia
8	BG_YN_AFP	Yantra	Bulgaria

Table 5: FEM evaluation results of potential floodplains of the tributaries in the Danube Floodplain GIS

Number	Floodplain Code	River	Country
1	RO_DE_PFP	Desnatui	Romania
2	SI_KR_PFP	Krka	Slovenia
3	SK_MR_PFP	Morava	Slovakia
4	HU_TI_AFP	Tisza	Hungary
5	BG_YN_AFP	Yantra	Bulgaria

The most recent results of the FEM ratings and Restoration demand parameter are published as maps for all active and potential floodplains along the Danube and tributaries in a public map service accessible via an internet browser (Figure 2-9.):

http://www.geo.u-szeged.hu/dfgis/

Functionality for navigation is available. Options to view and download the FEM ratings and Restoration parameter are available. The GIS layers can be downloaded.

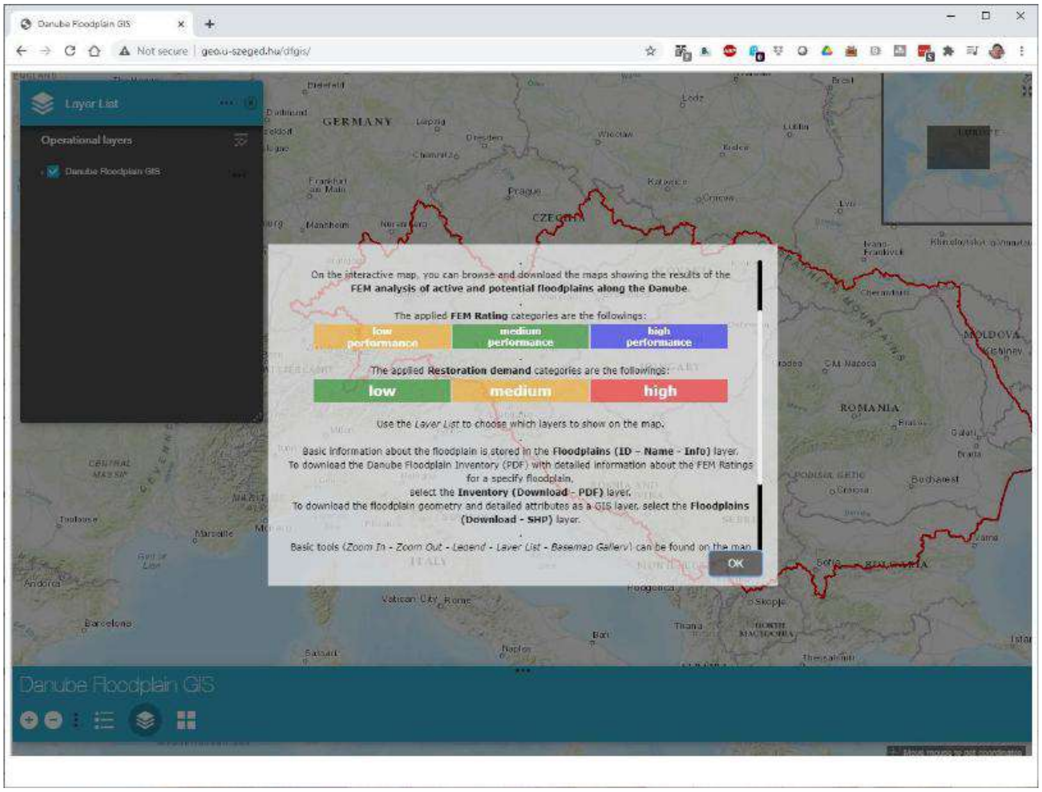


Figure 2: DFGIS web map service starting page providing general information about the DFGIS

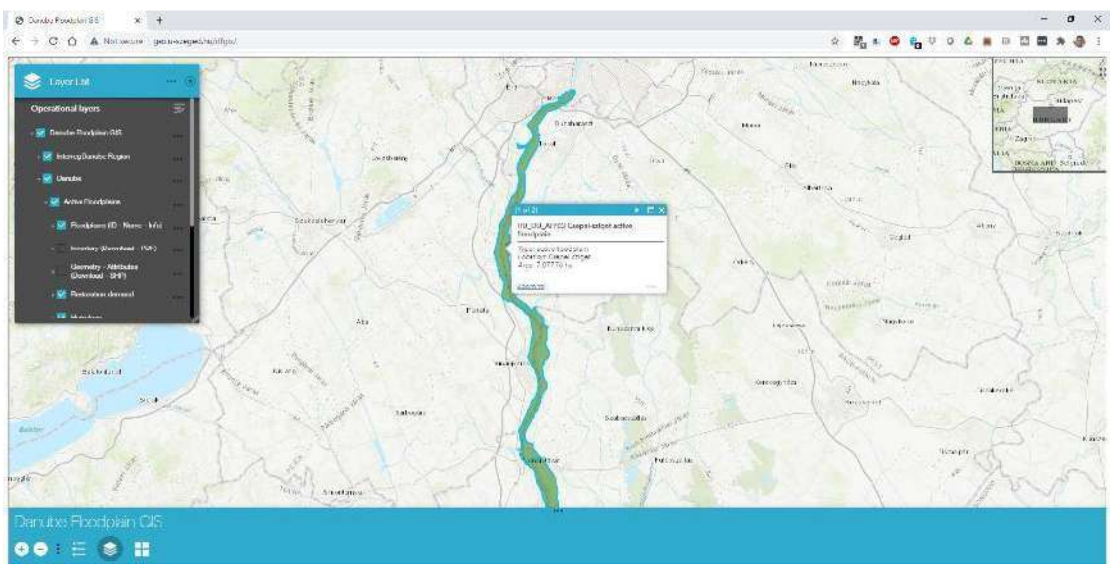


Figure 3:. DFGIS Floodplain map, with its name, ID and area

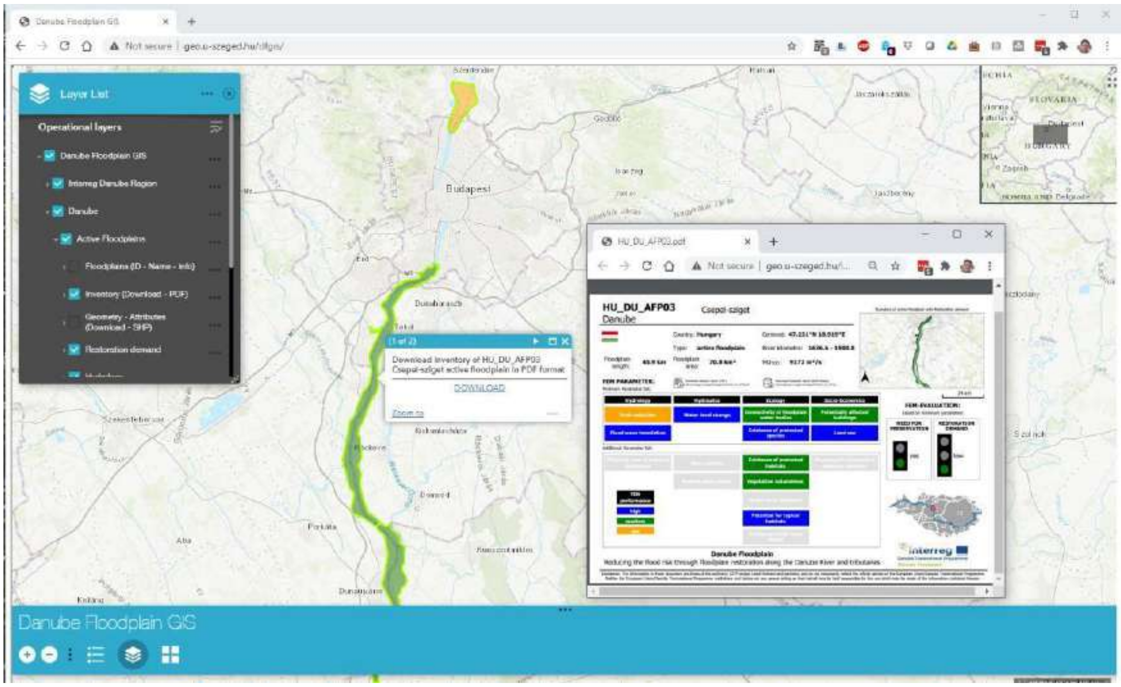


Figure 4: DFGIS Inventory download layer, with link to the PDF storing the FEM parameters

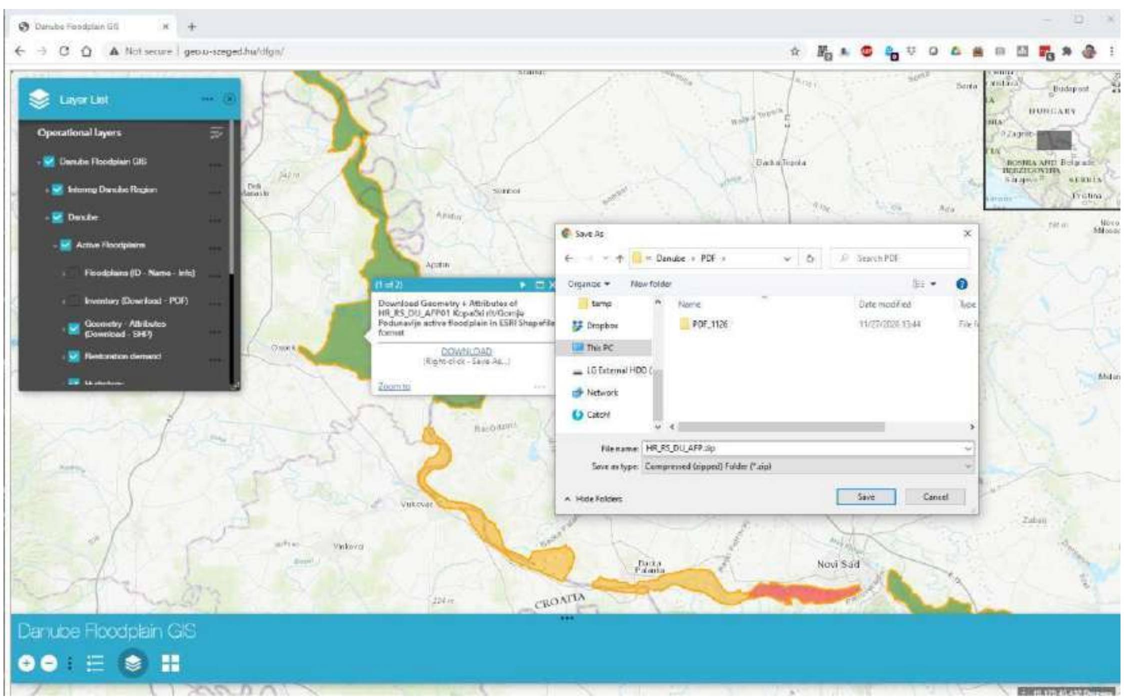


Figure 5: DFGIS map download layer, with the link to the zip file storing the shape files with attributes

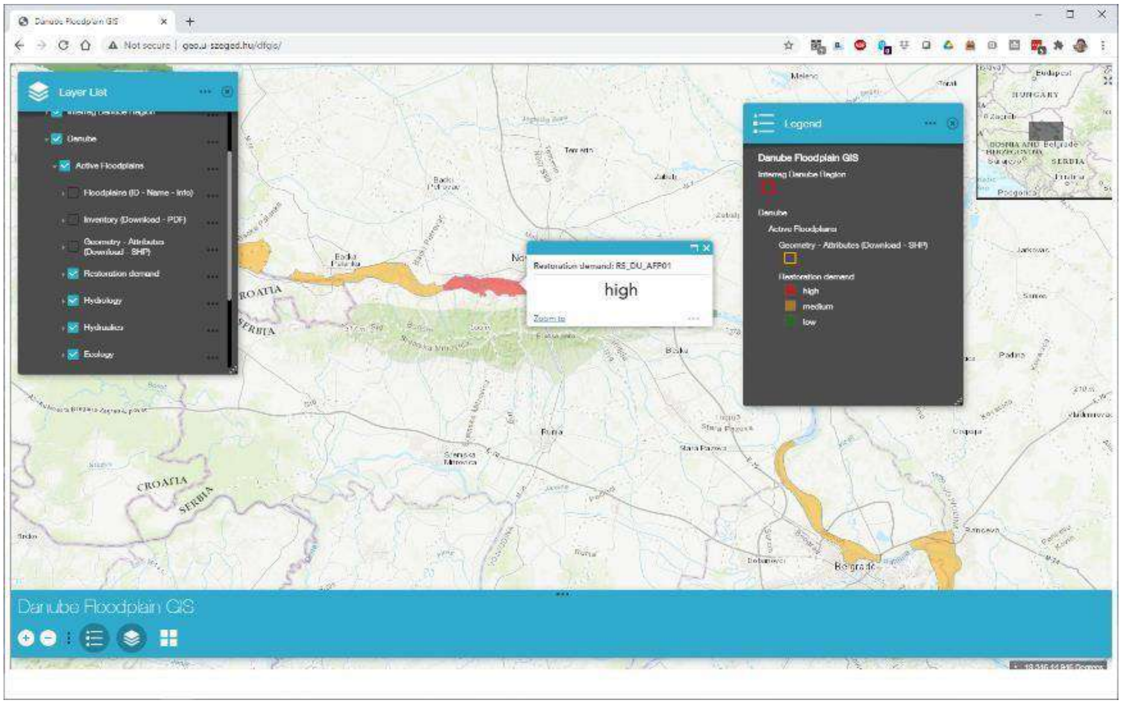


Figure 6:. DFGIS Active Floodplain Restoration demand layer

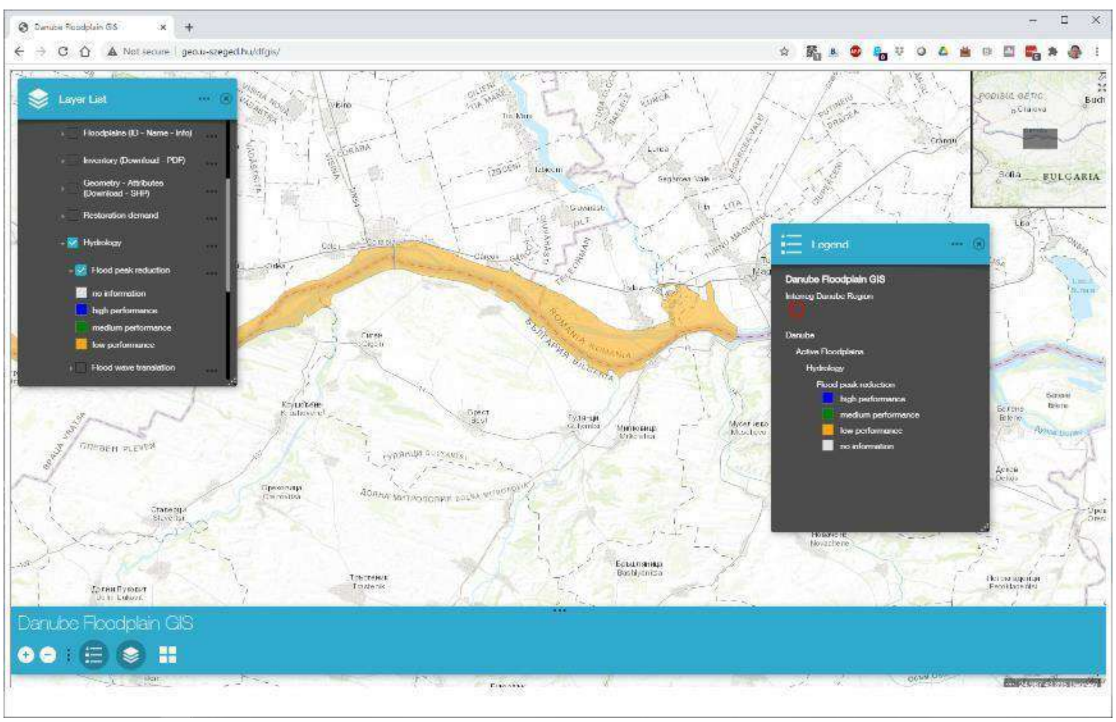


Figure 7: DFGIS Active Floodplain minimum parameter (here: Hydrology – peek reduction) FEM Rating layer

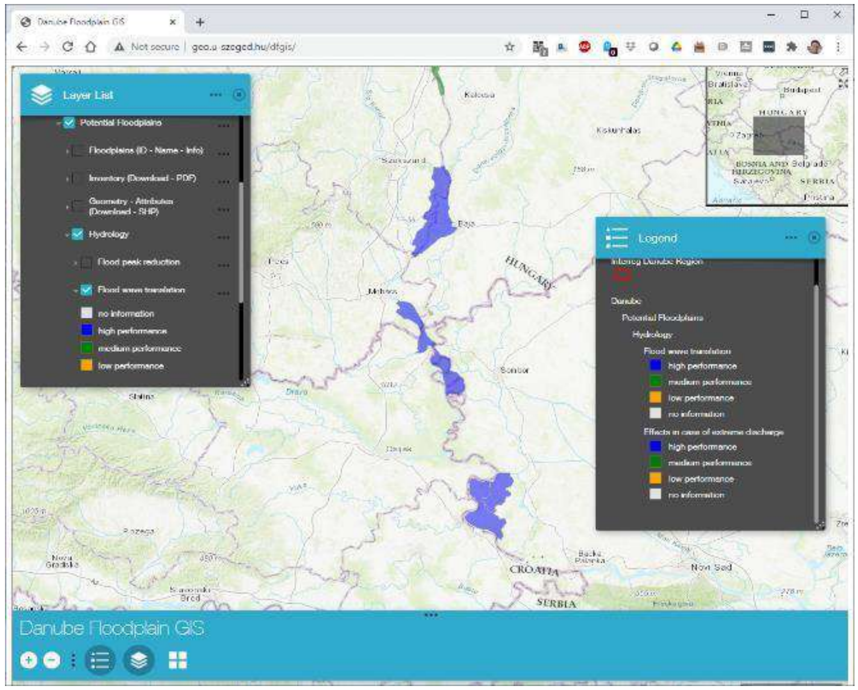


Figure 8: DFGIS Potential Floodplain Flood wave translation parameter

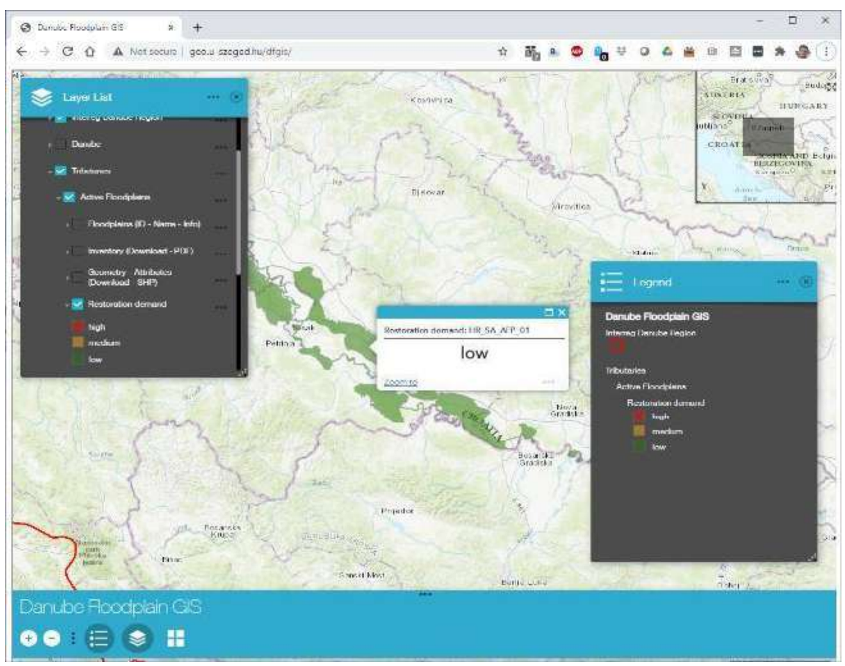


Figure 9: DFGIS *Active Floodplain (Sava) Restauration demand*

The FEM Ratings and Restoration demand for each active floodplain and FEM Ratings for potential floodplains along the Danube will be shared with the Danube GIS map service. The visualization parameters will be stored in a Styled Layer Descriptor (SLD) file. The FEM Ratings and Restorationdemand of the tributaries will only be published in DFGIS and the Danube Floodplain Inventory.

Deliverable 3.1.3. Danube Floodplain inventory for active and potentially restorable floodplains

An overview of the results of the active and potential floodplain modelling is published as the Danube Floodplain inventory. The Inventory gives a textual overview of the FEM ratings and Restoration demand as specified D.3.1.3. The data are automatically read from the geodatabase (D.3.1.2) and converted to the layout of the inventory. The parameters that are published in the DFInv are listed in Table 6.

Table 6: Selection of parameters published in the DFInv

Name of field	data type/length	Full name of the parameter	Unit
DFGIS_ID	text/50	ID of the floodplains	
FP_Type	text/50	Floodplain type	Yes/no
Location	text/50	Location of the Floodplain	
Transbound	text/10	Does the Floodplain cross country boundary	
HQ100	numeric, integer	HQ100	m^3/s
Km_from	numeric, double	Starting river kilometer	km
Km_to	numeric, double	End river kilometer	km
PDF	text/254	Link to the DFInv PDF file	
SHP	text/254	Link to the zip file with the shape files	
Area	numeric, double	Area (ha)	ha
FPlength	numeric, double	Length of the floodplain	km
Chan_width	numeric, integer	Width of the channel	m
R_delta_Q	numeric, integer	FEM Rating of peak reduction ΔQ	1, 3 or 5
R_delta_t	numeric, integer	FEM Rating of flood wave translation Δt	1, 3 or 5
R_delta_h	numeric, integer	FEM Rating of water level change Δh	1, 3 or 5
R_C_fp_wb	numeric, integer	FEM Rating of Connectivity	1, 3 or 5
R_Prot_spp	numeric, integer	FEM Rating of Existence of protected species	1, 3 or 5
R_Building	numeric, integer	FEM Rating of potentially affected buildings	1, 3 or 5
R_Land_use	numeric, integer	FEM of Rating of Land use	1, 3 or 5
R_Hyd_eff	numeric, integer	FEM Rating of effects in case of extreme discharge	1, 3 or 5
R_delta_v	numeric, integer	FEM Rating of flow velocity Δv	1, 3 or 5
R_prot_hab	numeric, integer	FEM Rating of Existence of protected habitats	1, 3 or 5
R_veg_nat	numeric, integer	FEM Rating of Vegetation naturalness	1, 3 or 5
R_WL_dyn	numeric, integer	FEM Rating of water level dynamics	1, 3 or 5
R_pl_int	numeric, integer	FEM Rating of Presence of documented planning interests	1, 3 or 5
R_delt_Tau	numeric, integer	FEM Rating of bottom shear stress Δτ	1, 3 or 5
R_p_tp_hab	numeric, integer	FEM Rating of potential for typical habitats	1, 3 or 5
R_wb_stat	numeric, integer	FEM Rating of ecological water body status	1, 3 or 5
Restoratio	text/25	Restoration demand	lower,

			medium, higher

The DFInv gives the FEM ratings per category. The colours indicate the performance on the parameters. A map with the outline of the active floodplain is provided in the colour of the Restoration demand, and an overview map is given showing the location of the floodplain in relation to the Danube region (Figure 10).

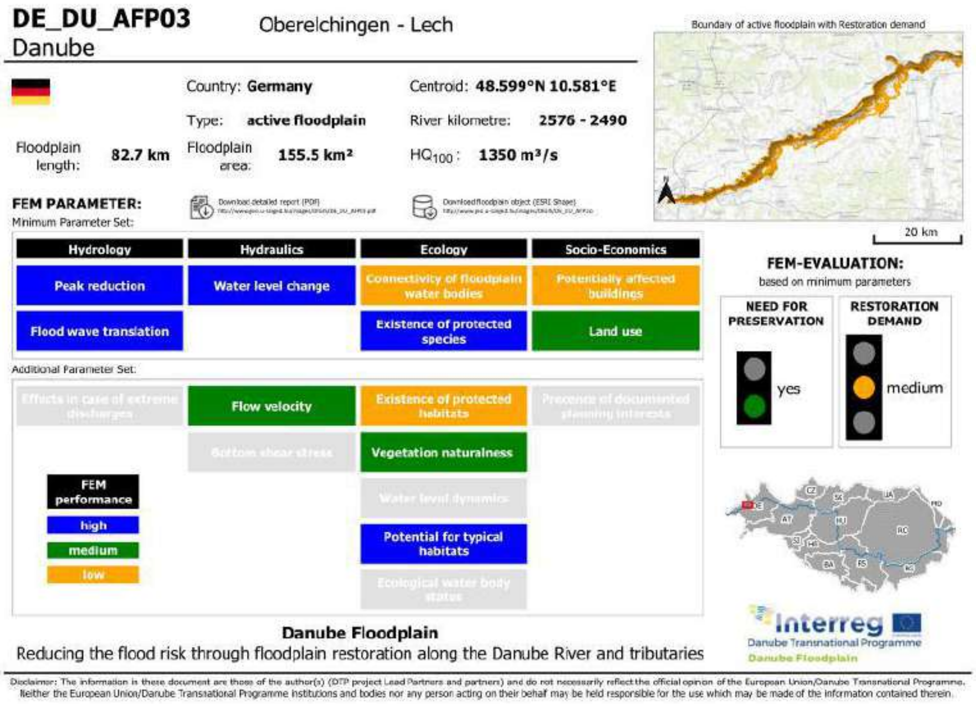


Figure 10:. Danube Floodplain inventory

II. Activity 3.2: Prioritization of existing and former floodplain restoration areas and associated measures

Deliverable D 3.2.1. Priority list with potential preservation and restoration areas (based on FEM tool)

Introduction and objectives

Among all natural disasters, floods have the greatest damage potential worldwide (UNISDR 2015). In recent years, awareness was raised, leading to the development of new approaches in integrated flood risk management, as demanded by the EU Floods Directive (2007/60/EC), by integrating non-structural and structural measures for flood protection. Such new flood mitigation methods should mainly focus on preserving and/or restoring floodplains (Habersack et al. 2015). Therefore, Activity 3.2 of the Danube Floodplain project aims to identify and evaluate still hydraulically active floodplains as well as reconnection potential of areas along the whole Danube River from the spring in Germany to the Danube Delta in Romania.

First, a methodology was developed for the identification of active and potential floodplains along the Danube River. Hydraulically active floodplains are defined as all areas that are still flooded during a HQ_{100} flood event. Potential floodplains are currently not inundated in the case of a HQ_{100}, but with restoration measures, these areas can be reconnected to the river system leading to inundation during a HQ_{100} event. Both floodplain types are presented in the Danube GIS[1] and the Danube Floodplain GIS, a geographic information system developed within Activity 3.1 of the project. For this report, Institute of Hydraulic Engineering and River Research at the University of Natural Resources and Life Sciences, Vienna (BOKU) did as well a preliminary analysis of former floodplains areas based on the HQ_{1000} inundation outlines to estimate how much of the former floodplains are still active or potential inundation areas. A detailed analysis and identification of the former floodplains will be done in the extension of the Danube Floodplain project in Activity 6.2.

In the next step, both floodplain types were evaluated with the Floodplain Evaluation Matrix (FEM), a holistic, integrative method for assessing hydrological, hydraulic, ecological, and socio-economic effects of a floodplain. The FEM methodology was further developed with all project partner´s help to serve the project's needs best.

The last step was to create a priority list with preservation and restoration areas based on the FEM-assessment. For this process, the need for preservation and the restoration demand of a floodplain were determined.

[1] Geographic information system, using and providing geo-information services on the web, whose development is supported by the ICPDR contracting parties

1. Methodology

1.1. Identification of active, potential and former floodplains

Active floodplains:

Within Activity 3.1 and 3.2, a method was developed for the identification and delineation of hydraulically active floodplains[1]. The data basis for the identification are HQ_{100} inundation areas. A flood event with a return period of 100 years is widely accepted in the Danube region as the design discharge for flood protection measures. In 2012, the Danube FLOODRISK project (https://environmentalrisks.danube-region.eu/projects/danube-floodrisk/) created hazard and risk maps for three different scenarios (frequent event HQ_{30}, medium event HQ_{100}, extreme event HQ_{1000}) for the whole Danube and published the results in the Danube Atlas. Hence, HQ_{100} outlines were available for all countries along the Danube River. If the countries could offer better (more up-to-date) national flood hazard maps (e.g. more accurate, more recently developed), these maps were used for the identification.

Based on the inundation areas of a HQ_{100} and the following three delineation criteria, the hydraulically active floodplains were identified:

- **Ratio factor** of $width_{floodplain}/width_{river}$ (to identify the beginning and end of a floodplain)
- **Minimum size** of an active floodplain (to avoid too small floodplains for the evaluation)
- Current **hydraulic characteristics** of the floodplain, like flow paths and stages may not be altered by the delineation (identified floodplains should represent the natural flow characteristics)

These criteria cannot only be used at the Danube River but are applicable at every river. In the Danube Floodplain project, the criteria were also applied at the selected tributaries in Activity 3.3. Only the values for the first two criteria have to be adjusted for the selected river. In general, the thresholds can be selected for each river individually under consideration of specific characteristics of the river and its floodplains. For the Danube River the following values were selected:

- A ratio factor of $width_{floodplain}/width_{river}$ > 1:1
- A minimum floodplain size of 500 ha
- Floodplain must be hydraulically connected, and characteristic flow behaviour is given

This methodology was developed to identify floodplains at the Danube, which should be evaluated with the Floodplain Evaluation Matrix (FEM) and displayed in the Danube GIS and Danube Floodplain GIS. All the floodplains that fulfilled the above criteria were assigned to the 1st group of floodplains. Smaller floodplain and riparian areas were assigned to the 2nd and 3rd group of floodplains, which are morphologically and ecologically valuable areas.

- **1st group:** floodplains identified according to the methodology described before, larger than 500ha, which will be evaluated and ranked by the FEM.
- **2nd group:** floodplains smaller than 500 ha but with a floodplain width bigger than the width of the river. These floodplains will not be displayed or evaluated, because the focus of this study is on larger floodplain areas.
- **3rd group:** riparian zones with a width smaller than the river width. These riparian zones will not be displayed or evaluated as the effect for flood risk management is minor but are nevertheless important for the ecology and morphology.

The methodology was then applied to the Danube River by BOKU and the identified floodplains were sent to each partner for their final approval. All identified hydraulically active floodplains were uploaded to the Danube Floodplain GIS (http://www.geo.u-szeged.hu/dfgis/). In total, 50 hydraulically active floodplains (excluding the Danube Delta) were identified. In Figure 11*:* , all active floodplains larger than 500 ha, including the Danube Delta, are shown.

Figure 11: All identified hydraulically active floodplains larger than 500 ha along the Danube River

Potential floodplains:

After identifying all hydraulically active floodplains along the Danube, a methodology was developed for the identification of potential floodplains. The potential floodplains have the potential for reconnection to the river system during a HQ_{100} flood event. Historical maps and/or inundation outlines of a $HQ_{extreme}$ (e.g., HQ_{300} or HQ_{1000}) are used to identify former floodplain first. The Danube FLOODRISK project also provides inundation outlines for extreme flood events along the entire Danube River. The assumption was that during a $HQ_{extreme}$, the dykes would overtop, and the potential floodplains beyond the dykes would be visible. Some partners also used historical maps to identify the former floodplains. Additionally, historical conditions could be analysed by modelling a historic scenario of the river section without dams, dikes and power plants. If a partner wanted to reconnect a certain area beyond the dyke, modifications in the hydrodynamic-numerical model were necessary to ensure that the potential floodplain is reconnected during a HQ_{100} before evaluating the effects of the additional area. One example of such a modification is removing the entire or part of dyke in the model. The connection of the potential floodplain at a HQ_{100} is necessary since the FEM-parameters are evaluated for such an event. If settlements, critical infrastructures and streets are located in the former floodplain, each country decides on their own if they want to identify this area as a potential floodplain. Settlements, streets and critical infrastructures had to be protected by complementary local flood defence measures (e.g., protective walls, earth deposits/dikes). If the former floodplain is currently used by agriculture, the country also has to decide if compensation is possible or not. If the partners decide that the land's compensation is not possible, no potential floodplain will be identified. In total 24, potential floodplains were identified. In Figure 12:, all potential floodplains along the Danube River are shown.

Figure 12: All identified potential floodplains along the Danube River

In the context of the project, it was decided to differentiate between two types of potential floodplains, namely potential and "operational" potential floodplains. The difference between these two types is that the "operational" potential floodplains are identified and discussed with stakeholders, technical experts and decision makers. In the following it is described how the identification of potential floodplains is working:

Step 1: Identify former floodplains by using the $HQ_{extreme}$ inundation outline from the Danube Atlas or historical maps.

Step 2: Exclude settlements, infrastructure and streets in the former floodplain.

Step 3: Exclude agricultural land where no compensation is possible or too expensive.

Step 4: Define reconnection measures (e.g., removal of dikes, cutting dikes etc.) for the remaining areas, which are the potential floodplains that are evaluated in the project.

Step 5: Discuss with stakeholders to define the "operational" potential floodplain and the detailed technical aspects of the reconnection. This is not done in the Danube Floodplain project.

Developing a method for identifying potential floodplains was a challenging task starting with the definition and identification of former floodplains ranging to the decision of which agricultural land can be used for the reconnection projects. The identified potential floodplains in the scope of the Danube Floodplain project are not representing all potential floodplains at the Danube River, but only some of them that the representatives of the individual countries identified in the project. In subchapter I.3.9.1, the area of active, potential and former floodplains are compared showing that there is still potential for additional floodplains since the percentage of active + potential floodplains from the former floodplains is in some countries lower than in others. The above-described methodology was accepted by all partners and applied in each country individually.

Former floodplains:

The identification of former/historic floodplains is very challenging. Nevertheless, it is essential to know the historical condition of the floodplains to identify and understand past developments. Historical maps or inundation areas of a $HQ_{extreme}$ (e.g. return period = 100 years) can be used to identify former floodplains. If $HQ_{extreme}$ inundation outlines are used for the identification, it is assumed that most flood protection dykes are overtopped and the area behind the dyke (=former floodplain) is flooded. The detailed analysis and identification of former floodplains were not part of the WP3 and will be done to extend the Danube Floodplain project in Activity 6.2. For this report, BOKU did a preliminary analysis of former floodplain areas based on the HQ_{1000} inundation outlines, which were available from the Danube FLOODRISK project. In chapter I.3.9, the results of this preliminary analysis are presented. For the detailed analysis and identification, it is recommend having a look at the Deliverable 6.2.3 (Danube Floodplain, in prep.)

1.2. Floodplain Evaluation Matrix (FEM)

1.2.1 Background

The Floodplain Evaluation Matrix (FEM) developed by the BOKU is a holistic method to evaluate river floodplains by considering multiple parameters that effect and determined the processes within floodplains Habersack et al. 2015). The project PRO_Floodplain (Habersack et al. 2008) was carried out in ERA-NET CRUE in order to develop an evaluation method for the effectiveness of floodplains in hydrological/hydraulic, ecological and sociological terms. The ecological parameters were based on GIS analysis (e.g. adapted land use), hydrodynamic-numerical modelling (e.g. Connectivity of water bodies) or with expert evaluation (e.g. potential for development of typical habitats). The sociological parameters (e.g. type of usage) were mainly based on questionnaires and surveys (Habersack et al. 2008; Habersack et al. 2015). The FEM should also serve as a method for decision support for relevant stakeholders. The FEM was already applied in different case studies in Austria and Germany and numerable parameters were identified and included based on literature research and questionnaires. Parameters for hydrology (e.g. peak reduction, flood wave translation) and hydraulics (e.g. water level change, flow velocity change) were calculated using hydrodynamic-numerical models. 2D-models are recommended for the application of the FEM. If no calibrated 2D-model is available, calibrated 1D-models can be used for the calculation too. In this project, mostly calibrated 1D-models were used, because 2D-models were not available to the partners. Most of the partners (except Austria – Hydro_AS-2D and Germany – 1D SOBEK) used 1D-HEC-RAS models.

With this methodology, a valuable decision support method is available for stakeholders and decision makers to assess multiple benefits that floodplain restoration and preservation as sustainable non-technical measures can offer. It allows the evaluation of various river reaches by setting up a priority ranking, which indicates where efforts of floodplain preservation / restoration should be spent first to obtain maximum benefits. The preservation of whole floodplains would stop the ongoing floodplain losses obtained over the last centuries.

2. Selected FEM-parameters and thresholds

For the Danube Floodplain project, the original FEM method was further developed to serve the project needs. Therefore, all possible parameters from the previous FEM application were collected and explained to the partners. Partners could also suggest additional parameters and this list was then discussed with all partners. From the list of parameters, the partners then selected which ones they see as important for the evaluation of floodplains. BOKU suggested a minimum set of parameters, which is mandatory for all partners to be calculated. All other parameters are additional ones, which can be evaluated and serve as additional information in the Danube Floodplain GIS but will not be considered for the ranking list. Nevertheless, the results will be valuable information for decision makers and, as such, be shown in the factsheet of each floodplain. The matrix itself consists of four categories: hydrology, hydraulics, ecology and socio-economics. For each category, one or two parameters were selected for the minimum set. The selected parameters and structure are presented hereafter:

Table 7: Floodplain Evaluation Matrix - Danube Floodplain project; in blue: minimum set, in green: additional parameters

Hydrology	Hydraulics	Ecology	Socio-Economics
peak reduction ΔQ	water level Δh	connectivity of floodplain water bodies	Potentially affected buildings
flood wave translation Δt		Existence of protected species	Land use
Additional parameters:			
effects (pos./neg.) in case of extreme discharges	flow velocity Δv	Existence of protected habitats	Precence of documented planning interests
	bottom shear stress	Vegetation naturalness	
		water level dynamics	
		Potential for typical habitats	
		ecological water body status	

After the calculation of the minimum parameters for the hydraulically active floodplain, the performance of each parameter is determined with the minimum parameters. Three levels of performance are possible for each parameter:

- High performance (5 points, colour code: blue)
- Medium performance (3 points, colour code: green)
- Low performance (1 point, colour code: yellow)

Based on the selected thresholds, the performance of the floodplain for each parameter can be determined. The thresholds can be selected for each river individually under consideration of specific characteristics of the river and its floodplains. It is recommended to start with the thresholds used at the Danube River and if necessary, adaptation can be made. The selected thresholds for most of the parameters are mainly based on results from previous studies and analysis (Habersack et al. 2008; BMLFUW 2014; Habersack et al. 2015; Habersack and Schobery 2020). For some new parameters, the thresholds were determined based on the results from this project according to expert knowledge. Most of the thresholds were also used at the selected tributaries in the Danube Floodplain project. Some thresholds were changed considering the different size of the tributaries and their characteristics. For further details on the FEM application at the tributaries see Danube Floodplain (2020). After determining the performance, the need for preservation and the demand for floodplain restoration can be evaluated. In Annexes 0 and 0, the FEM Handbooks for the minimum and additional set of parameters are attached. The calculation of the parameters is described in detail in the handbooks. For each parameter, examples are given. In the next subchapters, each parameter and its thresholds are explained briefly:

2.1. Hydrology

Flood peak reduction: This parameter considers the effect of a floodplain on the peak of a flood wave. To evaluate the peak reduction for a floodplain, the peak of an input hydrograph (e.g. HQ_{100}) at the beginning of the floodplain and the peak of the output hydrograph at the end of the floodplain will be determined. The difference between the peaks is the peak reduction ΔQ_{tot} [m^3/s] for the investigated floodplain or river section. For demonstrating only, the effect of the floodplains on the peak reduction, it is necessary to calculate the retention effect of the river channel too. Therefore, the peak reduction ΔQ_{RC} of the river channel is calculated with a model, where the floodplain is disconnected from the river channel by disabling these areas or by implementing fictive dykes, which cannot be overtopped. The same input hydrograph is used as for the calculation of ΔQ_{tot}. In Figure 13, the in- and output hydrographs for the river channel model (ΔQ_{RC}, Δt_{RC}) and the hydraulically active floodplain (ΔQ_{tot}, Δt_{tot}) are visible. It is shown that the retention effect of the floodplain is significant. In the absence of inundation areas, the peak reduction for the entire river reach would be close to zero, the flood wave translation would be reduced as well. For demonstrating only the effect of the floodplain on the peak reduction, ΔQ_{RC} has to be subtracted from ΔQ_{tot} (Equation 1).

$$\Delta Q = \Delta Q_{tot} - \Delta Q_{RC}[m^3 s^{-1}] \quad [1]$$

Additionally, the relative peak reduction ΔQ_{rel} [%] has to be calculated by dividing the ΔQ by the difference between Q_{max} and $Q_{bankfull}$ multiplied by 100 to make a comparison of different river reaches possible. The Q_{max} is the flood peak of the inflow wave and $Q_{bankfull}$ the discharge, where the river starts overtopping its bank.

$$\Delta Q_{rel} = \frac{\Delta Q}{(Q_{max} - Q_{Bankfull})} \times 100\ [\%] \quad [2]$$

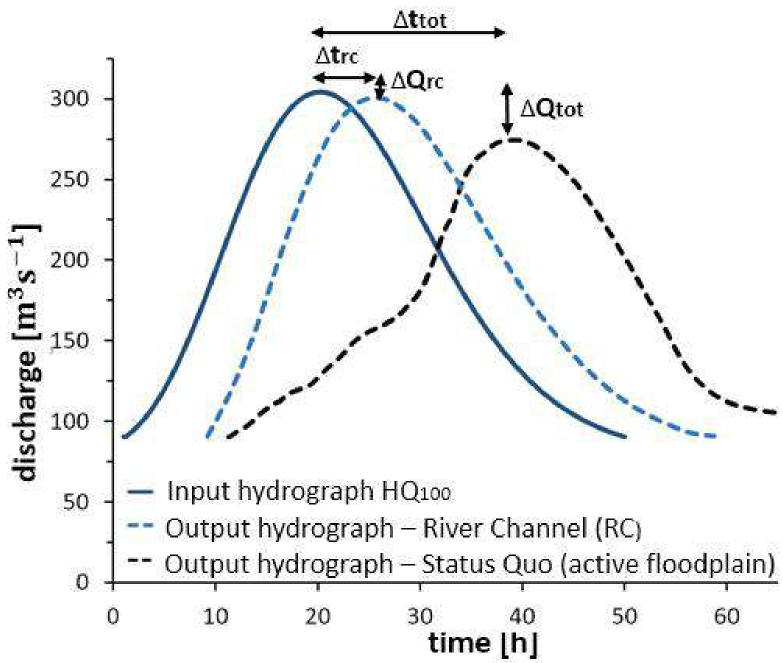


Figure 13: In- and output hydrographs for the river channel model (ΔQ_{rc}, Δt_{rc}) and the active floodplain (ΔQ_{tot}, Δt_{tot})

Thresholds: In Table 8:8 the thresholds are shown, which are used to determine the performance of the floodplain for the relative flood peak reduction. If the relative flood peak reduction (ΔQ_{rel}) is smaller than 1%, the performance of the floodplain is low. Between 1-2%, the performance is medium. All floodplains with a relative flood peak reduction above 2% perform high.

Table 8: Thresholds to determine the performance of the relative flood peak reduction ΔQrel in the FEM-Evaluation

Thresholds ΔQrel	
1	< 1 %
3	1 - 2 %
5	> 2 %

Flood wave translation: The flood wave translation is the second parameter required for the investigation of the process of wave attenuation due to a floodplain. This parameter is determined in a similar way as the peak reduction, namely by calculating the time difference Δt [h] between the occurrence of the out-/input hydrograph peak (Figure 13). You are using the same hydrographs as for the calculation of the peak reduction. For demonstrating only, the flood wave translation due to the floodplain, the Δt_{RC} of the river channel has to be subtracted from the Δt_{tot}.

$$\Delta t = \Delta t_{tot} - \Delta t_{RC} [h] \qquad [3]$$

Thresholds: In Table 9, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter flood wave translation. If the flood wave translation (Δt) is smaller than 1h, the performance of the floodplain is low. Between 1-5h, the performance is medium. All floodplains with a flood wave translation above 5h perform high.

Table 9: Thresholds to determine the performance of the flood wave translation Δt in the FEM-Evaluation

Thresholds Δt	
1	< 1 h
3	1 - 5 h
5	> 5 h

Effects in case of extreme discharge: Effects of floodplain areas on hydrological parameters (ΔQ, Δt) for scenarios with discharges larger ($HQ_{extreme}$) than the design discharge (HQ_{100}) of flood protection measures are also incorporated in the FEM to account for remaining risk (higher discharges due to climate change). Hydrodynamic-numerical modelling of the higher discharge (HQ_{1000}) can highlight additional capacities of floodplains or increased risks for settlements behind the dykes (e.g., by overtopping of existing dykes). The evaluation considers the effects on peak reduction and flood wave translation in each floodplain for this higher discharge compared to HQ_{100}. The calculation method is for $\Delta Q_{extreme}$ and $\Delta t_{extreme}$ the same as for ΔQ and Δt. The only difference is the higher input hydrograph. After the calculation of $\Delta Q_{extreme,rel}$ and $\Delta t_{extreme}$ a relation between ΔQ_{rel} and Δt is calculated.

$$\Delta Q_{compared} = \frac{\Delta Q_{rel}}{\Delta Q_{extreme,rel}} \times 100 \ [\%] \qquad [4]$$

$$\Delta t_{compared} = \frac{\Delta t}{\Delta t_{extreme,rel}} \times 100 \ [\%] \qquad [5]$$

Thresholds: No thresholds were selected, since no partner applied this additional parameter. and no previous results for this parameter were available. For defining appropriate thresholds, the results for several floodplains are needed.

2.2. Hydraulics

Water level change: In this project, we want to illustrate the effects of a total loss of a floodplain on the water level. It is assumed that the river is fully embanked and completely disconnected from the floodplain. The hydrodynamic-numerical model (river channel model), which was used for the calculation of ΔQ_{RC} and Δt_{RC}, can be used for the determination of the water level without floodplains (h_{RC}). For the calculation of h_{tot}, the same hydrodynamic-numerical model can be used, which is used to determine the hydrological parameters (ΔQ_{tot} and Δt_{tot}). The water levels h_{tot} and h_{RC} are observed at a defined cross-section in the middle of the river channel. It is recommended to take a mean water level across the cross-section, but it is also possible to take only one water level at a certain point in the middle of the river channel at the defined cross-section. The water level change Δh is the difference between h_{RC} and h_{tot}. The water level change Δh demonstrates the water level increase due to the total floodplain loss.

$$\Delta h = \mathrm{h}_{tot} - \mathrm{h}_{RC} [m] \quad [6]$$

Thresholds: In Table 10:10, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter water level change. If the water level change (Δh) is smaller than 10 cm, the performance of the floodplain is low. Between 10-50 cm, the performance is medium. All floodplains with a water level change above 50 cm perform high.

Table 10: Thresholds to determine the performance of the water level change Δh in the FEM-Evaluation

Thresholds Δh	
1	< 10 cm
3	10 - 50 cm
5	> 50 cm

Flow velocity: We want to show the effects of a total loss of a floodplain on the flow velocity. We assume again that the river is fully embanked and completely disconnected from the floodplain. The hydrodynamic-numerical model (river channel model), which was used for the calculation of ΔQ_{RC} and Δt_{RC}, can be used determining the flow velocity without floodplains (v_{RC}). For the calculation of v_{tot}, the same hydrodynamic-numerical model can be used, which is used to determine the hydrological parameters (ΔQ_{tot} and Δt_{tot}). The flow velocity v_{tot} and v_{RC} are observed at a defined cross-section in the middle of the river channel. It is recommended to take a mean flow velocity across the cross-section, but it is also possible to take only one velocity at a certain point in the middle of the river channel at the defined cross-section. The flow velocity change Δv is the difference between v_{RC} and v_{tot}. The flow velocity change Δv demonstrates the velocity increase due to the total floodplain loss.

$$\Delta v = \mathrm{v}_{tot} - \mathrm{v}_{RC} [ms^{-1}] \quad [7]$$

Thresholds: In Table 11:11, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter flow velocity change. If the flow velocity change (Δv) is smaller than 0.1 m/s, the performance of the floodplain is low. Between 0.1-0.2 m/s, the performance is medium. All floodplains with a flow velocity change above 0.2 m/s perform high.

Table 11: Thresholds to determine the performance of the flow velocity change Δv in the FEM-Evaluation

Thresholds Δv	
1	< 0.1 m/s
3	0.1 - 0.2 m/s
5	> 0.2 m/s

Bottom shear stress: We want to show the effects of a total loss of a floodplain on the bottom shear stress. We assume again that the river is fully embanked and completely disconnected from the floodplain. The hydrodynamic-numerical model (river channel model), which was used for the calculation of ΔQ_{RC} and Δt_{RC}, can be used for the determination of the bottom shear stress without floodplains (τ_{RC}). For the calculation of τ_{tot}, the same hydrodynamic-numerical model can be used, which is used to determine the hydrological parameters (ΔQ_{tot} and Δt_{tot}). The bottom shear stress τ_{tot} and τ_{RC} are observed at a defined cross-section in the middle of the river channel. It is recommended to take a mean bottom shear stress across the cross-section, but it is also possible to take only one bottom shear stress at a certain point in the middle of the river channel at the defined cross-section. The bottom shear stress change $\Delta\tau$ is the difference between τ_{RC} and τ_{tot}. The bottom shear stress change $\Delta\tau$ demonstrates the increase of the bottom shear stress due to a loss of the floodplain.

Thresholds: In Table 12:12, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter bottom shear stress change. If the bottom shear stress change ($\Delta\tau$) is smaller than 1.5 N/m², the performance of the floodplain is low. Between 1.5-3 N/m², the performance is medium. All floodplains with a bottom shear stress change above 3 N/m² perform high.

Table 12: Thresholds to determine the performance of the bottom shear stress change Δτ in the FEM-Evaluation

Thresholds τ	
1	< 1.5 N/m²
3	1.5 - 3 N/m²
5	> 3 N/m²

2.3. Ecology

Connectivity of floodplain water bodies: Longitudinal, lateral and vertical connectivity is crucial for the functionality of riverine ecosystems. Nevertheless, for simplification, the connectivity of floodplain water bodies will be investigated only in the lateral direction, which refers to the connection of the river channel and the floodplain. The parameter is determined with the help of 3 scenarios:

1. mean water level
2. bankfull flow
3. above bankfull flow

For determining the connectivity, a hydrodynamic-numerical model is necessary. With the model, which can be the same as for the calculation ofΔQ_{tot} and Δt_{tot}, the 3 scenarios are calculated. Only the input hydrographs have to be changed accordingly to the investigated scenario (mean water level, bankfull, above bankfull). The inundation areas of each scenario are used to determine the connectivity of water bodies (e.g., branches, oxbows) in the floodplain. You have to find out at which discharge the water bodies are connected. The next step is to define the "natural (historical)" status of water bodies on the floodplains. Therefore, historic maps have to be checked. There are 4 possible outcomes on the comparison between the current status and the historic status:

1. No "natural" (historical) water bodies on the floodplain
2. Existing water bodies on the floodplain (historical and current status)
3. On the historical maps "natural" (historical) water bodies existed, but at the hydraulically active floodplain no water bodies are left, due to human activity (e.g., dykes etc.)
4. On historic maps "natural" (historical) water bodies existed and are still existing, but were cut off by a dyke

If the river system is meandering, the connectivity is naturally beginning at bankfull discharge so, if this is given, it gets the best rating (5 points) in the FEM and no further steps are needed. For (historically) braided or anastomosing river types the best rating (5 points) is given when the side arms are already connected at discharges below mean water level. The detailed scenarios are listed below:

1. Water bodies connected up to mean water level / No “natural” (historical) water bodies on the floodplain / meandering river systems connected above bankfull discharge (5 points)
2. Water bodies connected at mean water level up to bankfull discharge (3 points)
3. Water bodies not connected above bankfull discharge / On the historic maps “natural” (historic) water bodies existed, but at the hydraulically active floodplain no water bodies are left (1 point)

If water bodies are cut off by a dyke, but still existing on the floodplain, it will lead to a downgrade Into the next FEM-class. E.g., Water bodies are connected up to mean flow –> 5 points, but by checking the historical maps or DEM it was discovered that the existing water bodies were cut off. This leads to a downgrade into the next class: 3 points

Thresholds: For the connectivity parameter, the method allows determining the performance without defined thresholds but with the defined ranking method as described above.

Existence of protected species: A floodplain is valuable and should be preserved if red list species or species and habitats (recognized by Natura2000) are found in the area. Therefore, this parameter will evaluate how many protected species can be found at the floodplain according to Natura2000,the Emerald Network or national legislation.

Thresholds: In Table 13:13, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter existence of Natura 2000 protected species for the first step of the ranking process (see section 2.5). If no protected species are existing on the floodplain, the performance of the floodplain is low. Between 1-20 species, the performance is medium. All floodplains were more than 20 species are protected, perform high. These thresholds should be adapted to national legislation if Natura 2000 data is not available.

Table 13:: Thresholds to determine the performance of the parameter existence of protected species in the FEM-Evaluation for the first step of the ranking process

Thresholds protected species	
1	no protected
3	1 - 20
5	> 20

In Table 14:14, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter existence of Natura 2000 protected species for the second step of the ranking process. If less than 40 protected species are existing on the floodplain, the performance of the floodplain is low. Between 40-101 species, the performance is medium. All floodplains were more than 101 species are protected, perform high. These thresholds also should be adapted to national legislation if Natura 2000 data is not available.

Table 14: Thresholds to determine the performance of the parameter existence of protected species in the FEM-Evaluation for the second step of the ranking process

Thresholds protected species	
1	< 40
3	40 - 101
5	> 101

Existence of protected habitats: This parameter shows what part of the floodplain area is designated as protected area according to the Natura 2000 or other documents about protected species or habitats like the Emerald Network. The higher the share of protected areas, the more valuable is the floodplain. Therefore, the protected area ($A_{protected}$) is divided by the floodplain area ($A_{floodplain}$) and multiplied by 100.

$$protected\ habitat = \left(\frac{A_{protected}}{A_{floodplain}}\right) * 100 \qquad [8]$$

Thresholds: In Table 15:15, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter existence of protected habitats. If less than 33% of the floodplain area is protected, the performance of the floodplain is low. Between 33-67%, the performance is medium. If more than 67% of the floodplain area is protected, the performance is high.

Table 15: Thresholds to determine the performance of the parameter existence of protected habitats in the FEM-Evaluation

Thresholds protected habitats	
1	< 33 %
3	33 - 67 %
5	> 67 %

Vegetation naturalness: The landscape patterns of a floodplain can be a good indicator for the naturalness of vegetation. Therefore, it is possible to calculate patch-level landscape indices (like the class level landscape metric Area Weighted Mean Shape Index (AWMSI) for all land cover polygons of natural and semi natural areas (NSN). Mean Shape Index can be calculated by the V-LATE extension of ArcGIS. NSN patches with a complex shape with irregular edges indicate a higher level of naturalness. The riparian vegetation land cover dataset is available for all Danube floodplains and for most of the tributaries. This dataset can be downloaded from the Copernicus Land Monitoring Service website. Open the Copernicus Riparian Zone land cover maps with ArcGIS 10.x. For making a new shape file which will contains only the “natural or semi natural” land cover patches, select the following main land cover categories from the riparian zones land cover dataset: Woodland (code 3), Grassland (code 4), and Heathland (Code 5). Open the new “natural and semi natural” land cover map with ArcGIS 10.x. and click on the V-Late extension.

Following the V-late flowchart, you should calculate first the Perimeter and Area of each land cover polygons, clicking Area/Perimeter box. The V-late extension will automatically put these new attribute columns into the attribute table of your digital land cover map.

Follow the flowchart steps, click on Area Analysis, Edge Analysis, and Form Analysis boxes. You should select the unique id column of the polygon patches to calculate the values for the all patches. The V-late extension will automatically calculate and put the landscape indices (e.g., Shape Index = shape_idx) into the attribute table of the digital land cover map (Copernicus Riparian Zone). These landscape indexes are representing the area, and form characteristics of each land cover polygons new attribute columns. You will use only the Shape Index (MSI) data (shape_idx columns) of each land cover polygons for the further analyses.

Downloading and setting up the Geospatial Modelling Environment (GME), and R software for ArcGIS 10.x from this website (http://www.spatialecology.com/gme/gmedownload.htm). Open the GME icon in your computer. Choose and click on the “isectpolypoly” options on the left menus of the GME. This tool calculates the Area Weighted Average of MSI values of each natural and semi natural land cover polygons inside of the floodplain units (zonal polygon dataset). This tool automatically writes the results into the attribute table of the digital map of the active floodplain units (zonal polygon) dataset.

You should also select the zonal polygon shape file. This shape file will be the digital polygon map of the active floodplain units. You can put it into the “in” field (active floodplain unit data source).

You should select into this second polygon layer to process your “natural or semi natural” land cover polygon shape file, which attribute table includes yet the MSI data of each land cover polygons. You should select this shape file from your computer and select the MSI column from its attribute table. This MSI column will be the quantitative data to summarize field.

You should write into “prefixa” a short prefix to use in the summary statistic fields with AWM, the prefix should be no longer than 6 characters.

Set up the “thematic”, “proportion” and “where” menus into the FALSE options, the “area weighted mean” menu (AWM) into the TRUE options, the “minimum” (MIN), “maximum” (MAX), and “area weighted sum” (AWS) menus to the FALSE options (Figure 14:).

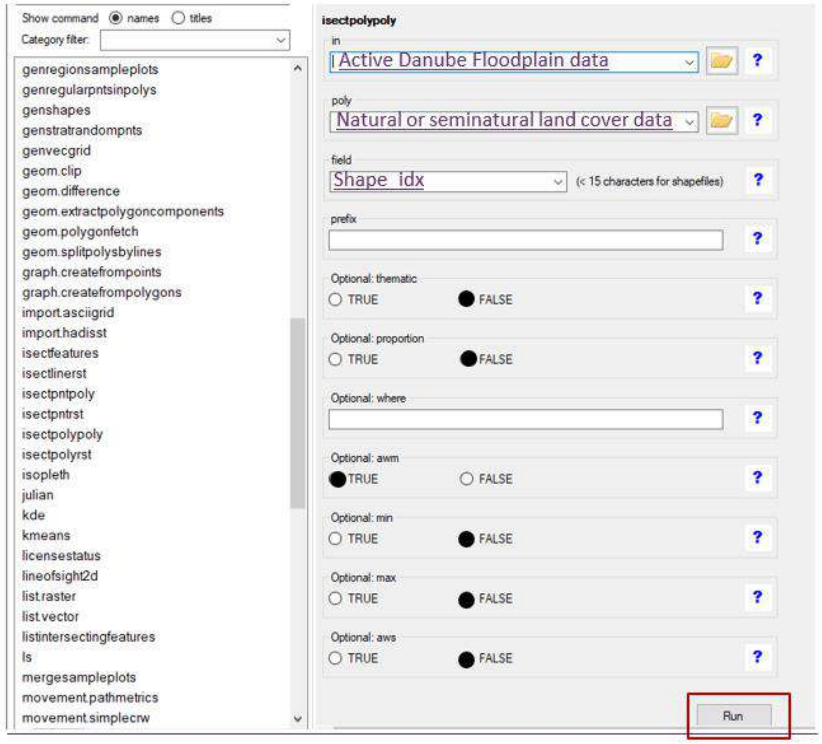


Figure 14: Input mask of the GIS tool to calculate the landscape metrics

Open the digital maps of active floodplain units (AFU) with ArcGIS 10.x. This file is containing yet the Area Weighted Mean Shape Index (AWMSI) values of each floodplain units (AFU). You should add a new field (column) into the attribute table of this shape file, and define it as the string column, which will represent the vegetation naturalness of each AFU. You should select the 0 – 3.7 AWMSI values and to write “low naturalness” into the new attribute table (in the Field calculator).

You should select the 3.71 – 6.00 AWMSI values and to write “medium naturalness” into the new attribute table.

You should select the over 6.01 AWMSI values and to write “high naturalness” into the new attribute table.

Thresholds: In Table 16:6, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter vegetation naturalness. If the vegetation naturalness is smaller than 3.7, the performance of the floodplain is low. Between 3.71-6.01, the performance is medium. All floodplains with a vegetation naturalness above 6.02 perform high.

Table 16: Thresholds to determine the performance of the vegetation naturalness in the FEM-Evaluation

Thresholds vegetation naturalness	
1	< 3.7
3	3.71 - 6.01
5	> 6.02

Water level dynamics: In order to restore floodplain habitats, rivers and floodplains must have a water level dynamic, almost like the one that exists in the natural floodplains. For this reason, the water level dynamics are used as a FEM parameter. If significant changes have been made on the river, floodplain areas may have completely different water level dynamics. This can result in permanently (excessive) high water levels in dammed up parts of the river or in dry floodplain areas in deepened river segments. The parameters water level duration, frequency of the flood and amplitude of the water levels are summarized describing the possible water level dynamics. The historical state before the development of the river serves as a point of reference. A detailed surface assessment for this parameter would be very time-consuming so that the assessment is made with the help of experts for the whole area at once. For the evaluation, a classification based on expert knowledge has to be set up: low disturbance of natural water level dynamics leads to a high rating within FEM.

First, information about the duration, frequency and amplitude of the water level dynamics (including headwater, riverbed, dykes (natural or human-made), street dams, swells, channel-bed erosions, barrages) are collected for the current and historical state. The duration, frequency and amplitude of the water level dynamics have to be compared. The following scenarios are then part of the evaluation:

5 – Duration, frequency and amplitude are **marginally** affected. Further aspects: headwaters are not obstructed, the riverbed is not deepened and there are no major obstacles for inundation

3 - Duration, frequency and amplitude are **moderately** affected. Further aspects: there are natural banks but the headwaters are dammed or dams and streets are in the floodplain

1 - Duration, frequency and amplitude are **strongly** affected. Further aspects: there are summer dykes existing, the riverbed is deepened and swells can be found

Thresholds: For the water level dynamics parameter, the method allows determining the performance without defined thresholds but with the defined ranking method as described above.

Potential for typical habitats: The typical river and floodplain habitats should have the possibility to re-establish habitats if they are not already existing. 14 habitat types typical for floodplains are included in the Habitats Directive. Not every floodplain area must consist of all, but the more habitat types exist or can be redeveloped, the more valuable this area is. The parameter evaluates how many of the typical habitats are available at the floodplain or could be restored.

Thresholds: In Table 17:7, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter potential for typical habitats. If less than 5 typical habitats exist or can be redeveloped, the performance of the floodplain is low. Between 5-10 habitats, the performance is medium. All floodplains were more than 10 typical habitats exist or can be redeveloped, perform high.

Table 17: Thresholds to determine the performance of the parameter potential for typical habitats in the FEM-Evaluation

Thresholds typical habitats	
1	< 5
3	5 - 10
5	> 10

Ecological water body status: As part of the water framework directive, the countries should evaluate the ecological of the water bodies. If the river section of this floodplain is rated with a good or high status, it should get the best rating for this parameter. Experts will assess the potential effect of restoration measures at the floodplain on the ecological water body status to the best of their knowledge.

Thresholds: In Table 18:8, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter ecological water body status. If the ecological water body status is bad or poor, the performance of the floodplain is low. If the water body status is moderate, the performance is medium. All floodplains with a good or high ecological water body status receive a high performance in the FEM-evaluation.

Table 18: Thresholds to determine the performance of the parameter ecological water body status in the FEM-Evaluation

Thresholds water body status	
1	bad, poor
3	moderate
5	high, good

2.4. Socio-Economics

Potentially affected buildings: This parameter determines the number of buildings on each hydraulically active floodplain. The more buildings are affected, the higher is the potential damage. To compare the results, the number of buildings will be divided by the total area of the floodplain.

Thresholds: In Table 19:9, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter potentially affected buildings. If more than 5 buildings per km² are on the floodplain, the performance of the floodplain is low. Between 1 and 5 buildings per km² the performance is medium. All floodplains with less than 1 building per km², perform high in the FEM-evaluation.

Table 19: Thresholds to determine the performance of the parameter potentially affected buildings in the FEM-Evaluation

Thresholds affected buildings	
1	> 5 [n/km²]
3	1 - 5 [n/km²]
5	< 1 [n/km²]

Land use: Land use that is adapted to future inundation will minimize the socio-economical vulnerability of the floodplain. Therefore, flood-adapted land use (=low vulnerability) gets the highest rating, non-adapted the lowest (settlements = high vulnerability). The different types of land uses are aggregated proportional to their areas to one evaluation value for the whole floodplain.

Thresholds: In Table 20:20, the thresholds are shown, which are used to determine the performance of the floodplain for the land use parameter. If the land use parameter is smaller than 2, the performance of the floodplain is low. Between 2-4, the performance is medium. All floodplains with a land use parameter above 4 perform high.

Table 20: Thresholds to determine the performance of the land use parameter in the FEM-Evaluation

Thresholds land use	
1	< 2
3	2 - 4
5	> 4

Presence of documented planning interests: This parameter evaluates the presence of infrastructure or spatial development plans/projects in the floodplain area or close to it. A presence would lead to a lower rating of the floodplain. This can also include plans from other interest groups (agriculture, tourism, hunting, fishing, etc.). If you find some plans, you can analyse their content regarding development projects for building, industry and infrastructure. If such interests are shown in the documents, this should be documented at a map or at least a table including the project, the planned area in the floodplain and the planned year.

Thresholds: No thresholds were selected, since no partner applied this additional parameter.

2.5. Priority list of floodplains to preserve and restore

One major goal of the project is to provide a priority list of floodplains that should be preserved and identify floodplains that can be restored. For creating the priority list, the FEM is adapted to the project's needs. After determining the performance, the need for preservation and the demand for floodplain restoration can be evaluated. First, the need for preservation is determined. A floodplain has to be preserved if at least one parameter of the minimum set is evaluated with a 5 (high performance). After that, the restoration demand is defined. Based on the minimum parameter evaluation, each floodplain is assigned to one of three groups (low, medium, high demand for restoration). The thresholds can be selected for each river individually. In Table 21:, the selected thresholds to determine the restoration demand for the Danube River are shown. In the Danube Floodplain project, the following thresholds were used: If a maximum of one parameter is evaluated with 1 (low performance) and two other parameters received a 3 (medium performance), the floodplain shows a low demand for restoration. The sum of the points received has to be ≥ 27, for getting a low demand for restoration. Floodplains with total points between 26 and 23 have medium restoration demand. All floodplains with <23 points show a high demand for restoration. Based on the total number of points, a ranking of the floodplains is possible. It is recommended to start with the thresholds used at the Danube River and if necessary, adaptation can be made. A list of measures (Danube Floodplain, 2021) that can improve the performance of the FEM-parameters was also prepared and those measures can help reduce restoration demand.

Table 21: Used thresholds in Danube Floodplain project for the Danube River to determine the restoration demand (low, medium, high)

Ranking		
Restoration Demand	**Rule**	**Min Sum Points**
High demand	All below 23 points	< 23
Medium demand	max 2x Medium (3) and 2x Low (1) or 3x Low (1)	23 - 26
Low demand	max 2x Medium (3) and 1x Low (1)	≥ 27

3. Results

3.1. Germany

3.1.1 Active and potential floodplains

In Germany, ten hydraulically active and five potential floodplains were identified. Eight active and all potential floodplain are located in Bavaria. The other two active floodplains are in Baden-Wuerttemberg and were not evaluated in the scope of this project. In Figure 15:, the floodplain ID, the location and the area of all active and potential floodplains in Germany are shown. For the active floodplain, the restoration demand is also illustrated.

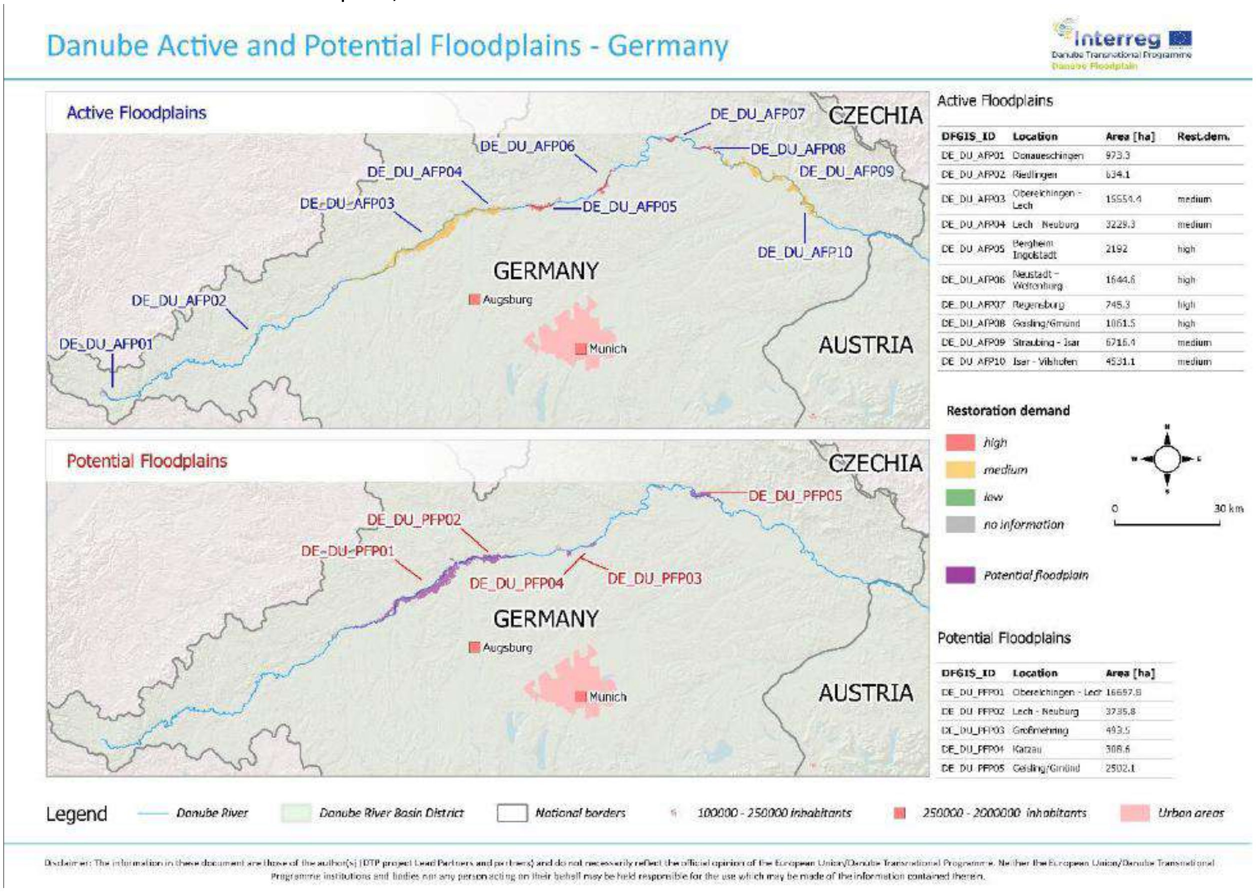


Figure 15: All active and potential floodplains along the German Danube (Danube Floodplain, 2021)

3.1.2 FEM-Evaluation – active floodplains (AFP) in Germany

Table 22 shows the results of the minimum FEM-parameters for all active floodplains along the Bavarian Danube. The relative peak reductions range from 0 to 16.98%, resulting in four floodplains with high (>2%) and four with low (<1%) performance in terms of this aspect of the hydrology. Due to the flow processes in the floodplains, the flood wave is decelerated by a range from 0.25 to 16.5 h. Four floodplains show a medium (1-5h), three a high (>5h) and one a low (<1h) performance for the flood wave translation parameter. Regarding the hydraulics, in the case of a total loss of the active floodplain, the water level in the river channel would change from 0 to 112 cm. For three floodplains, the water level would increase by more than 50 cm. Three floodplains are showing a rise between 24 and 42 cm. Only for two floodplains, the water level change is below 10 cm. From the ecological point of view, the lateral connectivity between the river channel and floodplain is impaired for all active floodplains along the German Danube by human interventions, leading to low performance for all of them. At all floodplains, more than 20 protected species are found (=high performance for the first step of the ranking). For the second step of the ranking, other thresholds are used for the protected species parameter to determine the restoration demand resulting in nine floodplains with a medium and only one with a high performance. At six floodplains, the number of affected buildings per km² is larger than 5, leading to a low performance for this parameter. Only two floodplains show a high (<1n/km²) performance. The land uses on seven floodplains have a medium vulnerability against flooding, resulting in a medium performance. Only on one floodplain, the vulnerability is low (5 – high performance).

Table 22: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Danube River in Germany. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	land use (-)
Germany	DE_DU_AFP_01								
	DE_DU_AFP_02								
	DE_DU_AFP_03	16.98	16.5	112	1	95	95	15.76	3.63
	DE_DU_AFP_04	2.63	9.5	89	1	54	54	15.58	3.92
	DE_DU_AFP_05	0.53	3	42	1	51	51	19.16	4.57
	DE_DU_AFP_06	0.07	1	0	1	41	41	17.93	3.40
	DE_DU_AFP_07	0.00	1.25	6	1	53	53	0.81	3.65
	DE_DU_AFP_08	0.08	0.25	24	1	53	53	0.19	3.64
	DE_DU_AFP_09	11.13	6.75	53	1	86	86	9.32	3.61
	DE_DU_AFP_10	2.83	5	38	1	**115**	**115**	11.39	3.52
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	<2
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	2-4
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	>4

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the German Danube should be preserved because at least one parameter is evaluated with high performance at each floodplain. Five floodplains show a high and three a medium demand for restoration (Table 23:23).

Table 23: Results of the need for preservation and restoration demand for all active floodplains along the Danube River in Germany. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-points
DE_DU_AFP_01				
DE_DU_AFP_02				
DE_DU_AFP_03	yes	peak reduction, wave translation, water level change, protected species	medium demand	23
DE_DU_AFP_04	yes	peak reduction, wave translation, water level change, protected species	medium demand	23
DE_DU_AFP_05	yes	protected species	high demand	17
DE_DU_AFP_06	yes	protected species, land use	high demand	13
DE_DU_AFP_07	yes	protected species, affected buildings	high demand	17
DE_DU_AFP_08	yes	protected species, affected buildings	high demand	17
DE_DU_AFP_09	yes	peak reduction, wave translation, water level change, protected species	medium demand	23
DE_DU_AFP_10	yes	peak reduction, protected species	high demand	21
FEM-ranking	Need for preservation	threshold	restoration demand	threshold
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.1.3 FEM-Evaluation – potential floodplains (PFP) in Germany

Table *24:*24 shows the results of the minimum FEM-parameters for all potential floodplains along the German Danube. The relative peak reductions range from 0 to 17.62%, resulting in two floodplains with high (>2%) and three with low (<1%) performance. The flood wave is decelerated from 0 up to 19 h. Two floodplains show a medium (1-5h), two a high (>5h) and one a low (<1h) performance for the flood wave translation parameter. In the case of a total loss of the potential floodplain, the water level in the river channel would change from 0 to 117 cm. For three floodplains, the water level would increase by more than 50 cm. One floodplain shows a rise of 25 cm and for another one, the water level would not change. The lateral connectivity between the river channel and floodplain is still impaired for all potential floodplains along the German Danube by human interventions, leading to low performance for all of them. At three floodplains, more than 20 and at two between 1 and 20 protected species are found. At four floodplains, the number of affected buildings per km² is larger than 5, leading to a low performance for this parameter. Only one floodplain shows a medium (1-5 n/km²) performance for the affected building's parameter. The land uses on four floodplains have a medium vulnerability against flooding, resulting in a medium performance. Only on one floodplain, the vulnerability is low (5 – high performance).

Table 24: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all identified potential floodplains along the Danube River in Germany. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain ID	Hydrology		Hydraulics	Ecology		Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)	affected buildings (n/km²)	l
Germany	DE_DU_PFP01	**17.62**	**19**	**117**	**1**	**95**	14.95	
	DE_DU_PFP02	2.41	11	108	**1**	54	16.78	
	DE_DU_PFP03	0.35	0	52	**1**	17	5.07	
	DE_DU_PFP04	0.02	2	0	**1**	15	**1.94**	
	DE_DU_PFP05	0.33	5	25	**1**	53	6.63	
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Th
	1 (low)	<1 %	<1 h	<10 cm	1	0	>5 n/km²	
	3 (medium)	1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	
	5 (high)	>2 %	>5 h	>50 cm	5	>20	<1 n/km²	

3.1.4 Example of a floodplain factsheet (DE_DU_AFP_03)

The active floodplain DE_DU_AFP_03 starts at Oberelchingen and ends at the confluence of the Lech River. The total floodplain area is 155.5 km². The FEM-Evaluation shows that there is a need for preservation of this floodplain and a medium demand for restoration, due to the performance of the evaluated parameters. In **Eroare! Fără sursă de referință.**, the evaluation results are illustrated for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter. The performance is determined using the selected thresholds.

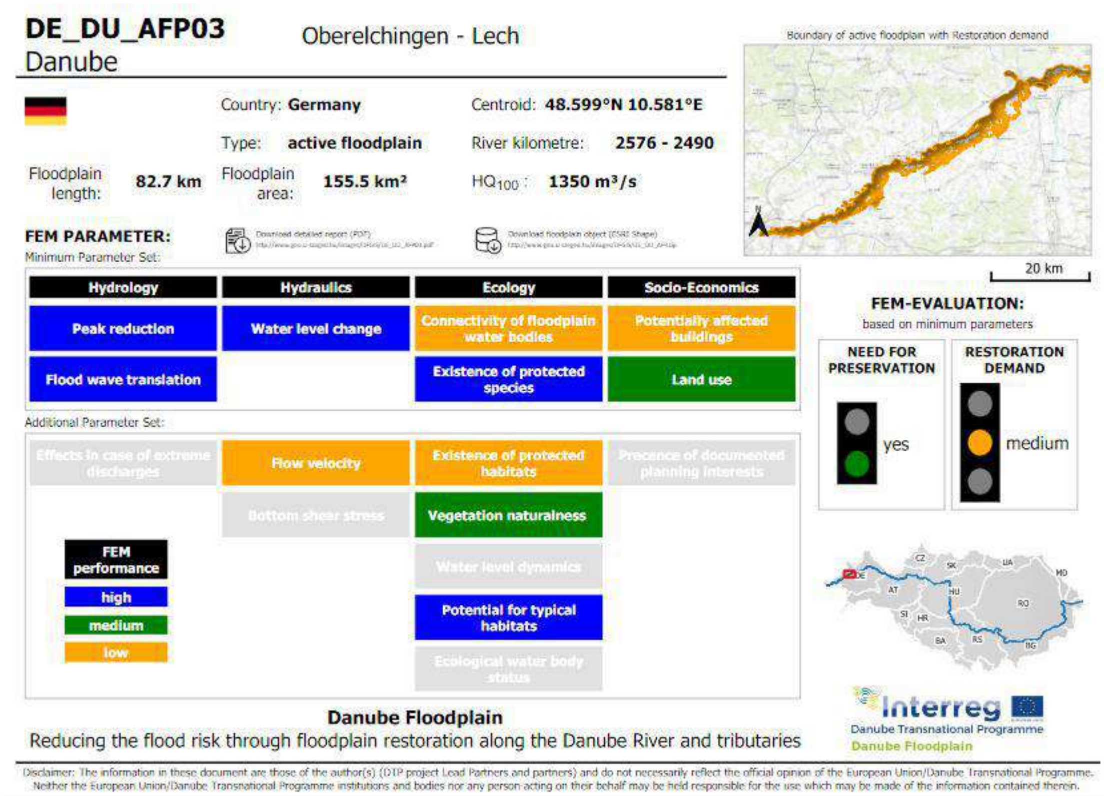


Figure 16: Factsheet for the active floodplain DE_DU_AFP_03

3.2. Austria

3.2.1 Active and potential floodplains

In Austria, five hydraulically active and two potential floodplains were identified. One active floodplain was identified along the Austrian/Slovakian section of the Danube River. In Figure 17:, the floodplain ID, the location and the area of all active and potential floodplains in Austria are shown. For the active floodplain, the restoration demand is also illustrated.

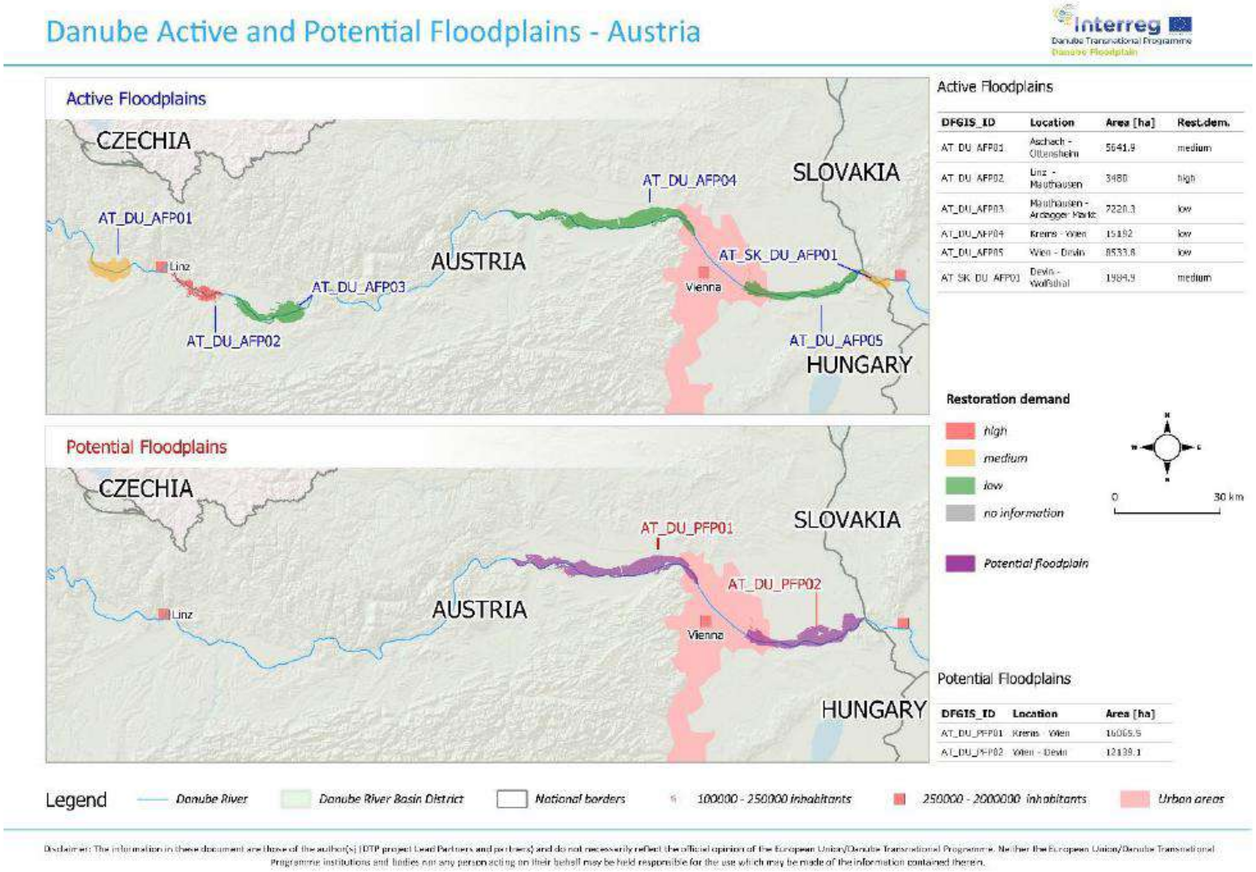


Figure 17: All active and potential floodplains along the Austrian Danube (Danube Floodplain, 2021)

3.2.2 FEM-Evaluation – active floodplains (AFP) in Austria

Table 25 shows the results of the minimum FEM-parameters for all active floodplains along the Austrian Danube. The relative peak reductions range from 1.21 to 15.64%, resulting in four floodplains with high (>2%) and two with medium (1-2%) performance. Due to the flow processes in the floodplains, the flood wave is decelerated from 2.5 to 20.5 h. Three floodplains show a high (>5h) and three a medium (1-5h) performance for the flood wave translation parameter. In the case of a total loss of the active floodplain, the water level in the river channel would change from 64 to 172 cm. The water level would increase by more than 50 cm for all floodplains, leading to high performance (>50cm). The lateral connectivity between the river channel and floodplain is impaired for most (five out of six) active floodplains along the Austrian Danube by human interventions, leading to low performance. Only one floodplain achieves a medium performance in terms of connectivity. More than 20 protected species are found at five floodplains, resulting in high performance for the first step of the ranking (=need for preservation). At one floodplain, 20 protected species can be found, leading to medium performance. For the second step of the ranking, other thresholds are used for the protected species parameter to determine the restoration demand resulting in two floodplains with a high, three with a medium and only one with a low performance. At three floodplains, the number of affected buildings per km² is larger than 5, leading to a low performance for this parameter. For the other three floodplains, a medium performance was assessed. The land uses on four floodplains have a medium vulnerability against flooding, resulting in a medium performance. Only at two floodplains, the vulnerability is low (5 – high performance).

Table 25: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Danube River in Austria and the Austria/Slovakian section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	land use (-)
Austria, Slovakia	AT_DU_AFP_01	15.64	5.5	64	1	20	20	19.58	3.40
	AT_DU_AFP_02	1.52	2.5	172	1	62	62	14.04	3.76
	AT_DU_AFP_03	8.24	5.5	68	1	85	85	3.52	3.81
	AT_DU_AFP_04	12.60	20.5	83	1	113	113	18.63	4.68
	AT_DU_AFP_05	4.68	5	109	3	**116**	**116**	1.38	4.74
	AT_SK_DU_AFP_01	1.21	4	81	1	51	51	3.98	3.56
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	<2
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	2-4
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	>4

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Austrian Danube should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. Two floodplains show a low, one a medium and three a high demand for restoration (Table 26:6).

Table 26: Results of the need for preservation and restoration demand for all active floodplains along the Danube River in Austria and the Austrian/Slovakian section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-points
AT_DU_AFP_01	yes	peak reduction, wave translation, water level change	high demand	21
AT_DU_AFP_02	yes	water level change, protected species	high demand	21
AT_DU_AFP_03	yes	peak reduction, wave translation, water level change, protected species	medium demand	25
AT_DU_AFP_04	yes	peak reduction, wave translation, water level change, protected species, land use	low demand	27
AT_DU_AFP_05	yes	peak reduction, wave translation, water level change, protected species, land use	low demand	29
AT_SK_DU_AFP_01	yes	water level change, protected species	high demand	21
FEM-ranking	Need for preservation	threshold	restoration demand	threshold
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.2.3 FEM-Evaluation – potential floodplains (PFP) in Austria

Table 27:7 shows the results of the minimum FEM-parameters for all potential floodplains along the Austrian Danube. The performance of all minimum hydrological and hydraulic FEM-parameters is for both floodplains high. The relative peak reductions range from 8.51 to 13.06 %. The potential floodplains would lead to a flood wave translation from 6.25 to 22 h. In the case of a total loss of the potential floodplain, the water level in the river channel would change from 65 to 154 cm.

The lateral connectivity is for one floodplain low and for the other medium. In both potential floodplains there are around 115 protected species leading to high performance in the FEM-evaluation. At one floodplain, the number of affected buildings per km² is much larger (17.65 n/km²) than 5, leading to low performance. The other potential floodplain shows a medium (1-5 n/km²) performance for the affected building's parameter. Both potential floodplains have a low vulnerability against flooding in terms of land use, resulting in high performance for this parameter in the FEM-evaluation.

Table 27: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all identified potential floodplains along the Danube River in Austria. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain ID	Hydrology		Hydraulics	Ecology		Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)	affected buildings (n/km²)	land use (-)
Austria	AT_DU_PFP01	**13.06**	**22**	65	1	113	17.65	4.75
	AT_DU_PFP02	8.51	6.25	**154**	**3**	**116**	**1.01**	**4.85**
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds
	1 (low)	<1 %	<1 h	<10 cm	1	0	>5 n/km²	<2
	3 (medium)	1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	2-4
	5 (high)	>2 %	>5 h	>50 cm	5	>20	<1 n/km²	>4

3.2.4 Example of a floodplain factsheet (AT_DU_AFP_05)

The active floodplain AT_DU_AFP_05 starts at Wien and ends at the confluence of the Morava River. The total floodplain area is 85.3 km². The FEM-evaluation shows that there is a need for preservation of this floodplain and a low demand for restoration, due to the high performance of the evaluated parameters. In, the evaluation results are shown for each parameter and the colour red background indicates the performance (high – blue, medium – green, low – yellow) of the parameter.

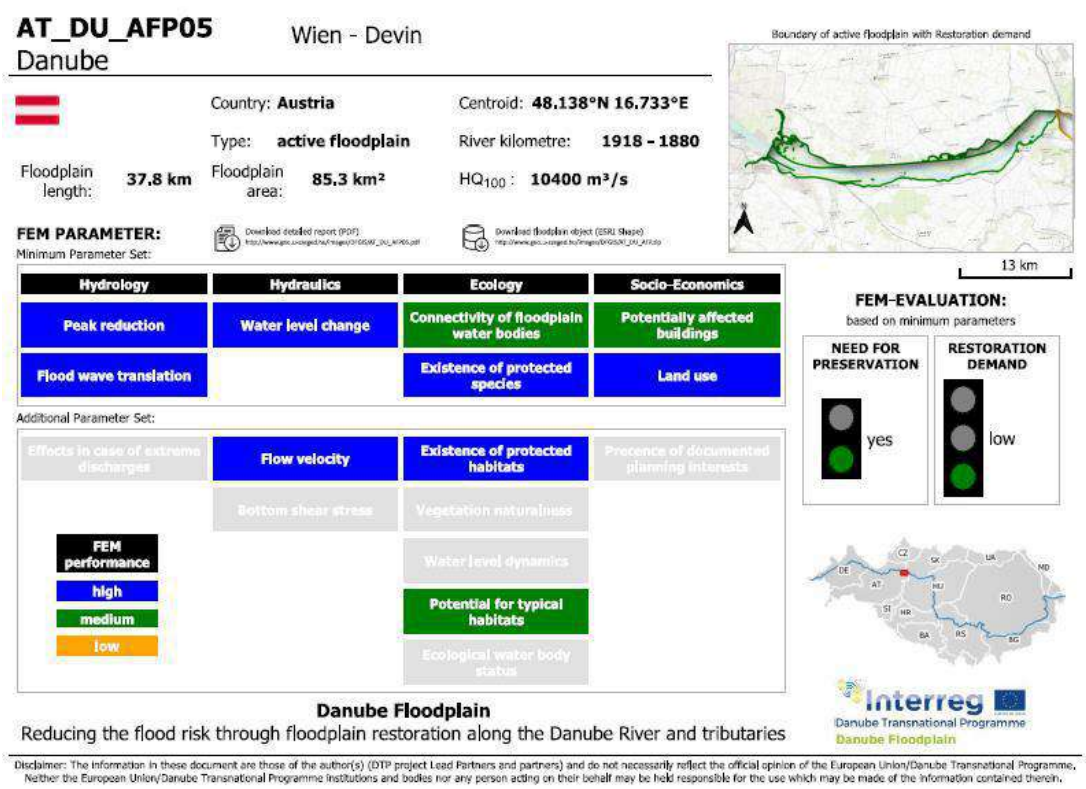


Figure 18: Factsheet for the active floodplain AT_DU_AFP_05

3.3. Slovakia/Hungary

3.3.1 Active and potential floodplains

At the transboundary Slovakian and Hungarian section of the Danube River, five active and one potential floodplains were identified. In Figure 19:, the floodplain ID, the location and the area of all active and potential for all floodplains along the Slovakian/Hungarian section are shown. For the active floodplain, the restoration demand is also illustrated.

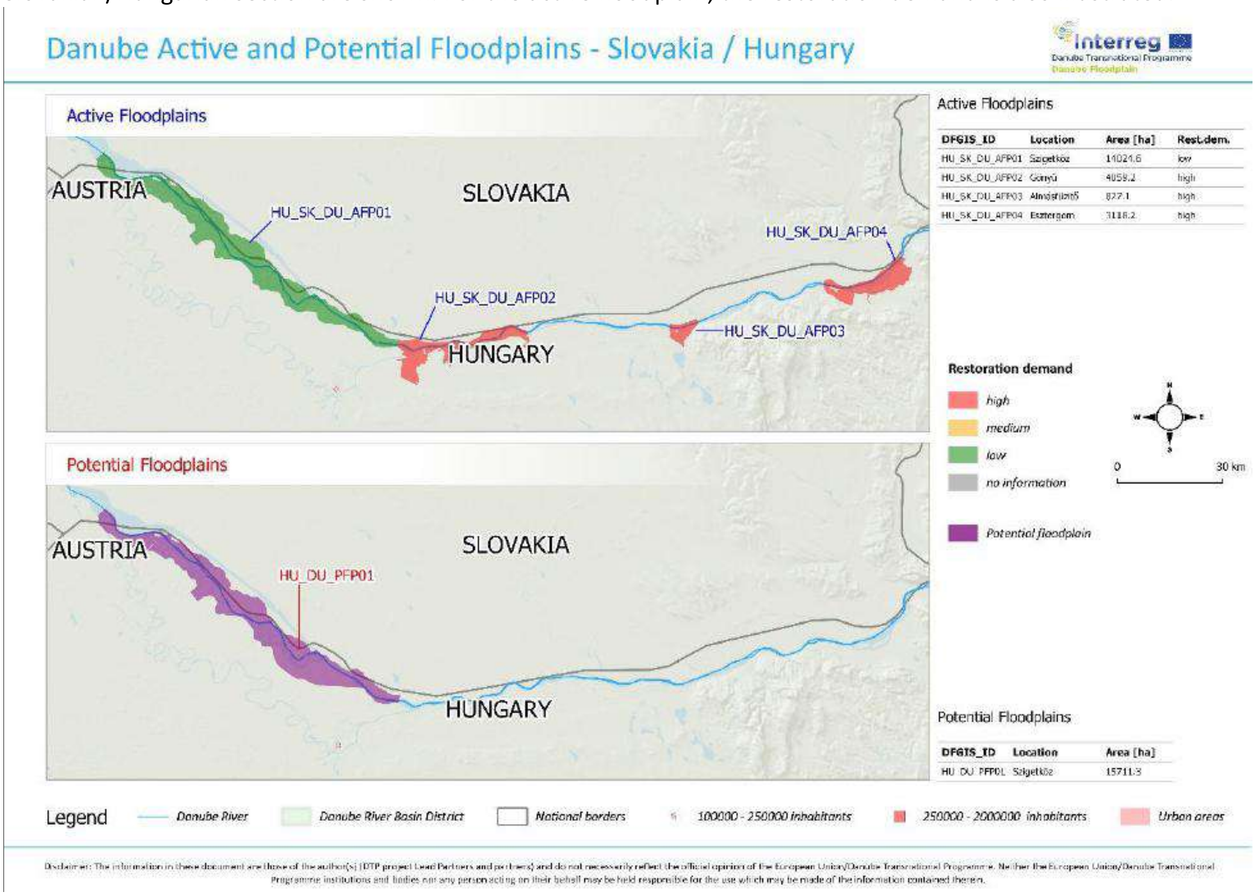


Figure 19: All active and potential floodplains along the Slovakian/Hungarian Danube (Danube Floodplain, 2021)

3.3.2 FEM-Evaluation – active (AFP) floodplains at the Slovakian/Hungarian section of the Danube River

Table 28:8 shows the results of the minimum FEM-parameters for all active floodplains along the Slovakian/Hungarian section of the Danube River*. One floodplain have a peak reduction of 11.4%, resulting in high performance (>2%) in the FEM-evaluation. The peak reduction for all other floodplains is less than 1%, leading to low performance (<1%). Due to the flow processes in the floodplains, the flood wave is decelerated from 0 to 7 h. One floodplain shows a high (>5h), two a medium (1-5h) and two a low (<1h) performance for the flood wave translation parameter. In the case of a total loss of the active floodplain, the water level in the river channel would change only for one floodplain above 50 cm, leading to high performance. For most other floodplains, the water level change in the river would be between 18 and 30 cm, resulting in medium performance. One floodplain shows a low performance (>10 cm) for this parameter. The lateral connectivity between the river channel and floodplain is impaired for three out five active floodplains along the Hungarian Danube by human interventions, leading to low performance. Two floodplains achieve a medium performance in terms of connectivity.

More than 20 protected species are found at all floodplains, resulting in high performance for the first step of the ranking (=need for preservation). For the second step of the ranking, other thresholds are used for the protected species parameter to determine the restoration demand resulting in medium performance for all floodplains. At three floodplains, the number of affected buildings per km² is larger than 5, leading to a low performance for this parameter. For the other two floodplains, a medium performance was assessed. The land uses on three floodplains have a low vulnerability against flooding, resulting in a high performance. At two floodplains, the vulnerability is medium (3 – medium performance).

Table 28: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Slovakian/Hungarian Danube section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	land use (-)
Slovakia, Hungary	HU_SK_DU_AFP_01	11.40	7	**158**	3	**70**	**70**	4.79	4.88
	HU_SK_DU_AFP_02	0.60	2	18	1	59	59	10.42	4.21
	HU_SK_DU_AFP_03	0.06	0	19	1	56	56	4.71	3.57
	HU_SK_DU_AFP_04	0.39	2	29	3	56	56	8.08	3.74
	HU_SK_DU_AFP_05	0.79	0.4	1	1	56	56	34.77	4.08
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	<2
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	2-4
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	>4

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Slovakian/Hungarian Danube section should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. Four floodplains show a high and one a low demand for restoration based on the FEM-evaluation.

Table 29: Results of the need for preservation and restoration demand for all active floodplains along the Slovakian/Hungarian Danube section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-points
HU_SK_DU_AFP_01	yes	peak reduction, wave translation, water level change, protected species, land use	low demand	29
HU_SK_DU_AFP_02	yes	protected species, land use	high demand	17
HU_SK_DU_AFP_03	yes	protected species	high demand	15
HU_SK_DU_AFP_04	yes	protected species	high demand	17
HU_SK_DU_AFP_05	yes	protected species, land use	high demand	13
FEM-ranking	Need for preservation	threshold	restoration demand	threshold
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.3.3 Example of a floodplain factsheet (HU_SK_DU_AFP01)

The active floodplain HU_SK_DU_AFP01 is 140.2 km² large. The FEM-Evaluation showed that there is a need for preservation of this floodplain and a low demand for restoration, due to the high performance of the evaluated parameters. In **Eroare! Fără sursă de referință.**, the evaluation results are shown for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter.

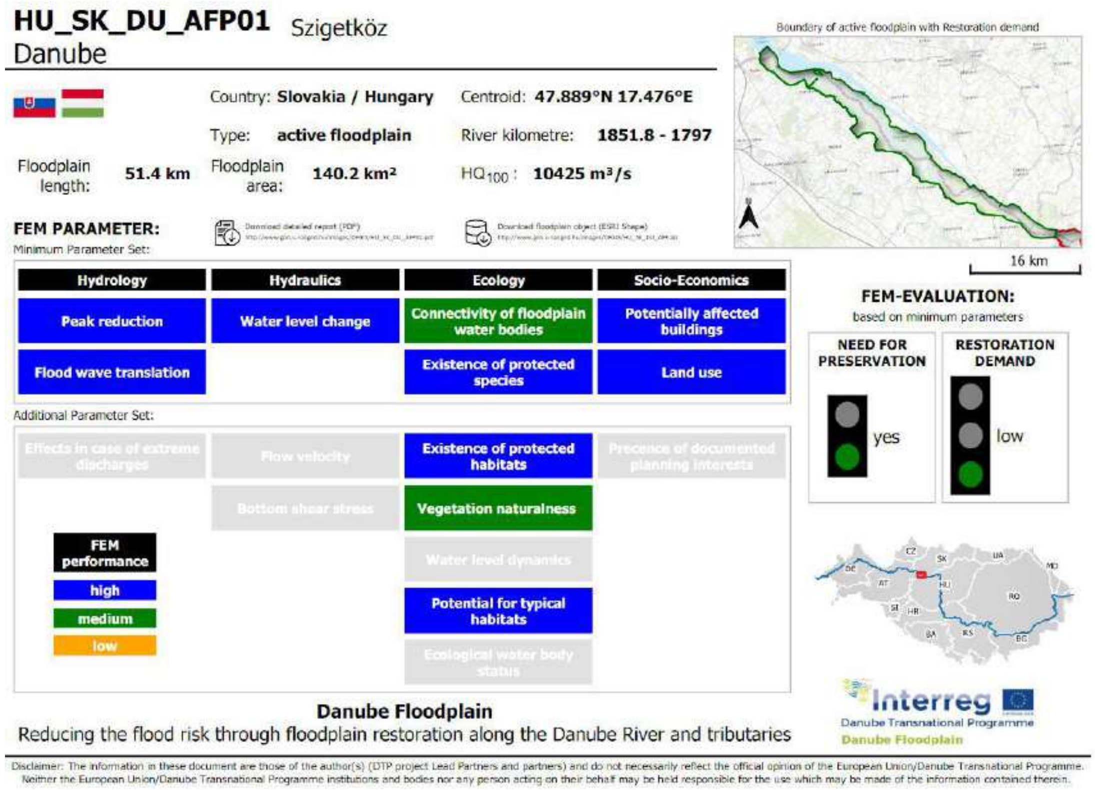


Figure 20: Factsheet for the active floodplain HU_SK_DU_AFP01

3.4. Hungary

3.4.1 Active and potential floodplains

At the Hungarian section of the Danube River, eight active and four potential floodplains were identified. A transboundary floodplain (HR_HU_AFP01) between Hungary, Croatia and Serbia was also identified. The results of this transboundary floodplain are also presented in this chapter. In Figure 21:, the floodplain ID, the location and the area of all active and potential for all floodplains along the Hungarian section are shown. For the active floodplain, the restoration demand is also illustrated.

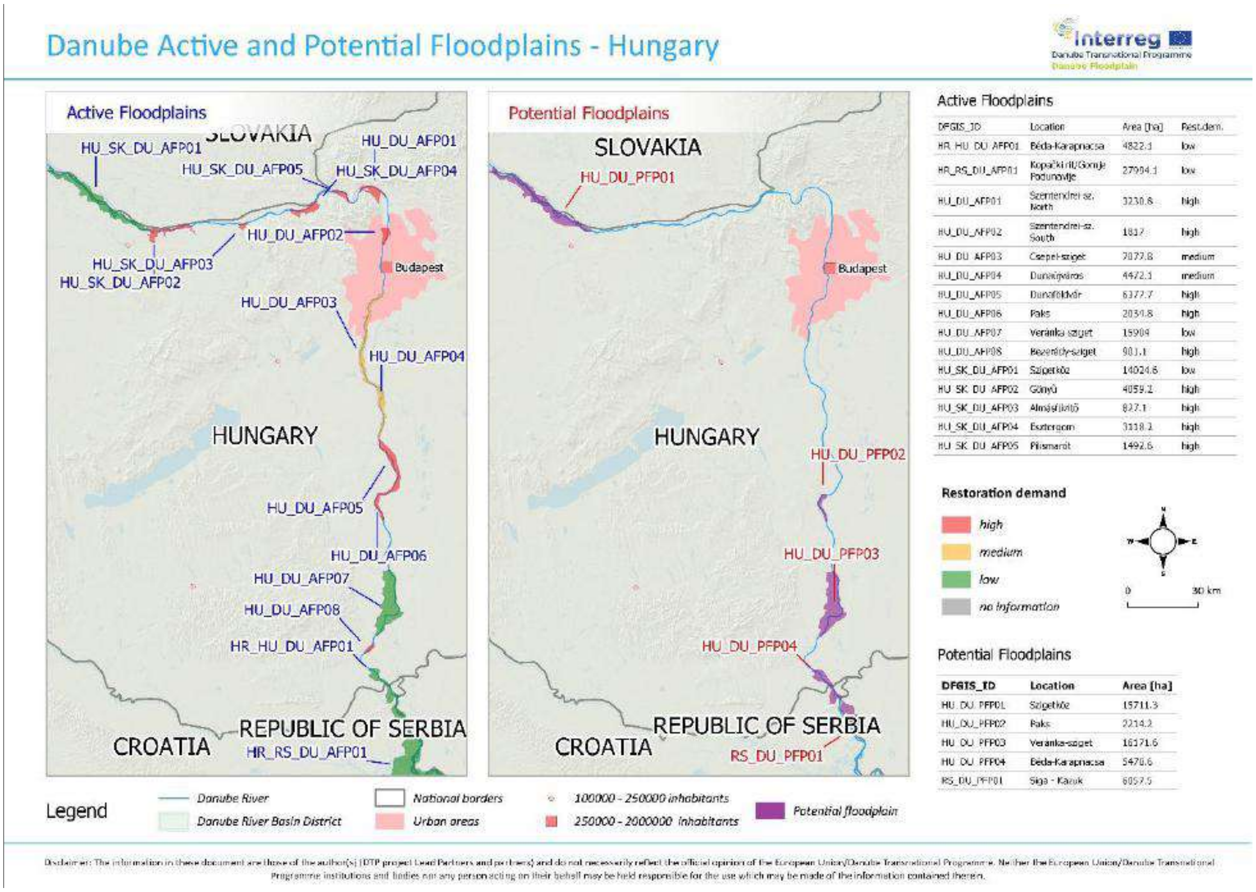


Figure 21: All active and potential floodplains along the Hungarian Danube (Danube Floodplain, 2021)

3.4.2 FEM-Evaluation – active floodplains (AFP) in Hungary

Table 30:0 shows the results of the minimum FEM-parameters for all active floodplains along the Hungarian section of the Danube River*.The relative peak reductions range from 0.05 to 5.22 resulting in two floodplains with high (>5%), four with medium (1-2%) and three with low (<1%). performance. Due to the flow processes in the floodplains, the flood wave is decelerated from 0 to 7 h. Three floodplains show a high (>5h), three a medium (1-5h) and three a low (<1h) performance for the flood wave translation parameter. In the case of a total loss of the active floodplain, the water level in the river channel would change for almost all floodplains more than 50 cm, leading to high performance. Only two floodplains show a low and a medium performance. The lateral connectivity is for one floodplain low and for the others medium. More than 20 protected species are found at all floodplains, resulting in high performance for the first step of the ranking (=need for preservation). For the second step of the ranking, other thresholds are used for the protected species parameter to determine the restoration demand resulting in four floodplains with a medium and five with a low performance. Only at four floodplains (two medium and two high performance), the number of affected buildings per km² is less than 5, leading to five floodplains with a low performance. Most of the active floodplains at the Hungarian section have a low vulnerability against flooding (=high performance). One floodplain shows a medium performance.

Table 30: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Hungarian Danube section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km^2)	land use (-)
Hungary	HU_DU_AFP_01	2.61	0	73	1	56	56	24.48	3.88
	HU_DU_AFP_02	0.05	3	34	3	35	35	25.37	4.25
	HU_DU_AFP_03	1.69	6	76	3	33	33	7.85	4.23
	HU_DU_AFP_04	1.03	7	79	3	33	33	8.52	4.42
	HU_DU_AFP_05	1.49	1	2	3	27	27	4.01	4.05
	HU_DU_AFP_06	0.34	0.5	86	3	27	27	2.61	4.69
	HU_DU_AFP_07	5.22	7	120	3	75	75	12.62	4.42
	HU_DU_AFP_08	0.20	0	125	3	**82**	**82**	0.99	4.95
	HU_HR_DU_AFP_01	1.41	5	128	3	**82**	**82**	0.14	4.91
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km^2	<2
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km^2	2-4
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km^2	>4

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Hungarian Danube section should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. Five floodplains show a high, two a medium and two a low demand for restoration based on the FEM-evaluation (

Table 31:1).

Table 31: Results of the need for preservation and restoration demand for all active floodplains along the Hungarian Danube section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-points
HU_DU_AFP_01	yes	peak reduction, water level change, protected species	high demand	19
HU_DU_AFP_02	yes	protected species, land use	high demand	17
HU_DU_AFP_03	yes	wave translation, water level change, protected species, land use	medium demand	23
HU_DU_AFP_04	yes	wave translation, water level change, protected species, land use	medium demand	23
HU_DU_AFP_05	yes	protected species, land use	high demand	19
HU_DU_AFP_06	yes	water level change, protected specie, land use	high demand	19
HU_DU_AFP_07	yes	peak reduction, wave translation, water level change, protected species, land use	low demand	27
HU_DU_AFP_08	yes	water level change, protected specie, land use, affected buildings	high demand	22
HU_HR_DU_AFP_01	yes	wave translation, water level change, protected species, affected buildings, land use	low demand	27
FEM-ranking	Need for preservation	threshold	restoration demand	threshold
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.4.3 FEM-Evaluation – potential floodplains (PFP) in Hungary

Table 32:2 shows the results of the minimum FEM-parameters for all potential floodplains along the Hungarian Danube. The relative peak reductions range from 0.42 to 11.61%, resulting in two floodplains with high (>2%), one with medium (1-2%) and one with low (<1%) performance. The flood wave is decelerated from 3 up to 9 h. Three floodplains show a medium (1-5h) and one a high (>5h) performance for the flood wave translation parameter. In the case of a total loss of the potential floodplain, the water level in the river channel would increase by more than 50 cm for all potential floodplains leading to a high performance. The lateral connectivity between the river channel and floodplain is still impaired for all potential floodplains along the Hungarian Danube by human interventions, leading to medium performance for all of them. At all floodplains, more than 20 protected species are found. Only at one floodplain less than 1 building is found per km² (=high performance). At three floodplains, the number of affected buildings per km² is between 1 and 5 (=medium performance). The land uses on all four floodplains show a low vulnerability against flooding, resulting in a high performance.

Table 32: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all identified potential floodplains along the Danube River in Hungary. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

		Hydrology		Hydraulics	Ecology		Socio-Economics	
Country	**Floodplain ID**	peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)	affected buildings (n/km²)	land use (-)
Hungary	HU_DU_PFP01	**11.61**	3	66	**3**	70	5.00	4.75
	HU_DU_PFP02	0.42	3	96	**3**	27	2.00	4.56
	HU_DU_PFP03	5.37	**9**	125	**3**	75	3.00	4.81
	HU_DU_PFP04	1.65	5	**130**	**3**	**82**	**0**	**4.90**
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds
	1 (low)	<1 %	<1 h	<10 cm	1	0	>5 n/km²	<2
	3 (medium)	1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	2-4
	5 (high)	>2 %	>5 h	>50 cm	5	>20	<1 n/km²	>4

3.4.4 Example of a floodplain factsheet (HU_DU_AFP07)

The active floodplain Veranka-Sziget (HU_DU_AFP07) has an area of 85.3 km². The FEM-Evaluation showed that there is a need for preservation of this floodplain and a low demand for restoration, due to the high performance of the evaluated parameters. In, the evaluation results are shown for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter.

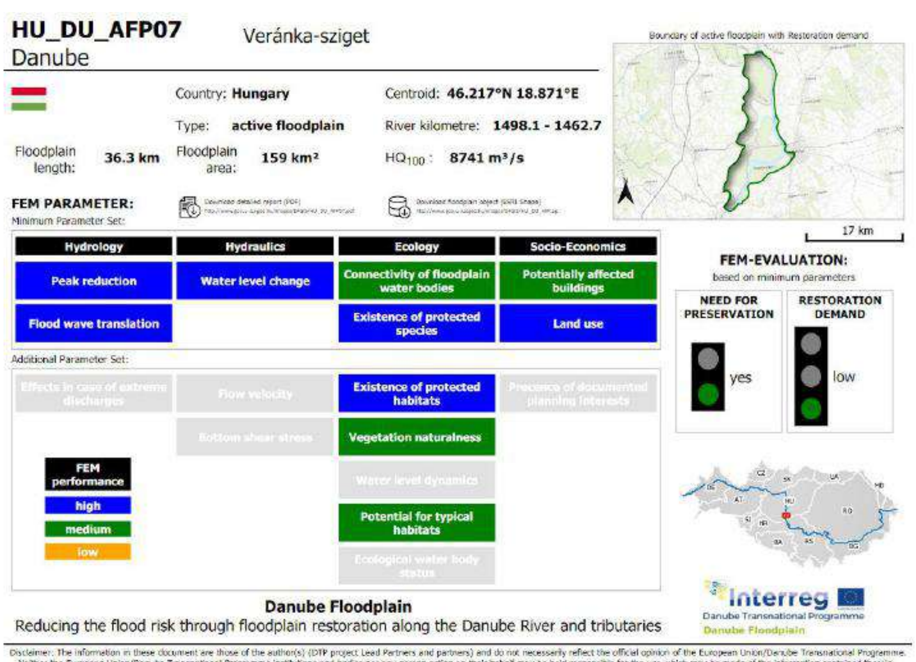


Figure 22: Factsheet of the floodplain HU_DU_AFP07

3.5. Croatia/Serbia

3.5.1 Active and potential floodplains

At the Croatian/Serbian section of the Danube River, five active and three potential floodplains (on the Serbian side) were identified. In Figure 23:, the floodplain ID, the location and the area of all active and potential for all floodplains along the Croatian/Serbian section are shown. For the active floodplain, the restoration demand is also illustrated.

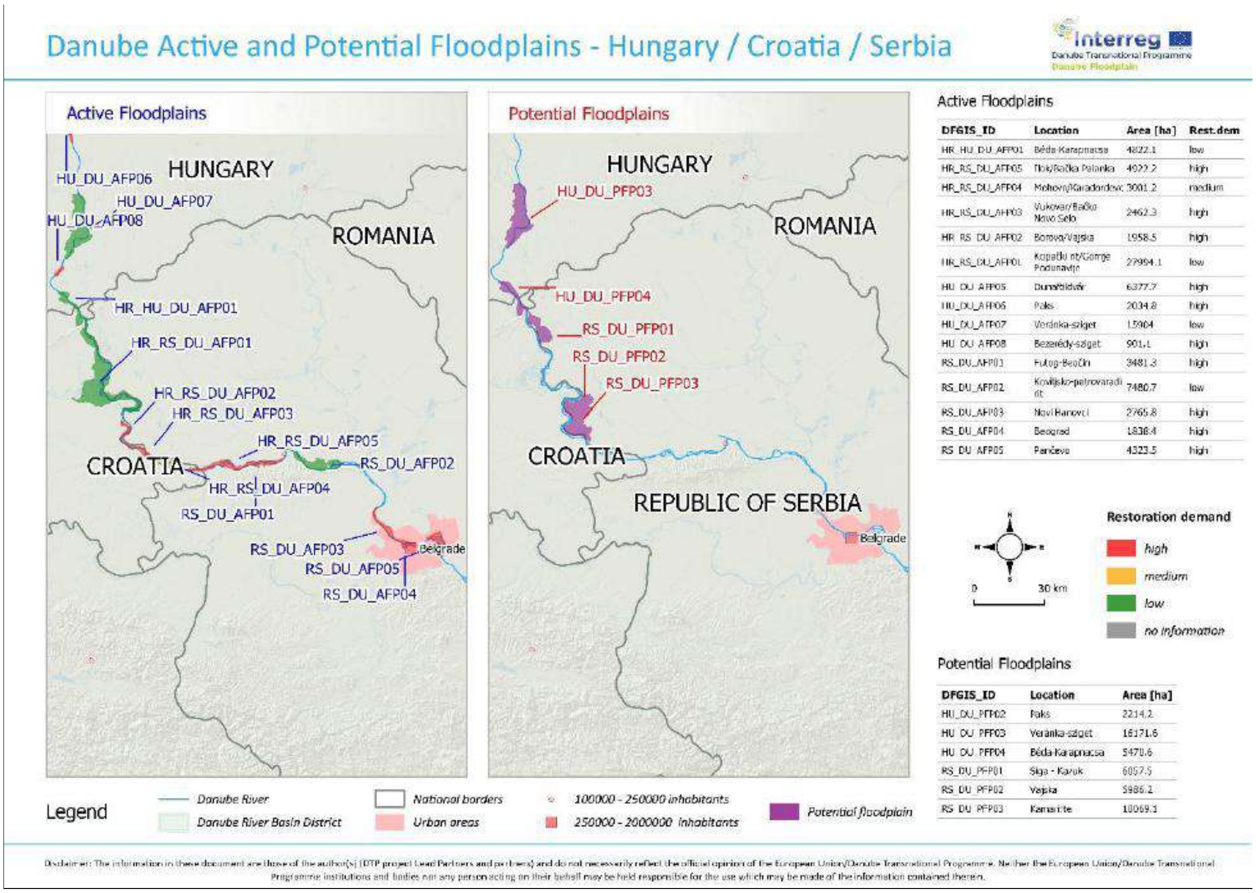


Figure 23: All active and potential floodplains along the Croatian/Serbian Danube section (Danube Floodplain, 2021)

3.5.2 FEM-Evaluation – active floodplains (AFP) at the Croatian/Serbian section of the Danube

Table 30:3 shows the results of the minimum FEM-parameters for all active floodplains along the Croatian/Serbian section of the Danube River. Only one floodplain shows a high relative peak reduction of 4.04%, resulting in high performance (>2%) in the FEM-evaluation. The peak reduction for all other floodplains is less than 1%, leading to a low performance (<1%). Due to the flow processes in the floodplains, the flood wave is decelerated from 2 to 41.5 h. Two floodplains show a high (>5h) and three a medium (1-5h) performance for the flood wave translation parameter. In the case of a total loss of the active floodplain, the water level in the river channel would change only for one floodplain above 50 cm, leading to high performance. For all the other floodplains, the water level change in the river channel would be between 15 and 48 cm, resulting in medium performance. The lateral connectivity between the river channel and floodplain is impaired for four out five active floodplains along the Croatian/Serbian Danube by human interventions, leading to low performance. One floodplain achieves a medium performance in terms of connectivity. More than 20 protected species are found at all floodplains, resulting in high performance for the first step of the ranking (=need for preservation). For the second step of the ranking, other thresholds are used for the protected species parameter to determine the restoration demand resulting in two floodplains with a high and three with a medium performance*. At three floodplains, the number of affected buildings per km² is between 1-5 leading to medium performance. Two floodplains achieve a high performance for this parameter. All floodplains at the Croatian/Serbian Danube have a low vulnerability against flooding (=high performance).

Table 33: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Croatian/Serbian Danube section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	land use (-)
Croatia, Serbia	RS_HR_DU_AFP_01	4.04	41.5	70	1	**144**	**144**	1.78	4.90
	RS_HR_DU_AFP_02	0.14	2	15	1	80	80	0.87	4.80
	RS_HR_DU_AFP_03	0.25	2.5	30	1	80	80	0.53	4.97
	RS_HR_DU_AFP_04	0.28	2.5	16	3	103	103	1.20	4.96
	RS_HR_DU_AFP_05	0.68	5	48	1	87	87	3.70	4.82
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	<2
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	2-4
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	>4

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Croatian/Serbian Danube section should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. One floodplain shows a low demand for restoration. Three floodplains have a high and one a medium demand for restoration based on the FEM-evaluation (Table 34:4).

Table 34: Results of the need for preservation and restoration demand for all active floodplains along the Croatian/Serbian Danube section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-points
RS_HR_DU_AFP_01	yes	peak reduction, water level change, wave translation, protected species, land use	low demand	29
RS_HR_DU_AFP_02	yes	protected species, affected buildings, land use	high demand	21
RS_HR_DU_AFP_03	yes	protected species, affected buildings, land use	high demand	21
RS_HR_DU_AFP_04	yes	protected species, land use	medium demand	23
RS_HR_DU_AFP_05	yes	protected species, land use	high demand	19
FEM-ranking	Need for preservation	threshold	restoration demand	threshold
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.5.3 FEM-Evaluation – potential floodplains (PFP) at the Croatian/Serbian section of the Danube

Table 32:5 shows the results of the minimum FEM-parameters for all potential floodplains along the Croatian/Serbian Danube. The potential floodplains at this section are on the Serbian side. The relative peak reductions range from 0.92 to 2.73%, resulting in one floodplain with high (>2%) and two with low (<1%) performance. All floodplains show a high performance for the flood wave translation parameter (>5h). In the case of a total loss of the potential floodplain, the water level in the river channel would increase by more than 50 cm for two potential floodplains leading to a high performance. For one potential floodplain, the water level would increase only 9 cm (=low performance). The lateral connectivity between river and floodplain water bodies would be for two floodplains restored resulting in high performance. At the other floodplain, the connectivity would be partly impaired (=medium performance). At all floodplains, more than 20 protected species are found*. Only at one floodplain, the number of affected buildings per km² is between 1 and 5 (=medium performance). For the other twos, less than 1 building per km² is found. The land uses have for two floodplains a medium and for one a low vulnerability against flooding.

Table 35: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all identified potential floodplains along the Croatian/Serbian Danube River. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

Country	Floodplain ID	Hydrology		Hydraulics	Ecology		Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)	affected buildings (n/km²)	land use (-)
Serbia	RS_DU_PFP01	2.73	16	66	3	173	0.17	4.95
	RS_DU_PFP02	0.92	11	9	5	240	0.25	3.05
	RS_DU_PFP03	0.92	8	193	5	240	1.62	3.30
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds
	1 (low)	<1 %	<1 h	<10 cm	1	0	>5 n/km²	<2
	3 (medium)	1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	2-4
	5 (high)	>2 %	>5 h	>50 cm	5	>20	<1 n/km²	>4

*) Disclaimer on the number of protected species in the common HR-RS section of the Danube River:

Not yet having Natura 2000 fully transposed in the relevant legislative and aiming at providing as harmonised data as possible for the common HR-RS section of the Danube River, the Serbian Project partner (JCI) used available information on protected species stated in the EMERALD network for RS_HR_DU_AFP01, RS_HR_DU_AFP04 and RS_HR_DU_AFP05 where protected areas "Gornje Podunavlje", "Karadjordjevo" and "Tikvara" and "Begecka Jama" (respectively) exist. The exercise of counting the total number of protected species in these active floodplains is carried out based on NATURA 2000 data for HR and EMERALD information for RS and agreed between two partners (CW and JCI). Having no data in RS for another two common active floodplains RS_HR_DU_AFP02 and RS_HR_DU_AFP03, the number of protected species is based exclusively on the Croatian data.

3.5.4 Example of a floodplain factsheet (HR_RS_DU_AFP01)

The active floodplain HR_RS_DU_AFP01 is one of the largest floodplains with an area of 279.9 km². The FEM-Evaluation showed that there is a need for preservation of this floodplain and a low demand for restoration, due to the high performance of the evaluated parameters. The evaluation results are shown for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter.

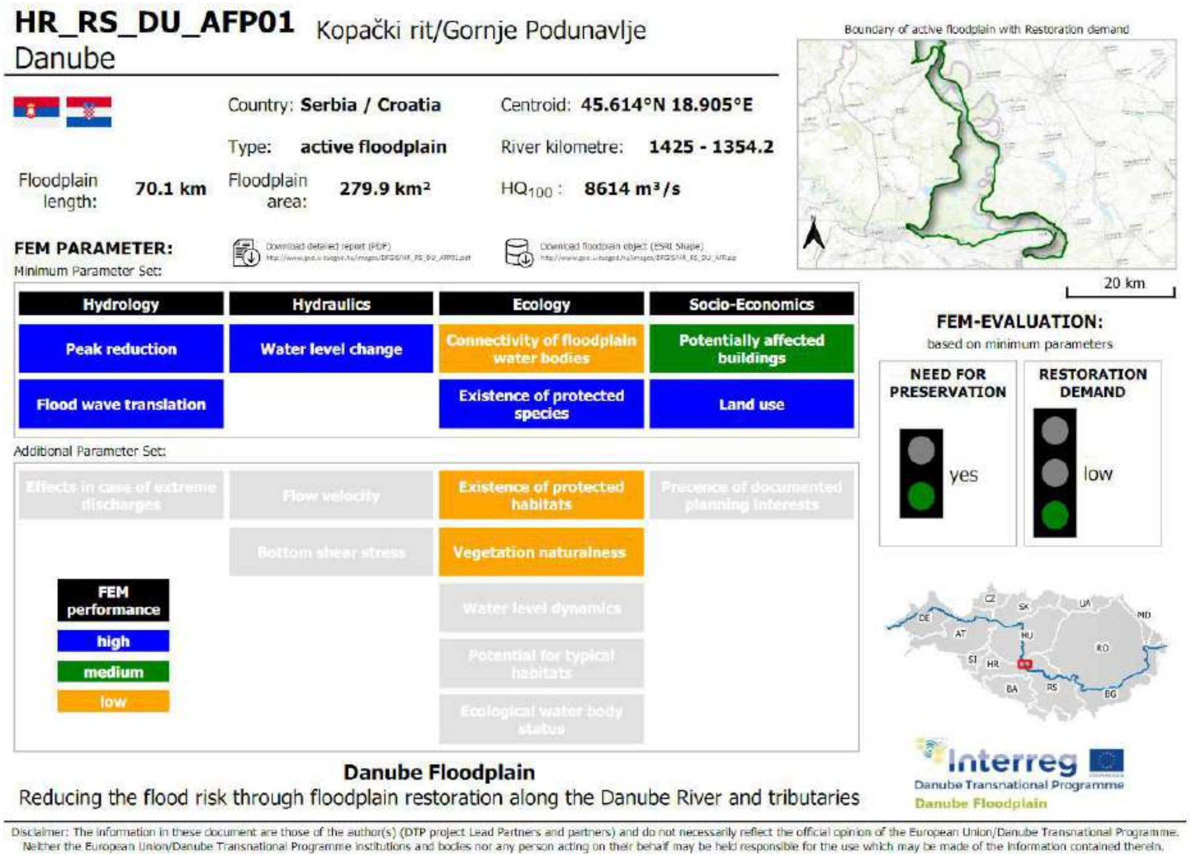


Figure 24: Factsheet of the floodplain HR_RS_DU_AFP01

3.6. Serbia

3.6.1 Active floodplains

At the Serbian section of the Danube River, five active and three potential floodplains were identified. The potential floodplains were presented in the last chapter. In Figure 25:5, the floodplain ID, the location, the area and the restoration demand of all active floodplains along the Serbian section are shown.

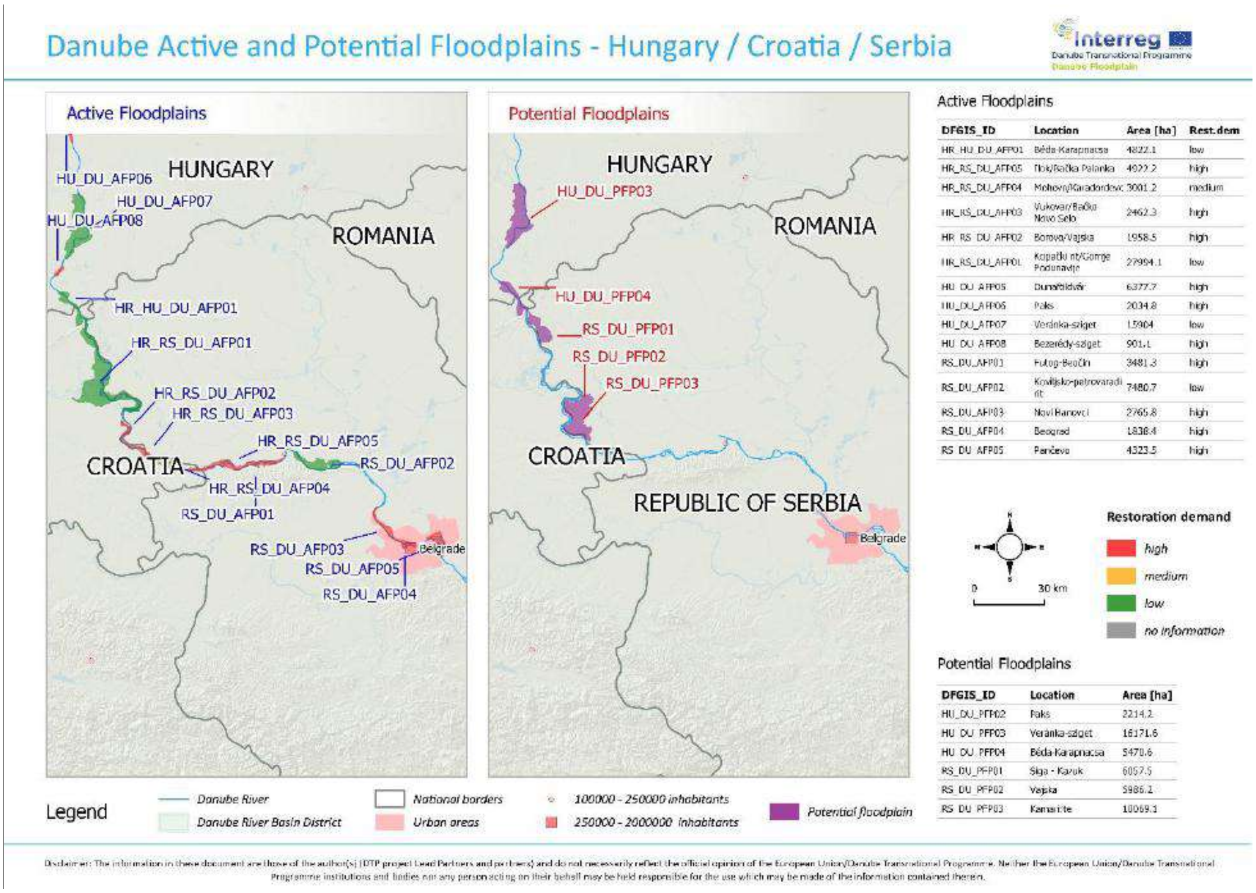


Figure 25: All active and potential floodplains along the Serbian Danube section (Danube Floodplain, 2021)

3.6.2 FEM-Evaluation – active floodplains (AFP) in Serbia

Table 36:6 shows the results of the minimum FEM-parameters for all active floodplains along the Serbian section of the Danube River. Only one floodplain shows a relative peak reduction above 2%, resulting in high performance in the FEM-evaluation. The peak reduction for all other floodplain is less than 1%, leading to low performance (<1%). Due to the flow processes in the floodplains, the flood wave is decelerated from 2.5 to 7.5 h. One floodplains shows a high (>5h) and four a medium (1-5h) performance for the flood wave translation parameter. In the case of a total loss of the active floodplain, the water level in the river channel would change only for one floodplain above 10 cm, leading to one medium and four low performances. The lateral connectivity between the river channel and floodplain is impaired for all active floodplains leading to two low and three medium performances for the connectivity parameter. More than 20 protected species are found at all floodplains, resulting in high performance for the first step of the ranking (=need for preservation). For the second step of the ranking, other thresholds are used for the protected species parameter to determine the restoration demand resulting in two floodplains with a high and three with a medium performance*. At three floodplains, the number of affected buildings per km² is less than 1 leading to a high performance. The other two floodplains receive a low and a medium performance. All floodplains at the Serbian section have a low vulnerability against flooding (=high performance).

Table 36: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Serbian Danube section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	land use (-)
Serbia	RS_DU_AFP_01	0.66	3	17	1	59	59	22.20	4.62
	RS_DU_AFP_02	2.21	7.5	8	1	**271**	**271**	0.13	4.95
	RS_DU_AFP_03	0.02	4	3	3	70	70	0.00	4.97
	RS_DU_AFP_04	0.27	3	1	3	60	60	0.27	4.79
	RS_DU_AFP_05	0.01	2.5	1	3	149	149	1.53	4.71
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	<2
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	2-4
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	>4

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Serbian Danube section should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. One floodplain shows a low demand for restoration. All the other floodplains have high demand for restoration based on the FEM-evaluation (Table 37:7).

Table 37: Results of the need for preservation and restoration demand for all active floodplains along the Serbian Danube section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-poi
RS_DU_AFP_01	yes	protected species, land use	high demand	17
RS_DU_AFP_02	yes	peak reduction, wave translation, protected species, affected buildings, land use	low demand	27
RS_DU_AFP_03	yes	protected species, affected buildings, land use	high demand	21
RS_DU_AFP_04	yes	protected species, affected buildings, land use	high demand	21
RS_DU_AFP_05	yes	protected species, land use	high demand	21
FEM-ranking	Need for preservation	threshold	restoration demand	thresho
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.6.3 Example of a floodplain factsheet (RS_DU_AFP02)

The active floodplain RS_DU_AFP02 is 74.8 km² large. The FEM-Evaluation showed that there is a need for preservation of this floodplain and a low demand for restoration, due to the high performance of the evaluated parameters. In **Eroare! Fără sursă de referință.**26, the evaluation results are shown for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter.

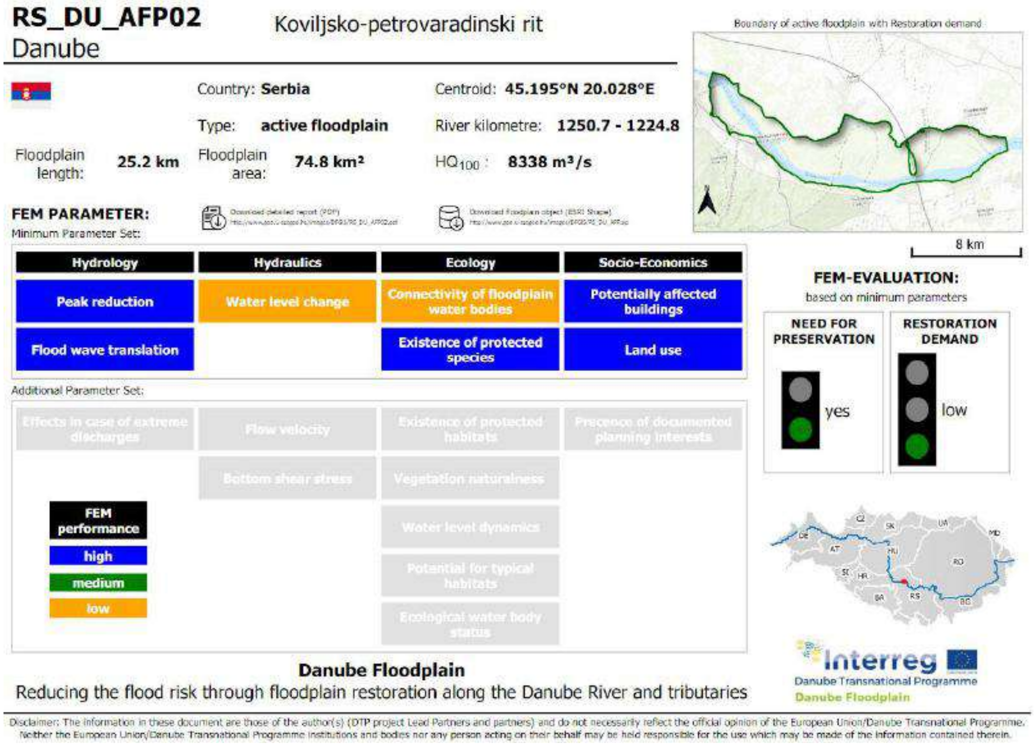


Figure 26: Factsheet of the floodplain RS_DU_AFP02

3.7. Bulgaria/Romania

3.7.1 Active and potential floodplains

At the Bulgarian/Romanian section of the Danube River, six active and five potential floodplains were identified. In

Figure *27:*, the floodplain ID, the location, the area and the restoration demand of all active and potential floodplains along the Bulgarian/Romanian section are shown. For the active floodplain, the restoration demand is also illustrated.

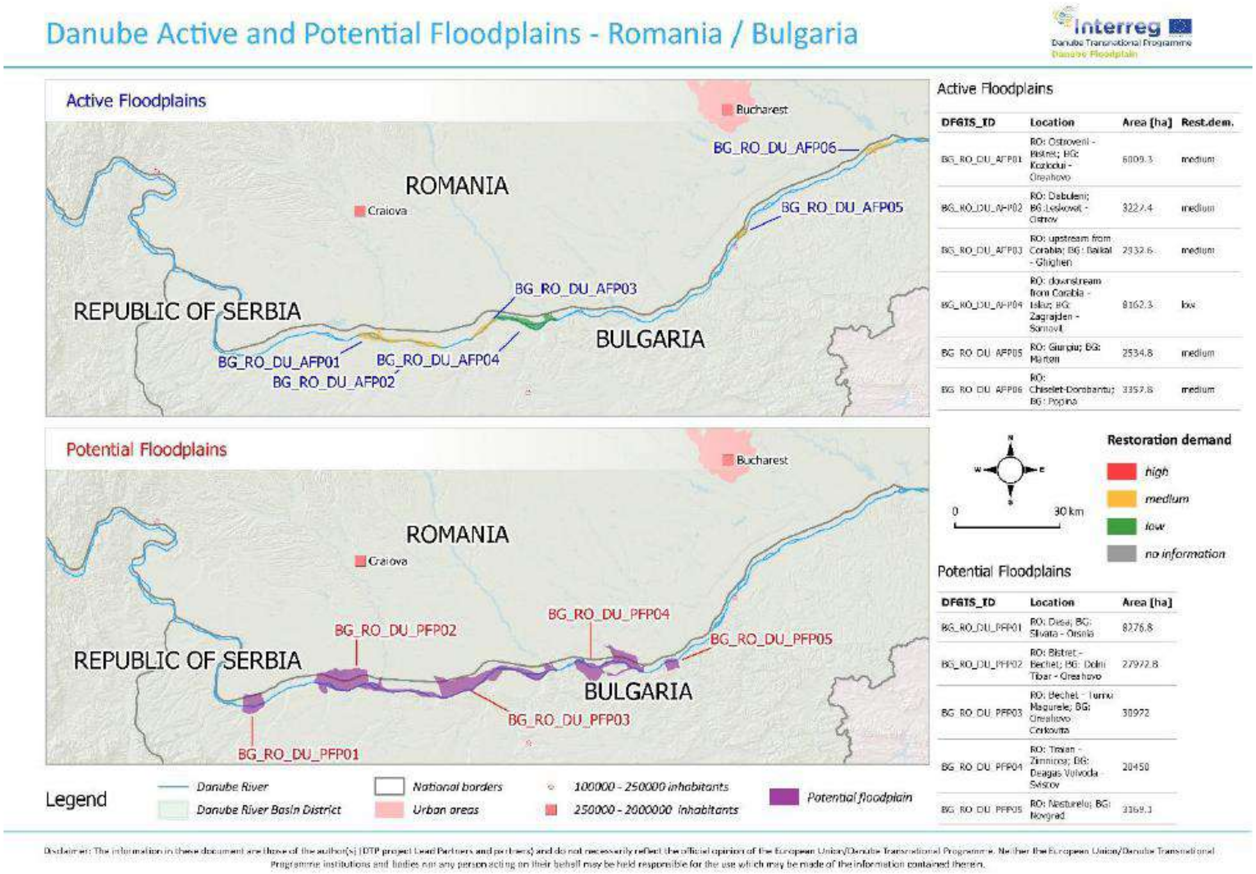


Figure 27: All active and potential floodplains along the Bulgarian/Romanian Danube section (Danube Floodplain, 2021

3.7.2 FEM-Evaluation – active floodplains (AFP) at the Bulgarian/Romanian section of the Danube

Table 38*:*8 shows the results of the minimum FEM-parameters for all active floodplains along the Bulgarian/Romanian section of the Danube River. All floodplains show a relative peak reduction below 1%, resulting in low performance in the FEM-evaluation. Due to the flow processes in the floodplains, the flood wave is decelerated from 1 to 4 h. Hence, all floodplains were evaluated with a 3 (=medium performance). In the case of a total loss of the active floodplain, the water level in the river channel would change between 12 and 13 cm for three floodplains (=medium performance) and between 4 and 8 cm (=low performance) for the other three. The lateral connectivity between the river channel and floodplain is impaired for all active floodplains leading to medium performances for the connectivity parameter. More than 20 protected species are found at all floodplains, resulting in high performance for the first step of the ranking (=need for preservation). For the second step of the ranking, other thresholds are used for the protected species parameter to determine the

restoration demand resulting in five floodplains with a high and one with a medium performance. At all floodplains less than 1 building per km² is found (=high performance). All floodplains at the Bulgarian/Romanian section have a low vulnerability against flooding (=high performance).

Table 38: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Bulgarian/Romanian Danube section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economi	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	la
Bulgaria, Romania	RO_BG_DU_AFP_01	0.22	1	8	3	176	176	0.38	
	RO_BG_DU_AFP_02	0.01	2	4	3	164	164	0.00	
	RO_BG_DU_AFP_03	0.01	2	7	3	131	131	0.24	
	RO_BG_DU_AFP_04	0.06	4	12	3	161	161	0.21	
	RO_BG_DU_AFP_05	0.03	2	13	3	165	165	0.28	
	RO_BG_DU_AFP_06	0.01	2	12	3	67	67	0.15	
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thr
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Bulgarian/Romanian Danube section should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. All floodplains show a medium demand for restoration (Table 39:9).

Table 39: Results of the need for preservation and restoration demand for all active floodplains along the Bulgarian/Romanian Danube section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-poi
RO_BG_DU_AFP_01	yes	protected species, affected buildings, land use	medium demand	23
RO_BG_DU_AFP_02	yes	protected species, affected buildings, land use	medium demand	23
RO_BG_DU_AFP_03	yes	protected species, affected buildings, land use	medium demand	23
RO_BG_DU_AFP_04	yes	protected species, affected buildings, land use	medium demand	25
RO_BG_DU_AFP_05	yes	protected species, affected buildings, land use	medium demand	25
RO_BG_DU_AFP_06	yes	protected species, affected buildings, land use	medium demand	25
FEM-ranking	Need for preservation	threshold	restoration demand	thresho
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.7.3 FEM-Evaluation – potential floodplains (PFP) at the Bulgarian/Romanian section of the Danube

Table 40:0 shows the results of the minimum FEM-parameters for all potential floodplains along the Bulgarian/Romanian Danube. All floodplains show a relative peak reduction below 1%, resulting in low performance in the FEM-evaluation. Due to the flow processes in the floodplains, the flood wave is decelerated from 1 to 22 h leading to two floodplains with high and three with medium performances. In the case of a total loss of the potential floodplain, the water level in the river channel would change between 6 and 84 cm resulting in two medium and low performances. Only one floodplain receives a high performance (>50 cm). All floodplains are still partly impaired by human interventions leading to medium performance for the lateral connectivity. More than 100 protected species are found at all floodplains, resulting in high performance for this parameter. At most floodplains (only one exception) less than 1 building per km² is found (=high performance). At one floodplain 1.23 buildings per km² are found (=medium performance). Three out of five floodplains at the Bulgarian/Romanian section have a low vulnerability against flooding (=high performance).The other two have a medium vulnerability (=medium performance).

Table 40: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all identified potential floodplains along the Bulgarian/Romanian Danube River. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

Country	Floodplain ID	Hydrology		Hydraulics	Ecology		Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)	affected buildings (n/km²)	lanc (
Bulgaria, Romania	BG_RO_DU_PFP01	0.04	1	6	3	153	0.05	4
	BG_RO_DU_PFP02	0.27	9	23	3	205	0.02	3
	BG_RO_DU_PFP03	0.67	22	84	3	198	0.09	4
	BG_RO_DU_PFP04	0.19	4	7	3	200	0.23	3
	BG_RO_DU_PFP05	0.05	2	11	3	157	1.23	4
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thre
	1 (low)	<1 %	<1 h	<10 cm	1	0	>5 n/km²	[illegible]
	3 (medium)	1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	2
	5 (high)	>2 %	>5 h	>50 cm	5	>20	<1 n/km²	[illegible]

3.7.4 Example of a floodplain factsheet (BG_RO_DU_AFP01)

The active floodplain BG_RO_DU_AFP01 is 60.1 km² large. The FEM-Evaluation showed that there is a need for preservation of this floodplain and a medium demand for restoration, due to the performance of the evaluated parameters. In **Eroare! Fără sursă de referință.**, the evaluation results are shown for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter. The performance is determined using the selected thresholds presented in chapter 2

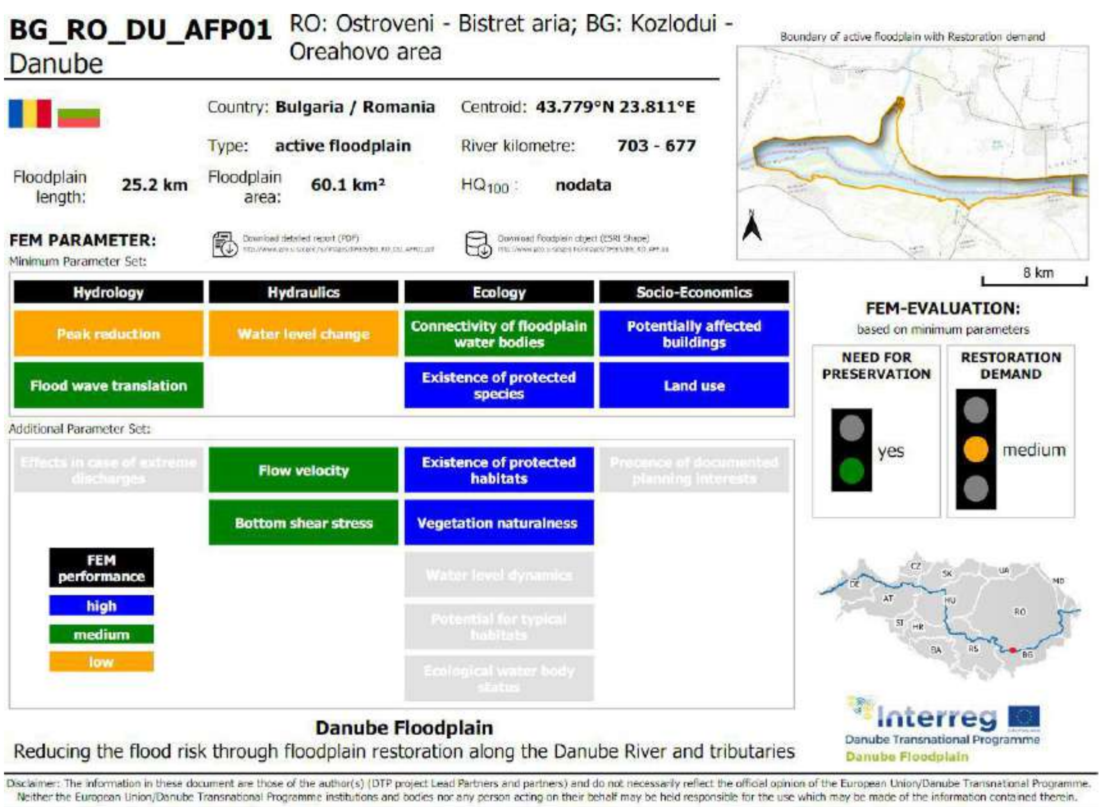


Figure 28: *Factsheet of the floodplain BG_RO_DU_AFP01*

3.8. Romania

3.8.1 Active and potential floodplains

At the Romanian section of the Danube River, four active and five potential floodplains were identified. In Figure 29:, the floodplain ID, the location, the area and the restoration demand of all active and potential floodplains along the Romanian section are shown. For the active floodplain, the restoration demand is also illustrated.

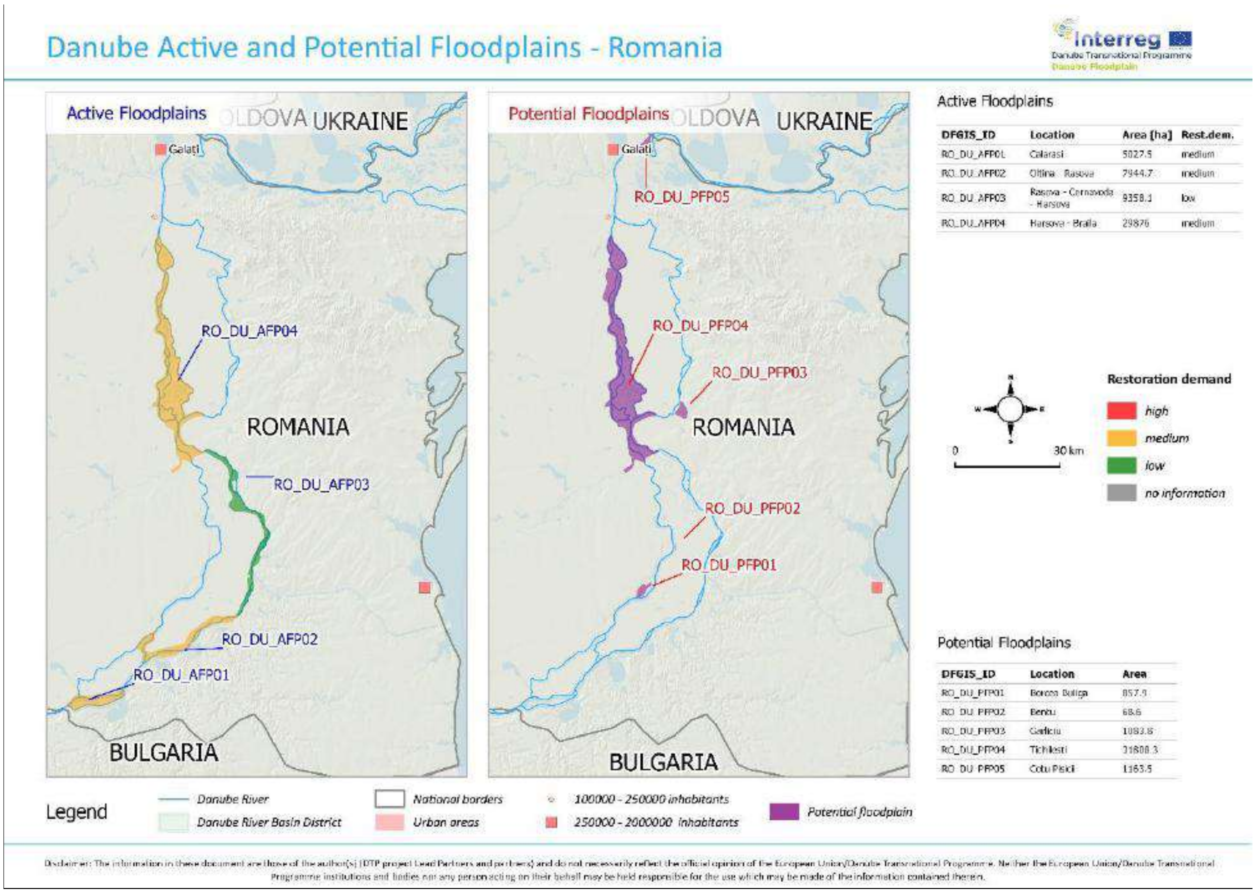


Figure 29: All active and potential floodplains along the Romanian Danube section (Danube Floodplain, 2021)

3.8.2 FEM-Evaluation – active floodplains (AFP) in Romania

Table 41:1 shows the results of the minimum FEM-parameters for all active floodplains along the Romanian section of the Danube River. All floodplains show a relative peak reduction below 1%, resulting in low performance in the FEM-evaluation. Due to the flow processes in the floodplains, the flood wave is decelerated by 1 to 39 h leading to two floodplains with high and medium performances. In the case of a total loss of the active floodplain, the water level in the river channel would change between 12 and 57 cm resulting in three medium (10-50 cm) and one high (>50 cm) performances. All floodplains are still partly impaired by human interventions leading to medium performance for the lateral connectivity. More than 100 protected species are found at all floodplains, resulting in high performance for both ranking steps (need for preservation, restoration demand). At all floodplains less than 1 building per km² is found (=high performance). All active floodplains along the Romanian section show a low vulnerability against flooding (=high performance).

Table 41: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all active floodplains along the Romanian Danube section. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

country	Floodplain	Hydrology		Hydraulics	Ecology			Socio-Economi	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)		affected buildings (n/km²)	lar
Romania	RO_DU_AFP_01	0.02	1	24	3	116	116	0.56	
	RO_DU_AFP_02	0.27	5	34	3	161	161	0.14	
	RO_DU_AFP_03	0.44	11	57	3	180	180	0.45	
	RO_DU_AFP_04	0.23	39	12	3	240	240	0.13	
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thr
	low	<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	
	medium	1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	
	high	>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	

Based on the FEM-assessment, the need for preservation and the restoration demand are determined. All active floodplains along the Romanian Danube section should be preserved because at least one parameter is evaluated with 5 points (high performance) at each floodplain. Two floodplains show a low and two a medium demand for restoration (Table 42:2).

Table 42: Results of the need for preservation and restoration demand for all active floodplains along the Bulgarian/Romanian Danube section. In the last row, thresholds for the need for preservation (if one minimum FEM-parameter is evaluated with 5 – high performance, the floodplain has to be preserved) and restoration demand (<23 FEM-points – high, 23-26 points – medium, ≥ 27 low demand)

Floodplain ID	Need for preservation	Parameters with high performance	Demand for restoration	FEM-poi
RO_DU_AFP_01	yes	protected species, affected buildings, land use	medium demand	25
RO_DU_AFP_02	yes	protected species, affected buildings, land use	medium demand	25
RO_DU_AFP_03	yes	wave translation, water level, change, protected species, affected buildings, land use	low demand	29
RO_DU_AFP_04	yes	wave translation, protected species, affected buildings, land use	low demand	27
FEM-ranking	Need for preservation	threshold	restoration demand	thresho
	yes	at least one parameter evaluated with 5	low	≥ 27
			medium	23-26
	no	no parameter evaluated with 5	high	<23

3.8.3 FEM-Evaluation – potential floodplains (PFP) in Romania

Table 43:3 shows the results of the minimum FEM-parameters for all potential floodplains along the Romanian Danube. All floodplains show a relative peak reduction below 1%, resulting in low performance in the FEM-evaluation. Due to the flow processes in the floodplains, the flood wave is decelerated from 0.5 to 3 h leading to one floodplain with low (<1h) and four with medium (1-5h) performance. In the case of a total loss of the potential floodplain, the water level in the river channel would change for two floodplains above 10 cm (13 cm and 28 cm = medium performance). For all other floodplains the water level change would be below 10 cm (=low performance). All floodplains are still partly impaired by human interventions leading to medium performance for the lateral connectivity. More than 20 protected species are found at all floodplains, resulting in high performance for this parameter. At most floodplains (only one exception) less than 1 building per km² is found (=high performance). At one floodplain 2.15 buildings per km² are found (=medium performance). Four out of five potential floodplains at the Romanian section have a medium vulnerability against flooding (=medium performance).The other one has a low vulnerability (=high performance).

Table 43: Results of the minimum Floodplain Evaluation Matrix (FEM) parameters for all identified potential floodplains along the Romanian Danube River. In the last row, thresholds for each parameter to determine the performance of each floodplain. High performance (5 points) in blue. Medium performance (3 points) in green. Low performance in orange (1 point).

Country	Floodplain ID	Hydrology		Hydraulics	Ecology		Socio-Economics	
		peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species (-)	affected buildings (n/km²)	land use (-)
Romania	RO_DU_PFP01	0.14	1	6	3	83	0	2.96
	RO_DU_PFP02	0.05	0.5	1	3	79	0	3.00
	RO_DU_PFP03	0.08	1	13	3	61	0.83	3.19
	RO_DU_PFP04	0.03	3	28	3	281	0.24	4.83
	RO_DU_PFP05	0.07	1	6	3	33	2.15	3.04
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds
	1 (low)	<1 %	<1 h	<10 cm	1	0	>5 n/km²	<2
	3 (medium)	1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	2-4
	5 (high)	>2 %	>5 h	>50 cm	5	>20	<1 n/km²	>4

3.8.4 Example of a floodplain factsheet (BG_RO_DU_AFP01)

The active floodplain RO_DU_AFP04 is with 298.8 km² the largest one along the Danube River. The FEM-Evaluation showed that there is a need for preservation of this floodplain and a medium demand for restoration, due to the performance of the evaluated parameters. In **Eroare! Fără sursă de referință.**, the evaluation results are shown for each parameter and the coloured background indicates the performance (high – blue, medium – green, low – yellow) of the parameter. The performance is determined using the selected thresholds presented in chapter 2

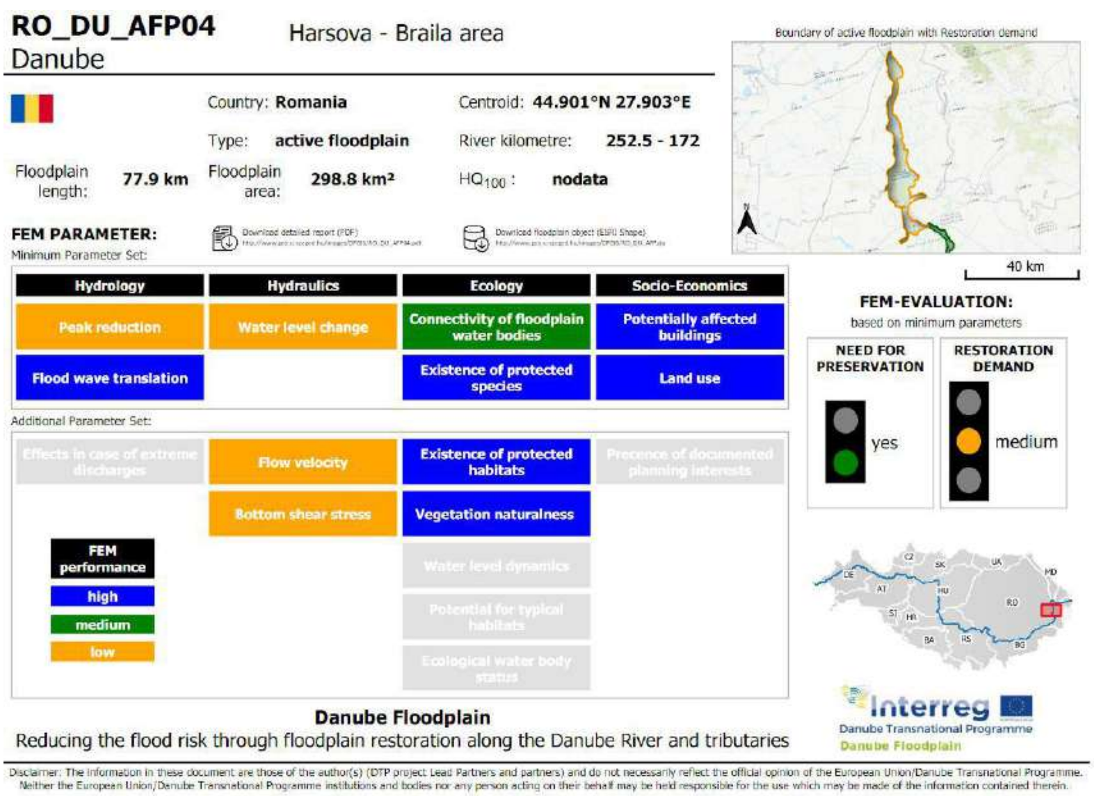


Figure 30: Factsheet for the active floodplain RO_DU_AFP04

3.9. Basin-wide analysis

3.9.1 Analysis of active, potential and former floodplains

In this section, selected results from the basin-wide analyses in the Danube Floodplain project are presented for active, potential and former floodplains along the Danube River. Since the Danube Delta is a special case, it was not included in the 50 identified hydraulically active floodplains and not evaluated with the FEM. Therefore, it also was excluded from the following analysis. In Figure 31:, all floodplains were sorted from up- to downstream and each floodplain area is shown. A trendline was inserted that shows only a slight increase in the area towards the lower part of the Danube River. Out of the 50 floodplains (without the Danube Delta) only five floodplains have an area above 150 km² and are located in different countries (DE, AT, HU, RS-HR, RO). 32 floodplains have an area below 50 km² and the mean value for all floodplains lies at 57.63 km².

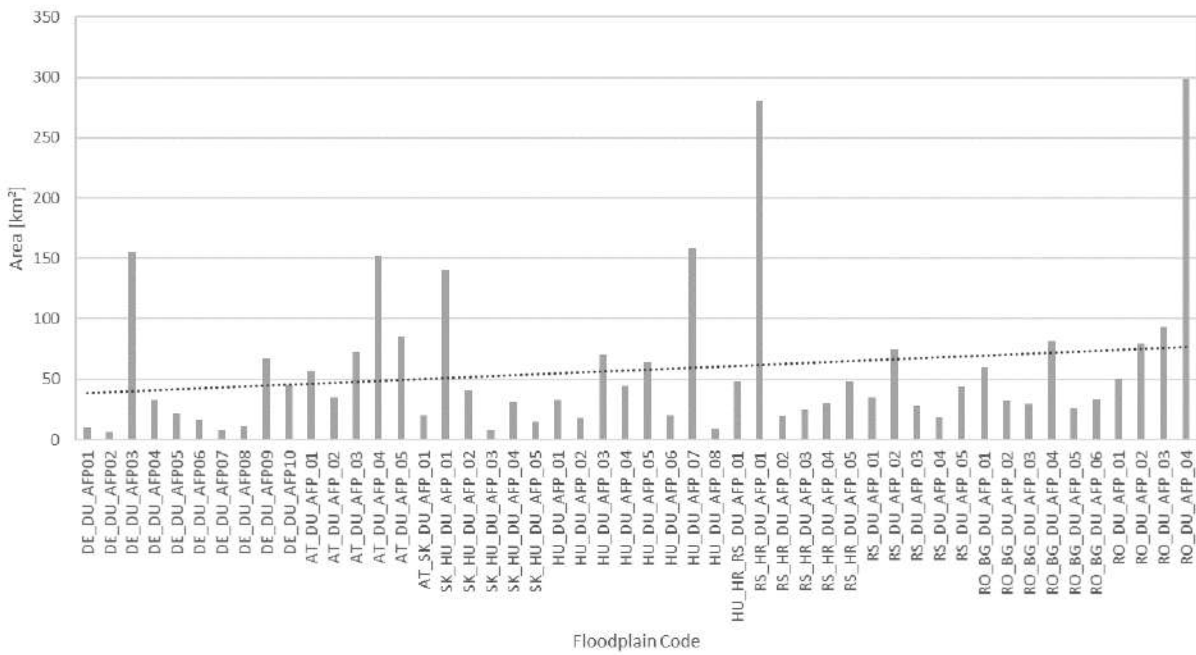


Figure 31: Area distribution of active Danube Floodplains from up- to downstream including the trendline

In total, 24 potential floodplains were identified. Half of them are extensions of active floodplains. The other half are additional areas that are now flooded in the case of a HQ_{100}. In Figure 32:, the areas of the potential floodplains are presented. The orange bar only shows the additional floodplain area. The yellow one illustrates the total area of the extension and the active floodplain.

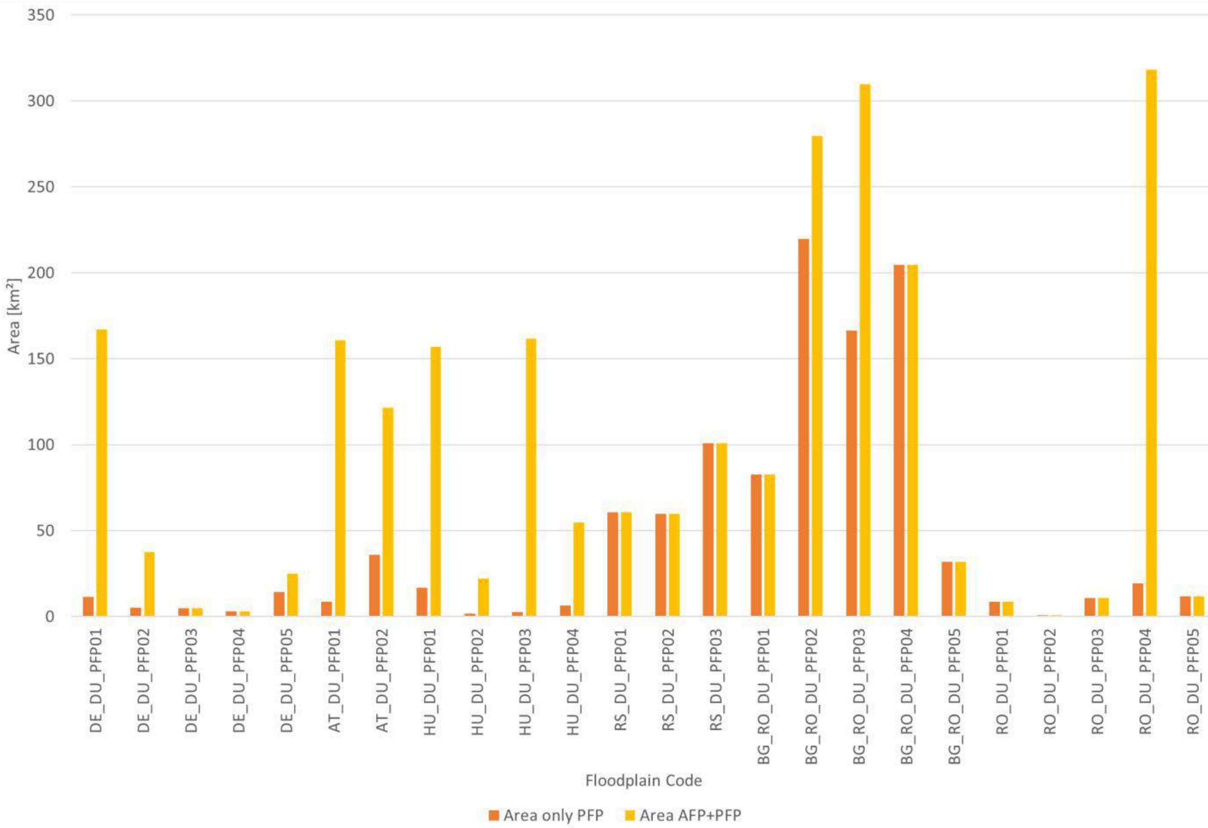


Figure 32: Area distribution of potential floodplains (in orange area of the additional area; in yellow: area of active + additional area)

In Figure 33:, the active, potential and former floodplains in each country are compared with each other. The detailed analysis and identification of former floodplains were not part of the WP3 and will be done in the extension of the Danube Floodplain project in Activity 6.2. For this report, BOKU did a preliminary analysis of former floodplain areas based on the HQ_{1000} inundation outlines available from the Danube FLOODRISK project (https://environmentalrisks.danube-region.eu/projects/danube-floodrisk/) for all countries except Germany. It was assumed that during a HQ_{1000}, flood protection measures would be overtopped, and the former floodplain area would be flooded. This approach was a simplification since it was not possible in the project's scope to remove all flood protection measures along the Danube River and calculate the inundation area of a HQ100 to show the former floodplain areas. For the detailed analysis and identification of former floodplains, it is recommended to look at the Deliverable 6.2.3 (Danube Floodplain, in prep.). Most of the former floodplain areas were in Romania, followed by Hungary, Serbia, Slovakia and Bulgaria (Figure 33:). To assess how much of the former floodplain is still a hydraulically active or a potential floodplain, the percentage of the active and active + potential floodplains from the former floodplains is illustrated for each country in Figure 34:. This comparison shows that Austria (75%) and Croatia (95%) preserved most of the former floodplains as hydraulically active floodplains. Austria can increase the preserved percentage of hydraulically floodplains even to 84% if the potential floodplains are also reconnected. In Romania, 32% of the former floodplain area still exists as active floodplains. In the other countries (Slovakia, Hungary, Serbia, Bulgaria) the percentage is less than 15%. Bulgaria can increase the percentage from 12% with the potential floodplains to 37%.

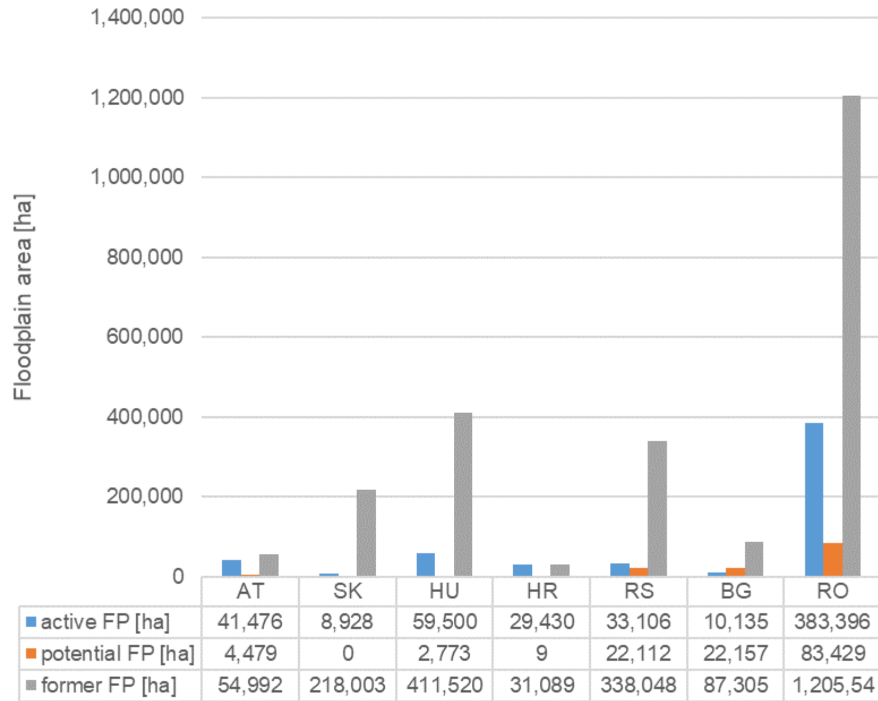


Figure 33: Area analysis of active, potential and former floodplains along the Danube River (without Germany due to data availability)

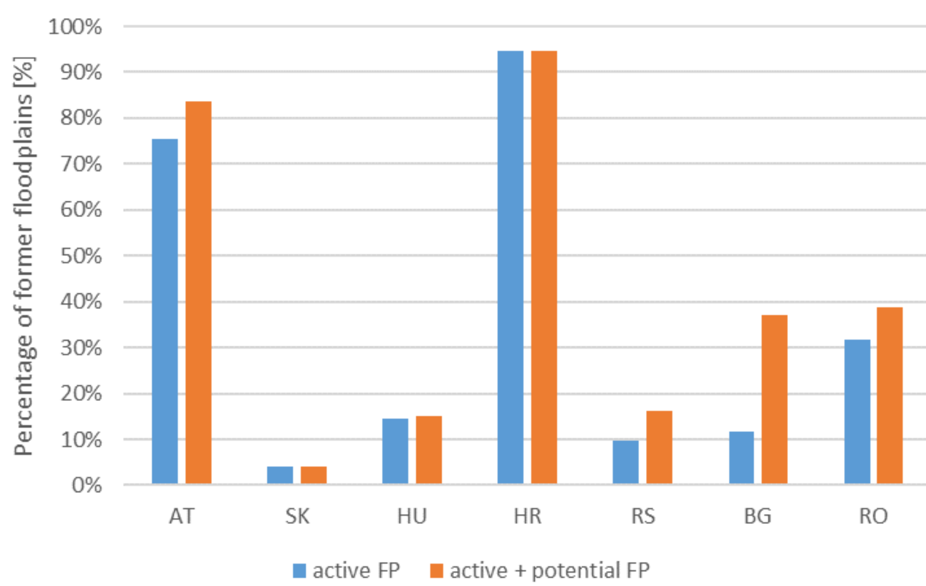


Figure 34: Area analysis of active, potential and former floodplains in relation to the former floodplains along the Danube River (without Germany due to data availability)

Figure 35*:* shows the percentage of the floodplain area for each country. Transboundary floodplains are presented independently and not included to one country (e.g. 8% of the floodplain area is along the Slovakian/Hungarian border). Almost half (46%) of the active floodplain area is found at the Middle Danube. The other 54% are distributed equally between the Upper and Lower Danube sections (Figure 36). The potential floodplains identified in this project are located mostly (53%) at the Lower Danube. 26% are found at the middle section and 22% at the Upper Danube.

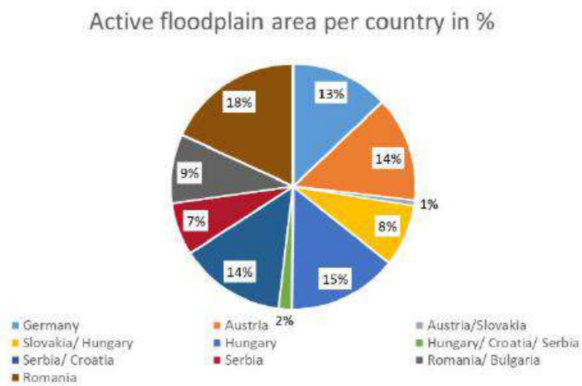


Figure 35: Active floodplain area per country in percentage

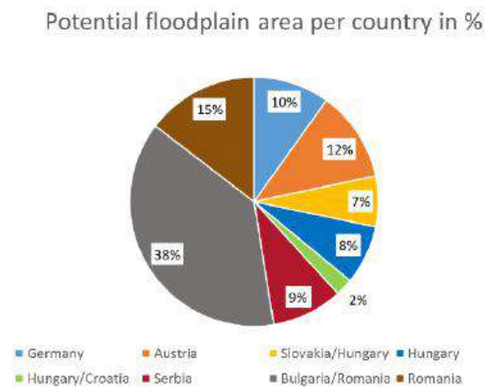


Figure 36: Potential floodplain area per country in percentage

In Figure 37*:*, the land uses for all active floodplains at the Danube River are shown. The percentage of artificial surfaces varies between 0 and 6.85%, with a mean value of 2.04%. Agricultural areas vary between 0.40 and 96.15% with a mean value of 24.95% whereas the Forest and semi-natural areas vary between 0 and 94.91% with a mean value of 41.09%. Wetlands are only present at 20 out of 50 active floodplains and mostly located at the Lower Danube. A tendency is visible from up- to downstream, showing that agricultural use is decreasing on the floodplains. At the upper and middle part of the Danube, the floodplains have, in general, a higher percentage of agricultural areas and a lower percentage of forest and semi-natural areas. This is not the case at some floodplains in Austria and some along the Slovakian and Hungarian border.

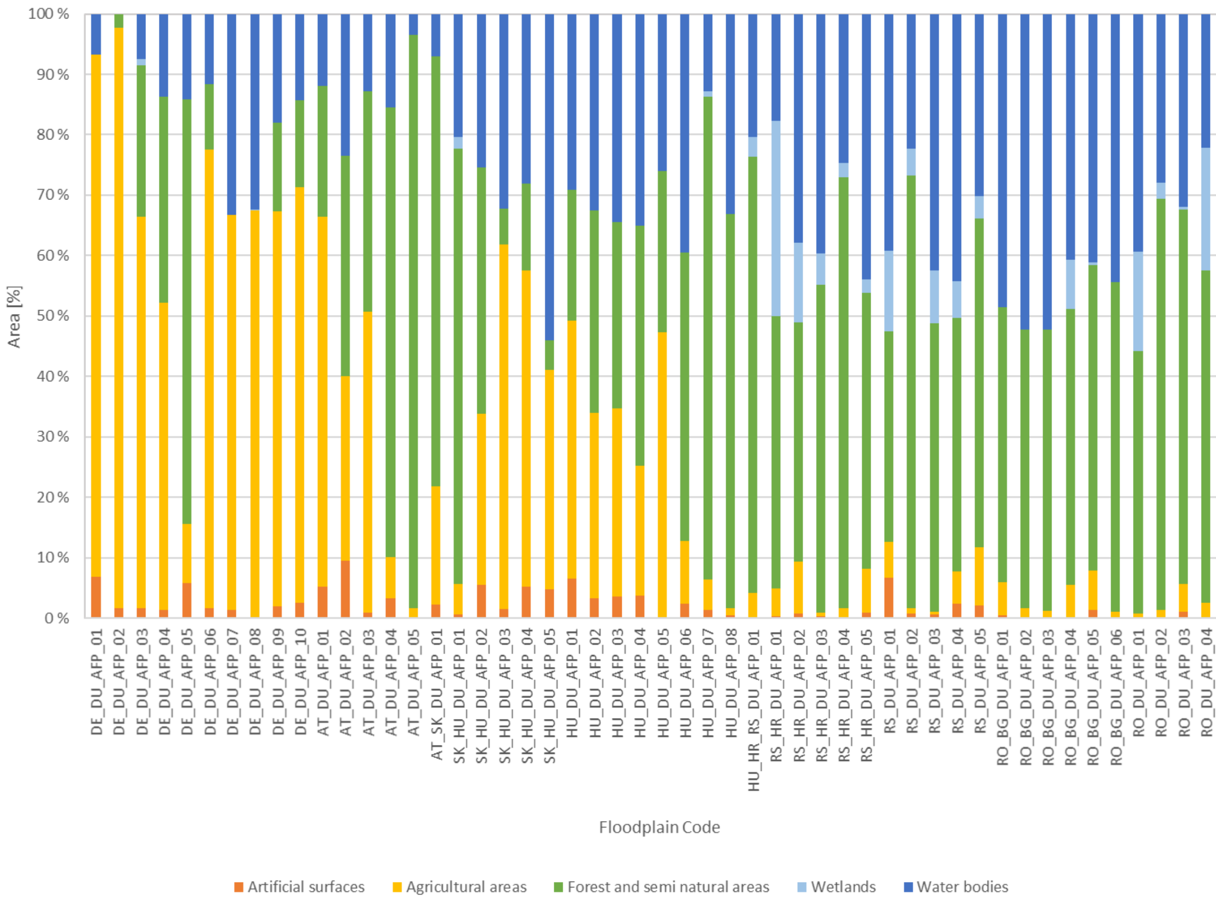


Figure 37: Distribution of land use classes in percentage for all active Danube floodplains from up- to downstream

3.9.2 Analysis for the minimum FEM-parameters for the active floodplains along the Danube River

In this chapter, all the results for the minimum FEM-parameters of all active floodplains along the Danube River are presented, compared and discussed.

In Figure 38, the results of the hydrological parameter relative flood peak reduction for all active floodplain along the Danube River are presented. The relative flood peak reduction ranges from 0 to 17%, with a mean of 2.4%. There is a clear tendency visible from up- to downstream since the highest values are at the Upper Danube and the lowest peak reductions are at the Lower Danube section. The high relative peak reduction at some floodplains in Germany (DE_DU_AFP_03 and 09) and Austria (AT_DU_AFP_01, 03 and 04) can be explained by dykes from hydropower plants. In Austria, these dykes are only overtopped at higher discharges (approximately at a HQ5), which leads to a higher peak reduction. Besides, more former floodplains (75%) are preserved in Austria than in other countries, which has also an effect on the flood peak reduction.

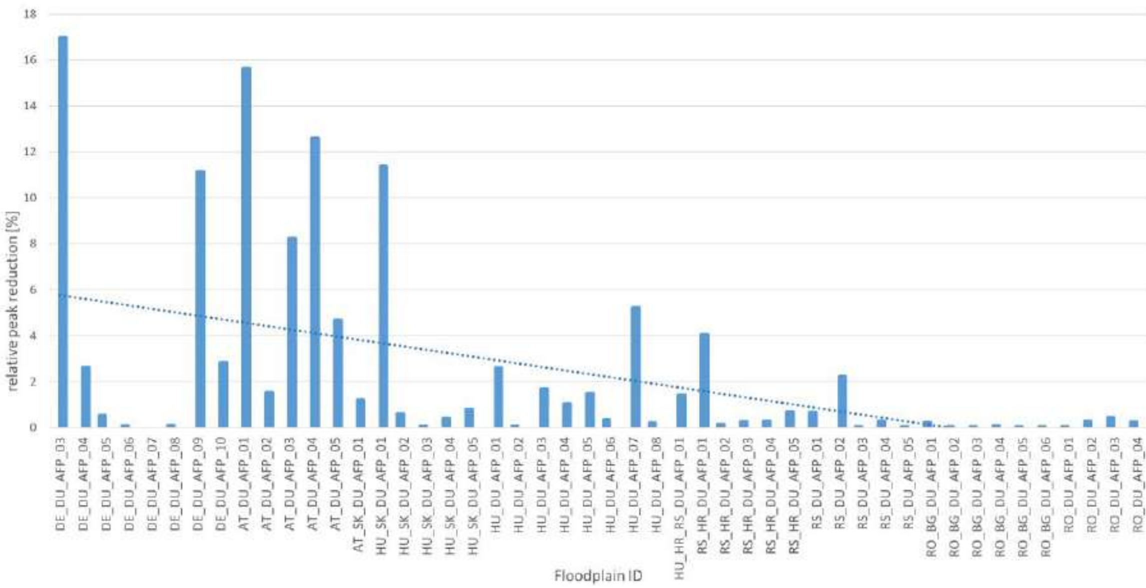


Figure 38: Relative flood peak reduction for all active floodplains along the Danube River including a trendline

Figure 39 provides an overview of the flood wave translation due to the active floodplain along the Danube River. The maximum translation (41.5 h) was simulated at a transboundary floodplain (RS_HR_DU_AFP01) between Serbia and Croatia. At three floodplains (SK_HU_DU_AFP03, HU_DU_AFP01, HU_DU_AFP08) the flood wave translation is less than 0.5 h. The mean value for the flood wave translation parameter is around 5.5 h. The flood wave translation shows a more constant tendency than the peak reduction. Two large outliers in Serbia and Romania ensure that the flood wave translation tends to increase downstream. Without these two outliers, the tendency would be reversed.

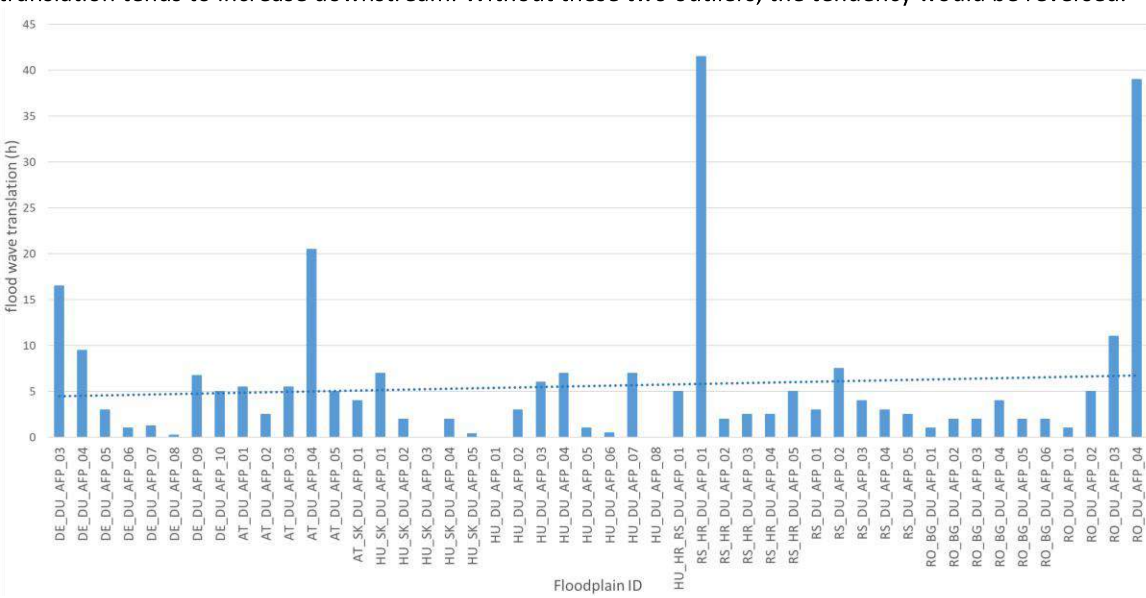


Figure 39: Flood wave translation for all active floodplains along the Danube River including a trendline

Figure 40*:* shows the water level change in the case of a total loss of the active floodplain for all active floodplains. The simulated water level changes are between 0 and 172cm. The mean is 45.58 cm. There is also a decreasing tendency from up- to downstream visible. One reason for that might be that a higher percentage of the former floodplains is preserved in

the upstream areas and disconnecting these areas from the river would lead to higher water level in the river channel at the Upper Danube.

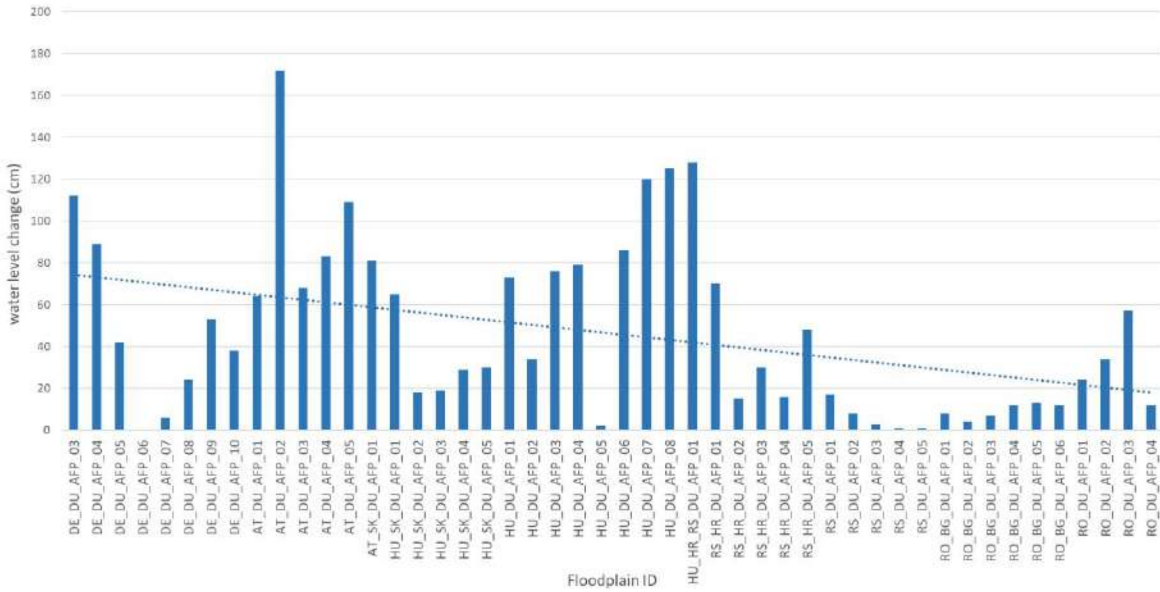


Figure 40: Water level change for all active floodplains along the Danube River including a trendline

The number of protected species shows a slightly upwards tendency from up- to downstream (Figure 41*:*). The number ranges from 20 to 271 species at one floodplain leading to a mean of 74.33. On the upstream floodplains, the agricultural usage is significantly higher than at the downstream areas, reducing the potential habitat for different species.

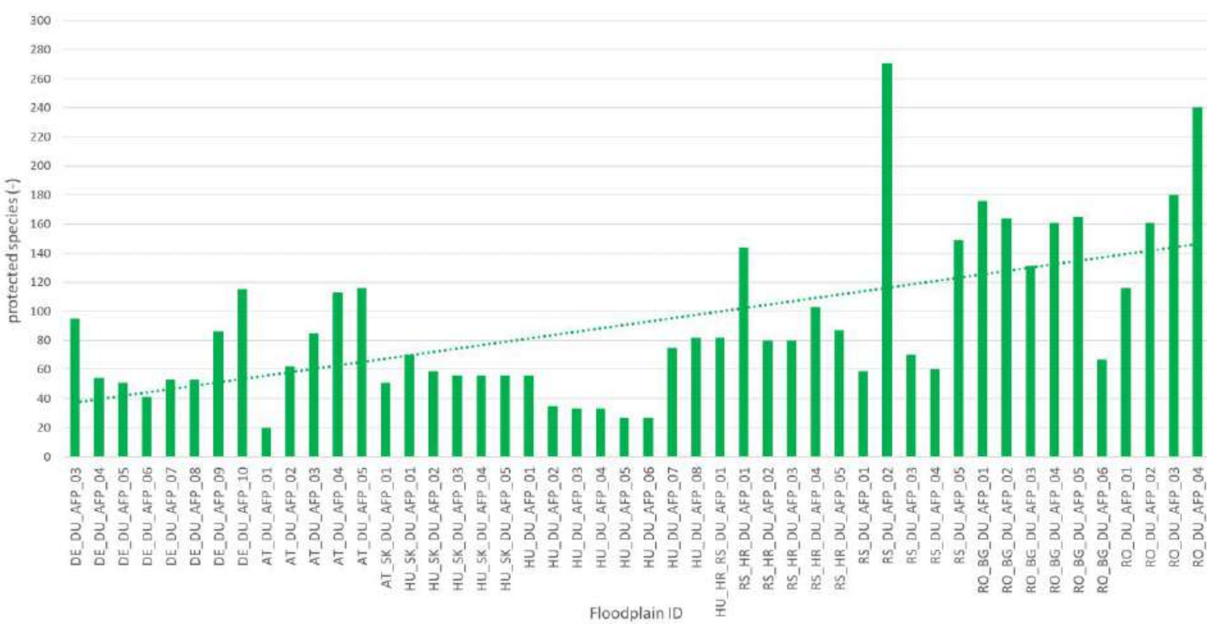


Figure 41: Number of protected species on active floodplains along the Danube River including a trendline

In Figure 42*:*, the FEM performance of all active floodplains (high=5; medium=3; low=1) for the minimum FEM parameter connectivity of floodplain water bodies is presented. In Germany and Austria, almost all floodplains received a low performance for the connectivity. In the Middle and Lower section of the Danube, the active floodplains have mostly a medium performance. No active floodplain received the best evaluation (high performance=5).

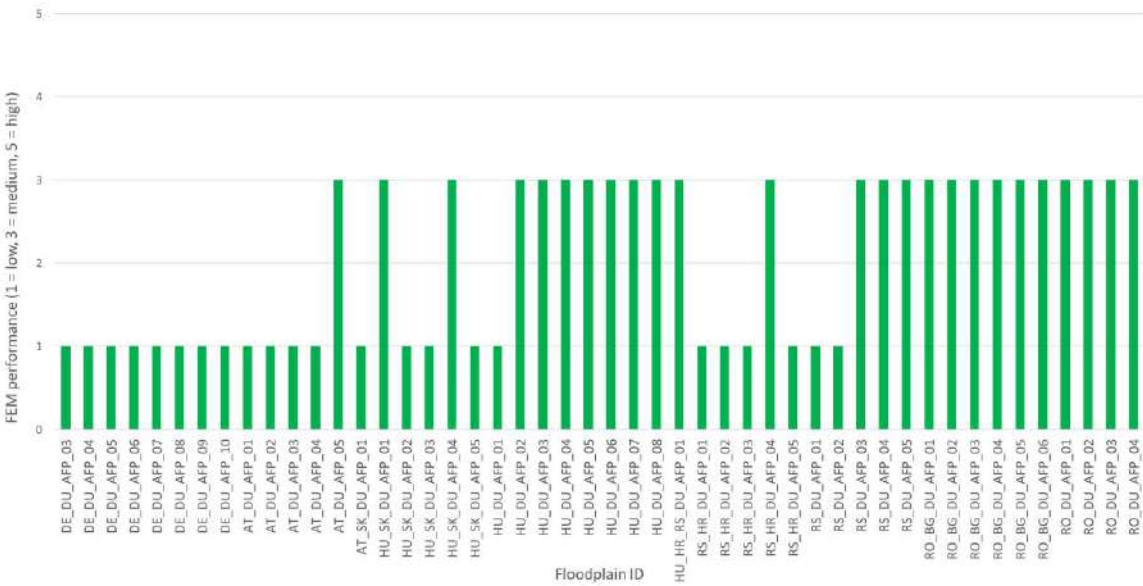


Figure 42: FEM performance (high=5; medium=3; low=1) for the parameter "connectivity of floodplain water bodies" of all active floodplains along the Danube River

One factor that is extremely relevant regarding the damage potential and thus the vulnerability at the floodplains is the number of affected buildings. For each floodplain the number of affected buildings per km² was calculated and a trendline was included (Figure 43*:*. The numbers vary between 0 Nr/km² and 34.77 buildings per km². The mean value lies by 6.98 Nr/km². There is a clear tendency visible from up- to downstream, where the numbers are strongly decreasing. The peak lies at the middle section of the Danube and almost no buildings are affected in the floodplains along the Lower Danube.

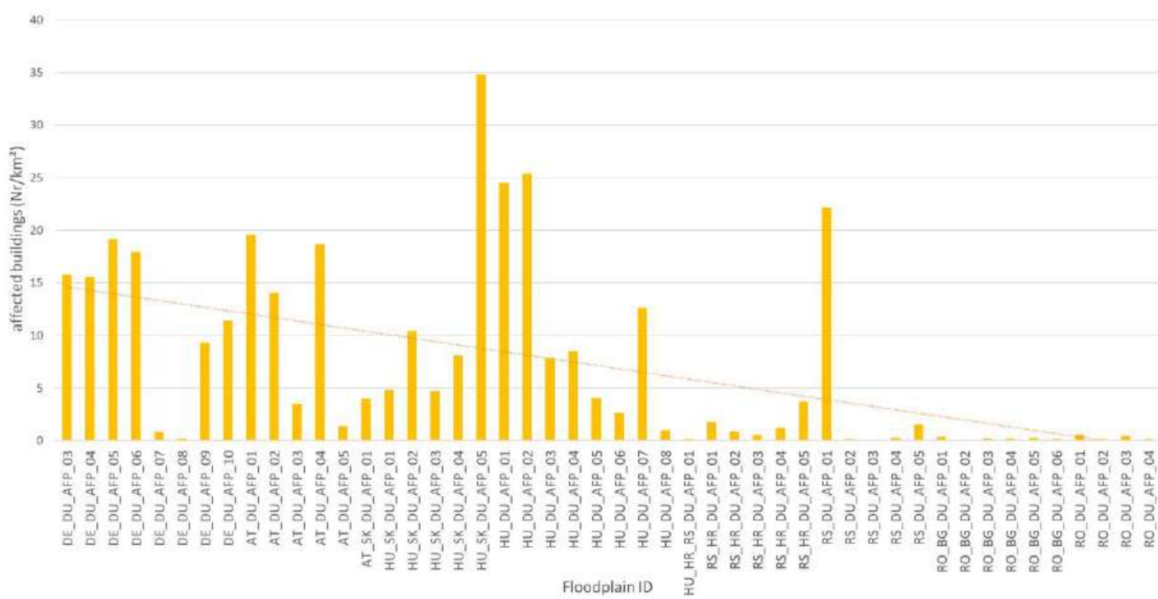


Figure 43: Distribution of affected buildings per km² for all active Danube floodplains from up- to downstream including a trendline

In Figure 44:, the performance of each active floodplain for the minimum FEM-parameter "land use" is shown. If the land use parameter is above 4, the vulnerability of the land use is low on the floodplain. Most active floodplains at the Middle and Lower Danube have a low vulnerability (=high performance in the FEM-evaluation) against flooding. At the Upper Danube, most floodplains are demonstrating a medium vulnerability.

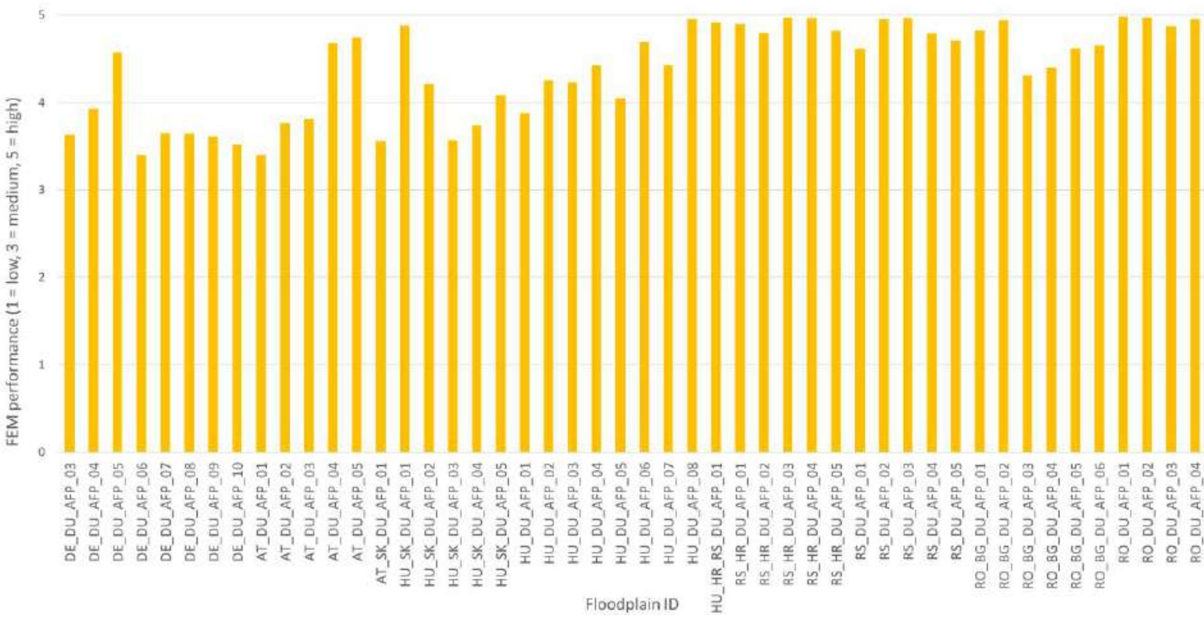


Figure 44: FEM performance for the land use parameter of all active floodplains at the Danube River (high performance = low vulnerability; medium performance = medium vulnerability; low performance = high vulnerability)

Figure 45*:* provides an overview of the results for the minimum FEM-parameters incl. ranking (need for preservation + restoration demand) for all active floodplains along the Danube River. In the subchapters 3.1 to 3.8, the individual FEM-results are presented and summarized. In Annex 0, all results for the additional parameters are presented.

Country	Floodplain		Hydrology: peak reduction (%)	Hydrology: flood wave translation (h)	Hydraulics: water level change (cm)	Ecology: connectivity (-)	Ecology: protected species (-)		Socio-Economics: affected buildings (n/km²)	Socio-Economics: land use (-)	Ranking: Need for preservation	Ranking: Restoration demand
Germany	DE_DU_AFP_01	1										
	DE_DU_AFP_02	2										
	DE_DU_AFP_03	3	16.98	16.5	112	1	95	95	15.76	3.63	yes	medium
	DE_DU_AFP_04	4	2.63	9.5	89	1	54	54	15.58	3.92	yes	medium
	DE_DU_AFP_05	5	0.53	3	42	1	51	51	19.16	4.57	yes	high
	DE_DU_AFP_06	6	0.07	1	0	1	41	41	17.93	3.40	yes	high
	DE_DU_AFP_07	7	0.00	1.25	6	1	53	53	0.81	3.65	yes	high
	DE_DU_AFP_08	8	0.08	0.25	24	1	53	53	0.19	3.64	yes	high
	DE_DU_AFP_09	9	11.13	6.75	53	1	86	86	9.32	3.61	yes	medium
	DE_DU_AFP_10	10	2.83	5	38	1	115	115	11.39	3.52	yes	high
Austria, Slovakia	AT_DU_AFP_01	11	15.64	5.5	64	1	20	20	19.58	3.40	yes	high
	AT_DU_AFP_02	12	1.52	2.5	172	1	62	62	14.04	3.76	yes	high
	AT_DU_AFP_03	13	8.24	5.5	68	1	85	85	3.52	3.81	yes	medium
	AT_DU_AFP_04	14	12.60	20.5	83	1	113	113	18.63	4.68	yes	low
	AT_DU_AFP_05	15	4.68	5	109	3	116	116	1.38	4.74	yes	low
	AT_SK_DU_AFP_01	16	1.21	4	81	1	51	51	3.98	3.56	yes	high
Slovakia, Hungary	HU_SK_DU_AFP_01	17	11.40	7	65	3	70	70	4.79	4.88	yes	low
	HU_SK_DU_AFP_02	18	0.60	2	18	1	59	59	10.42	4.21	yes	high
	HU_SK_DU_AFP_03	19	0.06	0	19	1	56	56	4.71	3.57	yes	high
	HU_SK_DU_AFP_04	20	0.39	2	29	3	56	56	8.08	3.74	yes	high
	HU_SK_DU_AFP_05	21	0.79	0.4	1	1	56	56	34.77	4.08	yes	high
Hungary	HU_DU_AFP_01	22	2.61	0	73	1	56	56	24.48	3.88	yes	high
	HU_DU_AFP_02	23	0.05	3	34	3	35	35	25.37	4.25	yes	high
	HU_DU_AFP_03	24	1.69	6	76	3	33	33	7.85	4.23	yes	medium
	HU_DU_AFP_04	25	1.03	7	79	3	33	33	8.52	4.42	yes	medium
	HU_DU_AFP_05	26	1.49	1	2	3	27	27	4.01	4.05	yes	high
	HU_DU_AFP_06	27	0.34	0.5	86	3	27	27	2.61	4.69	yes	high
	HU_DU_AFP_07	28	5.22	7	120	3	75	75	12.62	4.42	yes	low
	HU_DU_AFP_08	29	0.20	0	125	3	82	82	0.99	4.95	yes	high
	HU_HR_DU_AFP_01	30	1.41	5	128	3	82	82	0.14	4.91	yes	low
Croatia, Serbia	RS_HR_DU_AFP_01	31	4.04	41.5	70	1	144	144	1.78	4.90	yes	low
	RS_HR_DU_AFP_02	32	0.14	2	15	1	80	80	0.87	4.80	yes	high
	RS_HR_DU_AFP_03	33	0.25	2.5	30	1	80	80	0.53	4.97	yes	high
	RS_HR_DU_AFP_04	34	0.28	2.5	16	3	103	103	1.20	4.96	yes	medium
	RS_HR_DU_AFP_05	35	0.68	5	48	1	87	87	3.70	4.82	yes	high
Serbia	RS_DU_AFP_01	36	0.66	3	17	1	59	59	22.20	4.62	yes	high
	RS_DU_AFP_02	37	2.21	7.5	8	1	271	271	0.13	4.95	yes	low
	RS_DU_AFP_03	38	0.02	4	3	3	70	70	0.00	4.97	yes	high
	RS_DU_AFP_04	39	0.27	3	1	3	60	60	0.27	4.79	yes	high
	RS_DU_AFP_05	40	0.01	2.5	1	3	149	149	1.53	4.71	yes	high
Bulgaria, Romania	RO_BG_DU_AFP_01	41	0.22	1	8	3	176	176	0.38	4.82	yes	medium
	RO_BG_DU_AFP_02	42	0.01	2	4	3	164	164	0.00	4.94	yes	medium
	RO_BG_DU_AFP_03	43	0.01	2	7	3	131	131	0.24	4.31	yes	medium
	RO_BG_DU_AFP_04	44	0.06	4	12	3	161	161	0.21	4.40	yes	medium
	RO_BG_DU_AFP_05	45	0.03	2	13	3	165	165	0.28	4.62	yes	medium
	RO_BG_DU_AFP_06	46	0.01	2	12	3	67	67	0.15	4.65	yes	medium
Romania	RO_DU_AFP_01	47	0.02	1	24	3	116	116	0.56	4.98	yes	medium
	RO_DU_AFP_02	48	0.27	5	34	3	161	161	0.14	4.97	yes	low
	RO_DU_AFP_03	49	0.44	11	57	3	180	180	0.45	4.87	yes	low
	RO_DU_AFP_04	50	0.23	39	12	3	240	240	0.13	4.95	yes	low
FEM-rating	performance		Thresholds	Thresholds	Thresholds	Thresholds	Thresholds		Thresholds	Thresholds	Thresholds	Thresholds
	low		<1 %	<1 h	<10 cm	1	0	<40	>5 n/km²	<2	at least one parameter evaluated with 5	≥ 27
	medium		1-2 %	1-5 h	10 - 50 cm	3	1-20	41-100	1-5 n/km²	2-4		23-26
	high		>2 %	>5 h	>50 cm	5	>20	>101	<1 n/km²	>4	no parameter evaluated with 5	<23

*Figure 45:*Overview of the results for the minimum FEM-parameters incl. ranking (need for preservation + restoration demand) for all active floodplains along the Danube River

3.9.3 Analysis for the minimum FEM-parameters for the identified potential floodplains along the Danube River

Figure 46*:* provides an overview of the results for the minimum FEM-parameters for all identified potential floodplains along the Danube River. The relative peak reductions range from 0 to 17.62%, resulting in six floodplains with high (>2%) and eighteen (<1%) with low performance. Due to the flow processes in the floodplains, the flood wave is decelerated from 0 to 22 h. Nine floodplains showed a high (>5h), twelve a medium (1-5h) and two a low (<1h) performance for the flood wave translation parameter. In the case of a total loss of the active floodplain, the water level in the river channel would change from 0 to 193 cm. The water level would increase by more than 50 cm for twelve floodplains, leading to high performance (>50cm). The water level would increase between 10-50 cm for five floodplains, resulting in a medium performance. Nine floodplains showed a low performance (<10cm) for this parameter. At two potential floodplains, the lateral connectivity between the river channel and the floodplains was restored, leading to high performance. In six floodplains, the connectivity is still impaired by human intervention resulting in low performance. For sixteen floodplains, the lateral connectivity is partly disturbed (medium performance). On most of the potential floodplains (22 out of 24), more than 20 protected species are living. At the other two floodplains, at least 15 protected species are found. At eleven floodplains, the number of affected buildings per km² is less than 1, leading to high performance for this parameter. For eight floodplains, a medium performance (1-5 n/km²) was assessed. At five floodplains, more than 5 buildings are found

per km² resulting in low performance. Half of the potential floodplains have a land use which has a low vulnerability against flooding (high performance). The other half shows a medium vulnerability (=medium performance).

country	Floodplain		Hydrology		Hydraulics	Ecology		Socio-Economics	
			peak reduction (%)	flood wave translation (h)	water level change (cm)	connectivity (-)	protected species	affected buildings	land use (-)
Germany	DE_DU_PFP01	1	17.62	19	117	1	95	14.95	3.61
	DE_DU_PFP02	2	2.41	11	108	1	54	16.78	3.89
	DE_DU_PFP03	3	0.35	0	52	1	17	5.07	4.29
	DE_DU_PFP04	4	0.02	2	0	1	15	1.94	3.67
	DE_DU_PFP05	5	0.33	5	25	1	53	6.63	3.31
Austria	AT_DU_PFP01	6	13.06	22	65	1	113	17.65	4.75
	AT_DU_PFP02	7	8.51	6.25	154	3	116	1.01	4.85
Hungary	HU_DU_PFP01	8	0.90	3	66	3	70	5.00	4.75
	HU_DU_PFP02	9	0.20	3	96	3	27	2.00	4.56
	HU_DU_PFP03	10	2.75	9	125	3	75	3.00	4.81
	HU_DU_PFP04	11	0.80	5	130	3	82	0	4.90
Serbia	RS_DU_PFP01	12	2.73	16	66	3	173	0.17	4.95
	RS_DU_PFP02	13	0.92	11	9	5	240	0.25	3.05
	RS_DU_PFP03	14	0.92	8	193	5	240	1.62	3.30
Bulgaria, Romania	BG_RO_DU_PFP01	15	0.04	1	6	3	153	0.05	4.05
	BG_RO_DU_PFP02	16	0.27	9	23	5	205	0.02	3.99
	BG_RO_DU_PFP03	17	0.67	22	84	3	198	0.09	4.04
	BG_RO_DU_PFP04	18	0.19	4	7	5	200	0.23	3.93
	BG_RO_DU_PFP05	19	0.05	2	11	3	157	1.23	4.11
Romania	RO_DU_PFP01	20	0.14	1	6	5	83	0	2.96
	RO_DU_PFP02	21	0.05	0.5	1	5	79	0	3.00
	RO_DU_PFP03	22	0.08	1	13	3	61	0.83	3.19
	RO_DU_PFP04	23	0.03	3	8	3	281	0.24	4.83
	RO_DU_PFP05	24	0.07	1	6	5	33	2.15	3.04
FEM-rating	performance		Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds
	low		<1 %	<1 h	<10 cm	1	0	>5 n/km²	<2
	medium		1-2 %	1-5 h	10 - 50 cm	3	1-20	1-5 n/km²	2-4
	high		>2 %	>5 h	>50 cm	5	>20	<1 n/km²	>4

Figure 46: Overview of the results for the minimum FEM-parameters for all identified potential floodplains along the Danube River

4. Conclusions

In Activity 3.2 of the Danube Floodplain project, active and potential floodplains along the Danube River were identified and evaluated with the Floodplain Evaluation Matrix (FEM). The FEM is an integrative method for assessing hydrological, hydraulic, ecological and socio-economic effects of floodplains with different parameters. The method was further developed and adapted with all project partners' help to serve the project's needs best.

Methods for the identification of active, potential and former floodplains were developed. In total, 50 active and 24 potential floodplains were identified. In this project, potential floodplains are those former floodplains from which settlements, infrastructure, streets and, in some cases, agriculture land are excluded. The total area of former floodplains was also estimated. The analysis and comparison of all three floodplain types showed that only a small portion of the former floodplains is an active or a potential floodplain currently. However, there are significant differences between the individual countries. In Austria (75%) and Croatia (95%) most of the former floodplains are preserved as hydraulically active floodplains. Austria can increase the preserved percentage even to 84% if the potential floodplains are also reconnected. In Romania, 32% of the former floodplain area still exists as active floodplains. In the other countries (Slovakia, Hungary, Serbia, Bulgaria) the percentage is less than 15%. Bulgaria can increase the share from 12% with the potential floodplains to 37%. This analysis showed that the potential for the reconnection of former floodplain areas is quite different between the individual countries. One reason for these differences is that the extension of the valley bottom differs significantly in the different states, resulting in much larger former floodplains in the middle and lower section of the Danube River. Even though 24 potential floodplains were identified in the scope of the Danube Floodplain project, the percentage of active + potential floodplains from the former floodplains is still quite low in some countries. One future goal should be to increase these numbers and identify even more potential floodplains. There is still potential, especially in countries with a low percentage of active + potential floodplains from the former floodplains. The identified potential floodplains in the scope of the Danube Floodplain project are not representing all potential floodplains at the Danube River, but only some of them that the representatives of the individual countries identified in the project.

Active and potential floodplains were evaluated with the FEM. For each identified floodplain, the minimum FEM-parameters were calculated. The evaluation with hydrological, hydraulic, ecological and socio-economic parameters showed that each active floodplain is valuable and should be preserved. From Germany to Romania, there is a slight tendency that hydrological and hydraulic parameters perform better. In contrast to this, the ecological and socio-economic parameters are performing better at floodplains along the Middle and Lower Danube. The high relative peak reduction at some floodplains in Germany (DE_DU_AFP_03 and 09) and Austria (AT_DU_AFP_01, 03 and 04) might be explained by dykes from hydropower plants. In Austria, these dykes are only overtopped at higher discharges (approximately at a HQ_5), which leads to a higher peak reduction. On the other hand, the flood wave translation showed a more constant tendency from Germany to Romania than the peak reduction. Two large outliers in Serbia (RS_HR_DU_AFP_01) and Romania (RO_DU_AFP_04) ensured that the flood wave translation slightly tends to increase downstream. Without these two outliers, the trend would be reversed. The minimum hydraulic parameter demonstrated the water level change in the river channel in the case of a total loss of the active floodplain. There is a decreasing tendency of the water level change from up- to downstream. One reason for that might be that a higher percentage of the former floodplains is preserved and disconnecting these areas from the river would lead to higher water level in the river channel at the Upper Danube. The number of protected species on floodplains is increasing from up- to downstream. On the upstream floodplains, the agricultural usage is significantly higher than at the downstream areas, reducing the potential habitat for different species. The connectivity of floodplain water bodies is impaired by human intervention at all active floodplains, especially along the Upper Danube. At the floodplains along the Lower Danube, almost no buildings exist on the floodplains leading to low vulnerability of these areas.

Based on the minimum FEM-parameters, the restoration demand (high, medium, low) for each active floodplain was determined. In general, each restoration measure at any floodplain regardless of the restoration demand is seen as valuable and desirable. In the Danube Floodplain manual (Danube Floodplain, 2021) win-win measures are listed which can improve the performance of the FEM-parameters. An improvement of the FEM performance can also change the determined restoration demand. The best-case scenario would be that all active floodplains show a low restoration demand.

For the assessment of the FEM, different data sets and models are necessary that have uncertainties. Hydraulic models are widely used in flood risk management to design flood protection measures and prepare flood hazard maps despite uncertainties in flood frequency, roughness parameteristation et cetera. All used models in the project were calibrated. Most partners used 1D-models for the assessments, where available 2D-models were applied. In general, 2D-models should be preferred before 1D-models investigating hydraulic behavior on floodplains. Nevertheless, if adequate data is available and a thorough calibration of the 1D-model is performed, 1D-models can be used for simulating the retention effects of floodplains.

Despite certain limitations and uncertainties in the analyses, identifying and analyzing active, potential and former floodplains are necessary for sustainable flood risk and floodplain management. The evaluation of the floodplains with the FEM using hydrological, hydraulic, ecological and socio-economics parameters creates an adequate basis for further steps to achieve sustainable water management, emphasizing reducing flood risk, improving the ecological situation and considering socio-economic processes. Further assessments of floodplains at other rivers are desirable.

D3.2.2 Report on data included within database

Introduction

Among all natural disasters, floods have the greatest damage potential worldwide (UNISDR 2015). In recent years, awareness was raised, leading to the development of new approaches in integrated flood risk management as demanded by the EU Floods Directive (2007/60/EC) by integrating non-structural and structural measures for flood protection. Such new methods of flood mitigation should especially focus on preserving and/or restoring floodplains (Habersack, Schober & Hauer 2015). Therefore, the Activity 3.2 of the Danube Floodplain project aims to identify and evaluate the still active floodplains as well as the reconnection potential of areas along the whole Danube River from the spring in Germany to the Danube Delta in Romania, disconnected by flood protection structures.

A first step for this approach is to develop a methodology to identify the active and potential floodplains, find a consensus about it in the project team and then share this information with Activity 3.1 to display it in the Danube GIS[2] and the Danube Floodplain GIS. Active floodplains are defined as all areas which are still flooded during an HQ_{100} and potential floodplains are areas which are currently not flooded but have the potential to be reconnected to the river system again.

In the next step both floodplain types should be evaluated with the Floodplain Evaluation Matrix (FEM), which is a holistic, integrative tool for the assessment of hydrological, hydraulic, ecological and socio-economic effects of a floodplain. To serve the project needs best, the FEM parameters and FEM methodology was further developed and accepted by all project partners.

The last step will then be a ranking for all active and potential floodplains including a stakeholder consultation to identify priority areas for preservation and/or restoration.

5. Active and potential floodplains

5.1. Methodology for identification

Active floodplains:

According to the Danube Floodplain application form, Activity 3.1 has to develop a Danube Floodplain Inventory (DFInv) of hydraulically predefined floodplain sections focusing on common agreed parameters and attributes enabling a standard multicriteria and multiscale assessment of floodplain functionality. As the identification is largely affecting the application of the FEM in Activity 3.2, especially the numerical modelling for the hydrological and hydraulic parameters, it was decided that the two Activities will develop a methodology for the identification and delineation of floodplains together.

In 2012 the Danube FLOODRISK project created hazard and risk maps for three different scenarios (frequent event HQ_{30}, medium event HQ_{100}, extreme event HQ_{1000}) for the whole Danube and published the results in the Danube Atlas. The hydrological processing was performed at different degrees of complexity, depending on the future utilization of the results. Synthetical hydrographs were generated,

[2] Geographic information system, using and providing geo-information services on the web, whose development is supported by the ICPDR contracting parties

under the volume conservation hypothesis. For hydraulic simulations in steady state either a unique value of the maximum discharge corresponding to a probability of exceedance P% or an uncertainty interval of the maximum discharges was obtained if taking into account the hydrologic uncertainty. For unsteady state simulations, a family of hydrographs corresponding to the same probability of exceedance P% are obtained. The floods corresponding to the maximum discharges which could lead to the dyke overtopping was considered for hydraulic simulations. (Danube FLOODRISK 2012)

According to the DanubeFLOODRISK project the flood event with a return period of 100 is widely accepted as the design level for flood protection measures along the Danube River. Therefore, these inundation outlines were chosen as the data basis for the identification of the active floodplains in the Danube Floodplain project. If the countries could offer better national flood risk maps (e.g. more accurate, more recently developed), these maps were used for the identification.

To identify not only the inundation outlines of a given scenario but to identify the floodplains itself, a methodology was applied which consider three different criteria, which had to be fulfilled:

- **Ratio factor** of $width_{floodplain}/width_{river}$ (to identify the beginning and end of a floodplain)
- **Minimum size** of an active floodplain (to avoid too small floodplains for the evaluation)
- Current **hydraulic characteristics** of the floodplain, like flow paths and stages may not be altered by the delineation (identified floodplains should represent the natural flow characteristics)

These criteria cannot only be used at the Danube river, but are applicable at every river. In the Danube floodplain project, the criteria were also applied at the selected tributaries in Activity 3.3. Only the values for the first two criteria have to be adjusted for the selected river. For the Danube river the following values were selected:

- A ratio factor of $width_{floodplain}/width_{river}$ > 1:1
- A minimum floodplain size of 500 ha
- Floodplain must be hydraulically connected, and characteristic flow behaviour is given

This methodology was developed to identify floodplains at the Danube river which should be evaluated with the Floodplain Evaluation Matrix (FEM) and displayed in the Danube GIS. The methodology was then further developed to also take into account the floodplain areas which are not evaluated but nevertheless morphologically and ecologically valuable areas. Therefore, the floodplains were grouped in three groups:

- **1st group:** floodplains identified according to the methodology described before, larger than 500ha, which will be evaluated and ranked by the FEM
- **2nd group:** floodplains smaller than 500ha but with a floodplain width bigger than the width of the river. These floodplains will be displayed in the Danube Floodplain GIS, which will be developed by Activity 3.1
- **3rd group:** riparian zones with a width smaller than the river width. These riparian zones will not be displayed or evaluated as the effect for flood risk management is minor, but are nevertheless important for the ecology and morphology.

The methodology was then applied to the Danube River by BOKU and the resulting floodplains were sent to each partner for the final check-up. Proposed changes, like the splitting of floodplains if a major tributary had its confluence in the floodplain, were made and the final version of the floodplains were uploaded to the geodatabase of Activity 3.1.

Potential floodplains:

After the identification of all active floodplains along the Danube, BOKU developed a methodology for the identification of potential floodplains. The identified potential floodplains have the potential for reconnection to the river system. If settlements, critical infrastructures and streets are located in the former floodplain, each country decides on their own if they want to identify this area as a potential floodplain (settlements, streets and critical infrastructures had to be protected by complementary local flood defence measures – e.g. protective walls, earth deposits/dikes). If the former floodplain is now used by agriculture, each country decides on their own if a compensation is possible or not. If the partners decide that a compensation of the land is not possible, no potential floodplain will be identified. For the potential floodplains we again used the data from the Danube FLOODRISK project available at the Danube Atlas, but this time the $HQ_{extreme}$ was relevant for the delineation. For the identification it was suggested to the partners to also use historical maps if available.

In the context of the project, it was decided to differentiate between two types of potential floodplains, namely potential and "operational" potential floodplains. The difference between these two types is that the "operational" potential floodplains are identified and discussed with stakeholders, technical experts and decision makers. In the following it is described how the identification of potential floodplains is working:

Step 1: Identify former floodplains by using the $HQ_{extreme}$ inundation outline from the Danube Atlas or historical maps.

Step 2: Exclude settlements, infrastructure and streets in the former floodplain.

Step 3: Exclude agricultural land where no compensation is possible or too expensive. This can also be done after the modelling of the potential floodplains in WP4.

Step 4: Define the Danube Floodplain scenario for this potential floodplain. The scenario for the reconnection (e.g. cut of dams, removal of dams, land use change) will then be used for the modelling of the potential floodplains in WP4.

Step 5: Discuss with stakeholders to define the "operational" potential floodplain and the technical aspects of the reconnection. This is not done in the Danube Floodplain project.

Additionally, historical conditions could be analysed by modelling the whole river section without dams and power plants. The methodology was accepted by all partners and applied in each country individually.

5.2. Naming convention

To make the identification of the floodplains and thus the evaluation easier, each floodplain gets a unique code which will be used for communication and in the Danube Floodplain GIS as well as the FEM. The following code was proposed to the partners and accepted:

Country ISO code_River name (short)_floodplain type_number in the country

The name of the floodplain will consist of four parts. The first part is the country ISO code, the second part is the short name or code of the river, the third part is the type of the floodplain (AFP = active floodplain, PFP = potential floodplain) and the fourth part is the number of the floodplain in the country. For transboundary floodplains both country ISO codes will be at the beginning and the first floodplain in the country which is not transboundary will start again with the number 01.

Examples for the code are the following:
Hungary: HU_DU_PFP_01
Transboundary floodplain: HR_RS_DU_AFP_01

5.3. GIS data for geodatabase

The naming convention was applied for all identified active floodplains. The list can be found here:

Table 44: Floodplain Codes for identified active floodplains at the Danube

Number	Floodplain Code	Country	Area [ha]	Area [km²]
1	DE_DU_AFP01	Germany	973	9.73
2	DE_DU_AFP02	Germany	634	6.34
3	DE_DU_AFP03	Germany	15554	155.54
4	DE_DU_AFP04	Germany	3229	32.29
5	DE_DU_AFP05	Germany	2192	21.92
6	DE_DU_AFP06	Germany	1645	16.45
7	DE_DU_AFP07	Germany	745	7.45
8	DE_DU_AFP08	Germany	1061	10.61
9	DE_DU_AFP09	Germany	6716	67.16
10	DE_DU_AFP10	Germany	4531	45.31
11	AT_DU_AFP01	Austria	5642	56.42
12	AT_DU_AFP02	Austria	3480	34.80
13	AT_DU_AFP03	Austria	7220	72.20
14	AT_DU_AFP04	Austria	15192	151.92
15	AT_DU_AFP05	Austria	8534	85.34
16	AT_SK_DU_AFP01	Austria/ Slovakia	1985	19.85
17	SK_HU_DU_AFP01	Slovakia/ Hungary	14072	140.72
18	SK_HU_DU_AFP02	Slovakia/ Hungary	4057	40.57
19	SK_HU_DU_AFP03	Slovakia/ Hungary	777	7.77
20	SK_HU_DU_AFP04	Slovakia/ Hungary	3129	31.29
21	SK_HU_DU_AFP05	Slovakia/ Hungary	1493	14.93

22	HU_DU_AFP01	Hungary	3231	32.31
23	HU_DU_AFP02	Hungary	1817	18.17
24	HU_DU_AFP03	Hungary	7078	70.78
25	HU_DU_AFP04	Hungary	4472	44.72
26	HU_DU_AFP05	Hungary	6378	63.78
27	HU_DU_AFP06	Hungary	2035	20.35
28	HU_DU_AFP07	Hungary	15904	159.04
29	HU_DU_AFP08	Hungary	901	9.01
30	HU_HR_RS_DU_AFP01	Hungary/ Croatia/ Serbia	4822	48.22
31	RS_HR_DU_AFP01	Serbia/ Croatia	28048	280.48
32	RS_HR_DU_AFP02	Serbia/ Croatia	1961	19.61
33	RS_HR_DU_AFP03	Serbia/ Croatia	2462	24.62
34	RS_HR_DU_AFP04	Serbia/ Croatia	3000	30.00
35	RS_HR_DU_AFP05	Serbia/ Croatia	4843	48.43
36	RS_DU_AFP01	Serbia	3481	34.81
37	RS_DU_AFP02	Serbia	7481	74.81
38	RS_DU_AFP03	Serbia	2766	27.66
39	RS_DU_AFP04	Serbia	1838	18.38
40	RS_DU_AFP05	Serbia	4324	43.24
41	RO_BG_DU_AFP01	Romania/ Bulgaria	6012	60.12
42	RO_BG_DU_AFP02	Romania/ Bulgaria	3228	32.28
43	RO_BG_DU_AFP03	Romania/ Bulgaria	2933	29.33
44	RO_BG_DU_AFP04	Romania/ Bulgaria	8171	81.71
45	RO_BG_DU_AFP05	Romania/ Bulgaria	2548	25.48
46	RO_BG_DU_AFP06	Romania/ Bulgaria	3359	33.59
47	RO_DU_AFP01	Romania	5034	50.34
48	RO_DU_AFP02	Romania	7945	79.45
49	RO_DU_AFP03	Romania	9358	93.58
50	RO_DU_AFP04	Romania	29876	298.76
51	RO_DU_AFP05	Romania	3151000	3151.00

The first version of the floodplains was uploaded as a shape file to the geodatabase by BOKU. The partners then modified those files according to their internal decisions. A new version has to be uploaded after the evaluation of the floodplains took place. This version will then include additional fields for the FEM parameter values and the corresponding evaluation. The potential floodplains had to be uploaded directly by the partners and will also have an additional version after the FEM evaluation with the corresponding fields.

6. Floodplain Evaluation Matrix

6.1. Background

The Floodplain Evaluation Matrix (FEM) developed by the Institute of Hydraulic Engineering and River Research at the University of Natural Resources and Life Sciences, Vienna (BOKU) is a holistic tool to evaluate river floodplains by considering multiple parameters that effect and determined the processes within these floodplains (Habersack, Schober & Hauer 2015). The project PRO_Floodplain (Habersack et al. 2008) was carried out in ERA-NET CRUE in order to develop an evaluation method for the effectiveness of floodplains in hydrological/hydraulic, ecological and sociological terms, which was until then not available. The FEM should also serve as a tool for decision support for relevant stakeholders.

The FEM was already applied in different case studies in Austria and Germany and numerable parameters were identified and included based on literature research and questionnaires. Parameters for hydrology (e.g. peak reduction, flood wave translation) and hydraulics (e.g. water level change, flow velocity change) were calculated by using hydrodynamic-numerical models. The ecological parameters were based on GIS analysis (e.g. adapted land use), hydrodynamic-numerical modelling (e.g. Connectivity of water bodies) or with expert evaluation (e.g. potential for development of typical habitats). The sociological parameters (e.g. type of usage) were mainly based on questionnaires and surveys. (Habersack et al. 2008; Habersack, Schober & Hauer 2015)

With this methodology a valuable decision support tool is available for relevant stakeholders to assess the multiple benefits that floodplain restoration and preservation as a sustainable non-technical measure can offer as it is demanded by the EU Floods Directive (2007/60/EC). In general, it allows the evaluation of various river reaches by setting up a priority ranking which indicates where efforts of floodplain preservation / restoration should be spent first in order to obtain maximum benefits. The preservation of whole floodplains would stop the temporal floodplain losses, which were obtained over the last centuries.

6.2. Selected FEM-parameters

For the Danube Floodplain project, the original FEM method was further developed to serve the project needs. Therefore, all possible parameters from previous application of the FEM were collected and explained to the partners. Additional parameters could also be suggested by partners and this list was then discussed with all partners. From the list of parameters, the partners then selected which ones they see as important for the evaluation of the floodplains and they would see possible and meaningful to calculate. BOKU suggested a minimum set of parameters which is mandatory for all partners to be calculated. A medium and extended set of parameters was also prepared, out of the favoured parameters by all partners which serve as additional information in the Danube Floodplain GIS but will not be taken into account for the ranking list. The results will nevertheless be a valuable information for decision makers and as such be shown in the factsheet of each floodplain. The matrix itself consists now of four sections: hydrology, hydraulics, ecology and socio-economics. For each sector one or two parameters were selected as minimum set and at least one parameter for the medium or extended set. The selected parameters and structure is presented hereafter:

Table 45: Floodplain Evaluation Matrix - Danube Floodplain project; in blue: minimum set, in green: medium set, in yellow: extended set

Hydrology	Hydraulics	Ecology	Socio-Economics
peak reduction ΔQ	water level Δh	connectivity of floodplain water bodies	Potentially affected buildings
flood wave translation Δt	flow velocity Δv	Existence of protected species	Land use
effects (pos./neg.) in case of extreme discharges	bottom shear stress	Existence of protected habitats	Precence of documented planning interests
		Vegetation naturalness	
		water level dynamics	
		Potential for typical habitats	
		ecological, chemical and ground water status	

Hydrology:

Flood peak reduction – ΔQ: The flood peak reduction considers the effect of a floodplain on the peak of a flood wave. To evaluate the peak reduction for a floodplain, the peak of an input hydrograph (e.g. HQ_{100}) at the beginning of the floodplain and the peak of the output hydrograph at the end of the floodplain will be determined. The difference between the peaks is the peak reduction ΔQ [m³/s] for the investigated floodplain.

Flood wave translation – Δt: The flood wave translation is the second parameter required for the investigation of the process of wave attenuation due to a floodplain. This parameter is determined in a similar way as the peak reduction, namely by calculating the time difference Δt [h] between the occurrence of the output/input hydrograph peak.

Effects in case of extreme discharge: Effects of floodplain areas on hydrological parameters (ΔQ, Δt) for scenarios with discharges larger (HQ_{1000}) than the design discharge (HQ_{100}) of flood protection measures are also incorporated in the FEM to account for remaining risk (higher discharges due to climate change). Hydrodynamic-numerical modelling of the higher discharge (HQ_{1000}) can highlight additional capacities of floodplains or increased risks for settlements behind the dykes (e.g. by overtopping of existing dykes). The evaluation considers the effects on peak reduction and flood wave translation in each floodplain for this higher discharge compared to HQ_{100}.

Hydraulics:

Water level change – Δh: A hydrodynamic-numerical model is used to determine the influence of changes in floodplain geometry (e.g. by dyke-shifting). Reducing or extending floodplain widths by modelling of fictive dykes exhibits how big changes in the water level surface of the scenarios (Δh) can be. The observed values can be calculated in a cross section at the middle or/and end of the floodplain or in the next settlement. In this project, we want to show the effects of a total loss of a floodplain on the water level. Hence, we compare the water levels of the two scenarios in the river channel at the middle of the floodplain.

Flow velocity – Δv: A hydrodynamic-numerical model is used to determine the influence of changes in floodplain geometry (e.g. by dyke-shifting). Reducing or extending floodplain widths by modelling of fictive dykes exhibits how big changes in the flow velocity of the scenarios (Δv) can be. The observed values can be calculated in a cross section at the middle or/and end of the floodplain or in the next settlement. With this parameter, we want to show the effects of a total loss of a floodplain on the flow velocity. Hence, we compare the velocities of the two scenarios in the river channel at the middle of the floodplain.

Bottom shear stress – Δτ: A hydrodynamic-numerical model is used to determine the influence of changes in floodplain geometry (e.g. by dyke-shifting). Reducing or extending floodplain widths by modelling of fictive dykes exhibits how big changes in the bottom shear stress of the scenarios (Δτ) can be. The observed values can be calculated in a cross section at the middle or/and end of the floodplain or in the next settlement. With this parameter, we want to show the effects of a total loss of a floodplain on the bottom shear stress. Hence, we compare the bottom shear stresses of the two scenarios in the river channel at the middle of the floodplain.

Ecology:

Connectivity of floodplain water bodies: Connectivity is crucial for the functionality of riverine ecosystems. The longitudinal connectivity describes the connectivity in the up- and downstream direction and is especially relevant for the exchange of populations of water organisms and their migration during their life cycle, the lateral connectivity refers to the connection of the river channel and the floodplain and the vertical connectivity is the connection of the river channel and the ground water table in the floodplain (which might be crucial for small temporary water bodies in the floodplain). For simplification, the connectivity of floodplain water bodies will be investigated only in the lateral direction.

Existence of protected species: A floodplain is valuable and should be preserved if red list species or species and habitats (recognized by Natura2000) are found on the area. Therefore, this parameter will evaluate how many protected species can be found at the floodplain according to Natura2000 or the Emerald Network.

Existence of protected habitats: This parameter shows what part of the floodplain area is designated as protected area according to the Natura 2000 or other documents about protected species or habitats like the Emerald Network. The higher the share of protected areas, the more valuable is the floodplain.

Vegetation naturalness: The landscape patterns of a floodplain can be a good indicator for the naturalness of vegetation. Therefore, it is possible to calculate patch-level landscape indices (like the class level landscape metric Area Weighted Mean Shape Index (AWMSI) for all land cover polygons of natural and semi natural areas (NSN) with the V-LATE extension of ArcGIS. NSN patches with a complex shape with irregular edges indicate a higher level of naturalness.

Water level dynamics: In order to restore floodplain habitats, rivers and floodplains must have a water level dynamic, almost like the one that exists in the natural floodplains. For this reason, the water level dynamics are used as a FEM parameter. If significant changes have been made on the river, floodplain areas may have completely different water level dynamics. This can result in permanently (excessive) high water levels in dammed up parts of the river or in dry floodplain areas in deepened river segments. An uncontrolled retention is impossible where barrages have been built, which means that this is also a criterion for exclusion with a view to the implementation of non-technical floodplain enlargements. The parameters water level duration, frequency of the flood and amplitude of the water levels are summarized to describe the possible water level dynamics. The historical state before the development of the river serves as a point of reference.

Potential for typical habitats: The typical river and floodplain habitats should have the possibility to re-establish habitats if they are not already existing. 14 habitat types typical for floodplains are included in the Habitats Directive. Not every area must include all, but the more habitat types exist or can be redeveloped, the more valuable is this area. The parameter evaluates how many of the typical habitats are available at the floodplain or could be restored.

Ecological water body status: As part of the water framework directive, the countries should evaluate the ecological of the water bodies. If the river section of this floodplain is rated with a good or high status, it should get the best rating for this parameter. The potential effect of restoration measures at the floodplain on the ecological water body status will be assessed by experts to the best of their knowledge.

Socio-Economics:

Potentially affected buildings: This parameter determines the number of buildings on each active floodplain. The more buildings are affected, the higher is the potential damage. To compare the results, the number of buildings will be divided by the total area of the floodplain.

Land use: Land use that is adapted to future inundation will minimize the socio-economical vulnerability of the floodplain. Therefore, flood-adapted land use gets the highest rating, non-adapted the lowest (crop farming, settlements). The different types of land uses are aggregated proportional to their areas to one evaluation value for the whole floodplain.

Presence of documented planning interests: This parameter evaluates the presence of infrastructure or spatial development plans/projects in the floodplain area or close to it. A presence would lead to a lower rating of the floodplain. This can also include plans from other interest groups (agriculture, tourism, hunting, fishing, etc.)

6.3. Restoration demand

Based on the performance of each parameter the demand for floodplain restoration is determined. Each floodplain is assigned to one of three groups (lower, medium, higher demand for restoration).

6.4. Parameter structure for geodatabase

For all datasets, it was decided to use ESRI file Geodatabases in ETRS89 (European Terrestrial Reference System). For the geodatabase it is necessary to define for each FEM parameter the fieldname, the data type and the Unit. Together with the Activity 3.1 leader the parameter structure for the database was selected. This structure will be used for the shape files of the active and potential floodplains. The attribute table of each floodplain polygon has to be filled with the results of the FEM calculation and evaluation and the shapefile has to be uploaded in the database. The following structure is proposed for the database:

Table 46: parameter structure for geodatabase of active and potential floodplains (blue colouring indicates minimum, green colouring medium, yellow colouring extended FEM-parameters)

Name of field	**data type/length**	**Full name of the parameter**	**Unit**	**Example**
DFGIS_ID	text/50	ID of the floodplains		HU_DU_AFP03
FP_Type	text/25	Active, former, potential		active
Location	text/254	Name/location of the floodplain		Upstream from Novi Sad
Transbound	text/10	Countries sharing the floodplain		HR, RS
Area	numeric, double	Area (ha)	ha	6716
FPlength	numeric, double	Length of the floodplain	km	18.6
Chan_width	numeric, integer	Width of the channel	m	450
delta_Q	numeric, double	peak reduction ΔQ	%	1.87
delta_t	numeric, double	flood wave translation Δt	h	1.5
delta_h	numeric, double	water level change Δh	cm	0.7
C_fp_wb	numeric, integer	Connectivity of floodplain water bodies	no unit, direct FEM evaluation	3
Prot_spp	numeric, integer	Existence of protected species	Nr	25
Building	numeric, double	potentially affected buildings	Nr/km^2	52
Land_use	numeric, double	Land use	no unit, direct FEM evaluation	4.8
R_delta_Q	numeric, integer	FEM Rating of peak reduction ΔQ	1, 3 or 5	1
R_delta_t	numeric, integer	FEM Rating of flood wave translation Δt	1, 3 or 5	5
R_delta_h	numeric, integer	FEM Rating of water level change Δh	1, 3 or 5	3
R_C_fp_wb	numeric, integer	FEM Rating of Connectivity	1, 3 or 5	3
R_Prot_spp	numeric, integer	FEM Rating of Existence of protected species	1, 3 or 5	5
R_Building	Numeric, integer	FEM Rating of potentially affected buildings	1, 3 or 5	1

R_Land_use	numeric, integer	FEM of Rating of Land use	1, 3 or 5	3
Hyd_eff	numeric, double	effects in case of extreme discharge	% for dQ and h for dt	1.2 / 3
delta_v	numeric, double	flow velocity Δv	cm/s	1.3
prot_hab	numeric, double	Existence of protected habitats	%	12.5
veg_nat	numeric, double	Vegetation naturalness	no unit, direct FEM evaluation	3.2
WL_dyn	numeric, integer	water level dynamics	no unit, direct FEM evaluation	3
p_int	numeric, integer	Presence of documented planning interests	no unit, direct FEM evaluation	5
R_Hyd_eff	numeric, integer	FEM Rating of effects in case of extreme discharge	1, 3 or 5	1
R_delta_v	numeric, integer	FEM Rating of flow velocity Δv	1, 3 or 5	5
R_prot_hab	numeric, integer	FEM Rating of Existence of protected habitats	1, 3 or 5	3
R_veg_nat	numeric, integer	FEM Rating of Vegetation naturalness	1, 3 or 5	3
R_WL_dyn	Numeric, integer	FEM Rating of water level dynamics	1, 3 or 5	5
R_pl_int	numeric, integer	FEM Rating of Presence of documented planning interests	1, 3 or 5	5
delt_Tau	numeric, double	bottom shear stress Δτ	N/m²	2.5
p_tp_hab	numeric, integer	potential for typical habitats	Nr out of 14 (0 to 14)	12
wb_status	text/25	ecological water body status	high, good, moderate, poor, bad	moderate
R_delt_Tau	numeric, integer	FEM Rating of bottom shear stress Δτ	1, 3 or 5	3
R_p_tp_hab	numeric, integer	FEM Rating of potential for typical habitats	1, 3 or 5	5
R_wb_stat	numeric, integer	FEM Rating of ecological water body status	1, 3 or 5	1
Restoration	numeric, text/25	Restoration demand	Lower, medium, higher	medium

7. Floodplain factsheet

7.1. Content

In the Danube Floodplain GIS, which will be developed in Activity 3.1, the user should be able to see all relevant data for each active and potential floodplain along the Danube. This includes some general data, like the name and code of the floodplain, the type, location and the area, but also the evaluation of the floodplains. To show this data in a user-friendly way, the idea is to allow the user to select each floodplain separately and then get a "factsheet" about it. The factsheet shows all relevant data in a structured way. At the top it will display the general information about the floodplain and a graphic of it, at the bottom the user can find the evaluation of the floodplains for each sector and parameter. At this overview, only the minimum set of parameters are visible, which also offer the basis for the floodplain ranking, but if the user selects the button "additional information" all evaluated medium and extended parameters are displayed as well.

7.2. Design

A first draft version of the design was developed by BOKU to discuss it with the project partners and give the partners of Activity 3.1, which are responsible for the development of the geodatabase, an impression about how it should look at the end. The graphic of the factsheet is presented here:

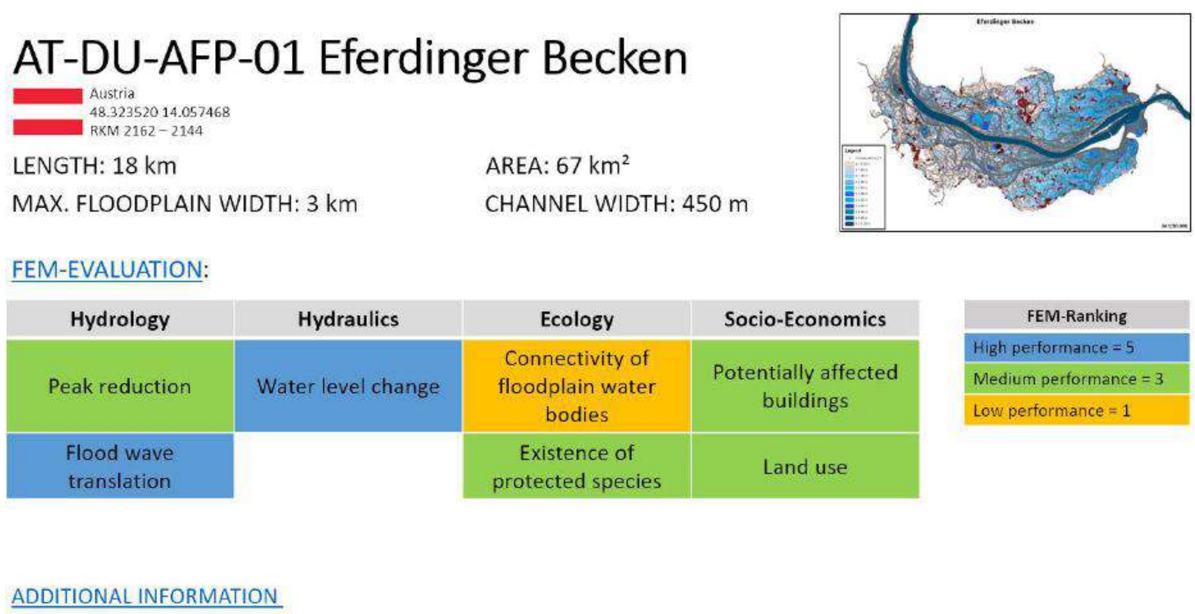


Figure 47: Example of Danube Floodplain factsheet

D3.2.3 Inventory of measures

Country	Name	Category	Type of Measure	River	rkm start	rkm end	Area [km²]	Description	Status	Source
AT	Nationalpark Donauauen	restoration	partly reconnected FP	Danube	1920	1880	95.54	Several measures in the national park were implemented. For examle: Improvement of side waters, riverbank restorations, reconnection of Johler sidearm, facilitation of rheophilic species.	finished	DRBMP
AT	relocation Machland Nord	restoration	asset relocation	Danube	2114	2068	-	Removal of receptors from flood prone areas, or relocation of receptors to areas of lower probability of flooding and / or of lower hazard through buy-out. This includes removing structures illegally built on flood-prone areas and relocation of most endangered population based on the information from risk maps (HQ100 zone as buy-out area).	finished	DFRMP
AT	relocation Eferdinger Becken	restoration	asset relocation	Danube	21.6	21.43	24.35	Removal of receptors from flood prone areas, or relocation of receptors to areas of lower probability of flooding and / or of lower hazard through buy-out. This includes removing structures illegally built on flood-prone areas and relocation of most endangered population based on the information from risk maps (HQ100 zone as buy-out area).	ongoing	Land OÖ
AT	revitalisation upper Drau	restoration	renaturation/ revitalisation	Drau	603	567	0.26	Several measures (5km reconnection of back-waters, establishing 10 new ponds, widening of the river channel, allowing self-development of structures) were implemented and supported in order to improve the rivermorphology (trend of river bed decrease) and ecology.	finished	DFRMP
AT	Revitalisation Schildorfer Au	restoration	renaturation/ revitalisation	Danube	-	-	-	Combination of two old waters to an old arm with bays and ponds as well as connection to the Danube	finished	viadonau Project
AT	Pilot project Bad Deutsch-Altenburg	restoration	renaturation/ revitalisation	Danube	1887.5	1884.5	-	Bank rebuilding and bank lowering, connection of a side arm, optimization of low water regulation, granulometric river bed improvement to stabilize the river bed	finished	viadonau Project
AT	LIFE+ Mostviertel – Wachau	restoration	totally reconnected FP	Danube	-	L= 4km + 1,5km	-	Construction of two side channel systems with a length of 4km and 1.5km connected to the Danube all year round and a biotope	finished	LIFE+ Project

AT	LIFE+ Traisen	restoration	renaturation/ revitalisation	Traisen	-	L= 9,4km	-	Building of a 9.4 km long ecologically valuable estuary with morphological dynamics, large scale land lowering and numerous newly created pond waters	finished	LIFE+ Project
AT	Side arm reconnection KG Angern	restoration	totally reconnected FP	March	32.92	32.1	-	Restoration and all-season reconnection of a side arm	finished	viadonau Project
AT	Thaya 2020	restoration	totally reconnected FP	Thaya	-	-	-	Integration of the two Thaya meanders D18 on Austrian side and D9 on Czech side to the flow system of the Thaya	ongoing	Interreg Project
AT	LIFE+ Renaturation Untere March-Auen	restoration	renaturation/ revitalisation	March	-	-	-	Far-reaching restoration of a near-natural river dynamic in the Lower March floodplain, the extensification of land management, as well as targeted measures for the protection of endangered species	ongoing	LIFE+ Project
AT	LIFE+ Project Auenwildnis Wachau	restoration	renaturation/ revitalisation	Danube	-	-		Restoration of riparian forests, side arm reconnection Rührsdorf / Rossatz, improvement of the existing tributary Rührsdorf / Rossatz by a creating anew tributary to the Danube	ongoing	LIFE+ Project
BG	Floodplain restoration in nature park Russenski Lom near Ivanovo	restoration	totally reconnected FP	Rusenski Lom	-	-	0.03	Restoration of a floodplain on river Russenski Lom near the Ivanovo rock monasteries by breaking the dyke of the river on three sections. The embankment of that river section was not an efficient flood protectionand the arable land and the road in the region were often flooded. As a result of the project, the natural water retention capacity increased by upto 100,000 m3. The conditions for the ecosystems improved and the biodiversity increased.	finished	FRMP
BG	Restoration of Vesselina river	restoration	renaturation/ revitalisation	Veselina	-	-	-	Reconnection of Veselina River, a Yantra- tributary, withits former meander near the Mindya village. The project led to reducing of the flood risk and soil erosion and providedbreeding conditions for many fish, amphibians and birds species.	finished	FRMP
BG	Restoration of old river bed of Ogosta river	restoration	renaturation/ revitalisation	Ogosta	-	-	-	Restoration of the former / natural river bed of the lowest section ofOgosta River. The River was straightened and modified in the second half of 20th century. It was connected together with another Danube tributary - Skatriver, so both rivers are forming a common river-section and are flowingto their confluence in the Danube in a common, modified river bed. The implementation of the project will reduce the	planned	FRMP

								flood risk in that region,caused by the increase of the Skat-water level and the ground water level,due to the backwater effect in case of high waters. A restoration of the biodiversity along the historical Ogosta river bed is also expected.		
BG	Strengthening and stabilization of the river bed of Iskar river and improvement of the river conductivity	construction	renaturation/ revitalisation	Iskar	-	L = 15km	-	Construction of correction (15 km length) of Iskar river in order to reduce the flood risk in Sofia urban area. The project envisages preservation of the existing river course, minimal height of the dikes and formation of water retention areas along the riverbed, by realization of an appropriate landscape layout. Among the 4 alternatives for realization of the project, it was choosen the most environmentally-friendly option for achieving the flood protection objectives, minimizing the negative impact on the water body status in line with the RBMP objectives.	ongoing	FRMP
BG	Formation of manageable polders and smallbuffer reservoirs in the river's flood prone areas	restoration	partly reconnected FP	Yantra; Rosica, Iskar; Osam; Berkovska;	-	-		Several measures,planned for APSFR in different river basins (Ogosta, Iskar, Yantra,Osam), aiming for the reduction of high-water quantity and velocity by controlled water retention, using the existing terrain forms.	planned	FRMP
BG	Construction of facilities for regulated water discharge behind the dikes	construction		Danube	-	-	-	Construction of facilities to provide a controlled discharge of water quantities into floodplains behind the levees	planned	FRMP
CZ	Connection of M26 and M28 former meander	restoration	partly reconnected	Morava	115.8	118.4	-	The meander will be connected at both ends, by removing the deposits, thearms will be deepened at the convex shore, the link between the shoulders and the floodplain biotopes will be strengthened.	ongoing	MRBMP
CZ	Attachment of former meander (new + Troubelka)	restoration	partly reconnected FP	Morava	269.5	272.4	-	Foresees the restoration of the restrained parts of the weaned meandersand their reconnection to the river, part of the flows should be directed to the newly created riverbed.	ongoing	MRBMP
CZ	Revitalization of the flow in km 243 - 245 (Horka n./Mor.hošťina Cholinka to the mouth of the Benkovský brook)	restoration	renaturation/ revitalisation	Morava	243	245	-	Stent removal of stone filing. Renovation of cut-off meanders (theirinfiltration).	ongoing	MRBMP
CZ	Nature friendly to the flood protection measures in km 235,400 - 247,400 (Horka nad Moravou, Chomoutov)	restoration	partly reconnected FP	Morava	235.4	247.4	-	Design of the northeastern relieving passage Horka nad Moravou,Chomoutov.	ongoing	MRBMP
CZ	Nature friendly to the flood control measures in km km 226,400 - 231,800 (under	restoration	partly reconnected FP	Morava	226.4	231.8	-	Flood protection measures at WWTP Olomouc, revitalization measures Nemilanka.	ongoing	MRBMP

	Olomouc po jeze Tážala)									
CZ	Intervention to the valley floodplain of Moravia (elective meander under the municipality of Leština, 290,400-292,600)	restoration	partly reconnected FP	Morava	290.4	292.6	-	The recovery of the "Zvolského" meander. Restoration of the wearing arm under the village of Leština. Reconstruction of shore and accompanying stands.	ongoing	MRBMP
CZ	Revitalization in cadastral zone of Dolní Morava	restoration	renaturation/ revitalisation	Morava	0	0.4	-	Complex revitalisation.	ongoing	MRBMP
CZ	Former meander M61, M62, M63 a M64, Staré Město	restoration	partly reconnected FP	Morava	155.9	158.3	-	Revitalization measures must focus on the engaging of the former meanderin the river system and the valley floodplain, and the restoration of the dynamic flow regime copying the natural hydrology of the Morava River.	ongoing	MRBMP
CZ	Realization of suitable nature-friendly flood protection measures	restoration	partly reconnected FP	Morava	-	-	-	Flood protection and measures for improvement of the hydromorphological status of watercourses on the basis of the study of the "Upper and Middle Moravia River Basin". Evaluation of hydromorphological status and proposals of nature-related flood protection measures on selected water courses (490 km) according to the requirements of the WFD.	ongoing	MRBMP
CZ	Dry reservoir Zichlinek	construction	totally reconnected FP	Moravska Sazava	-	-	-	Construction of a dry reservoir on Moravska Sazava River in the years 2005–2007 with total retention volume about 5.9 mil. m3 and the area ofabout 166 hectares. In the polder area the part of Moravska Sazava river was revitalized. The structure will reduce the flood Q100 = 126 m3/s to about Q20 = 83 m3/s.	finished	DFRMP
CZ	Nature friendly flood protection measures in the area of rivers Morava and Dyje confluence	restoration	renaturation/ revitalisation	confluence of Morava and Dyje	-	-	-	The project was realized in the area of confluence of Morava and Dyje rivers(polder Soutok) in the years 2011 – 2013 with the aim to optimize the control and operation in the polder Soutok on Czech territory during floods and to reduce the floods danger in the lower part of Morava river between Austria and Slovak Republic.	finished	DFRMP
DE	Dynamization of the Danube floodplain between Neuburg and Ingolstadt	construction	partly reconnected FP(controlled!)	Danube	2473	2464	12.00	Construction of a bypass river through the southern part of the floodplain forest, creation of new stream habitats and longitudinal connection in the Danube, reconnection of oxbows, construction of fish passes, controlled ecological floodings (of about 100 ha 1 to 4 times per year for about 1 to 4 days), groundwater management, etc.	finished	DRBMP / Project Bayern

DE	toration between Hundersingenand Binzwangen	restoration	renaturation/ revitalisation	Danube	2658.3	2660.7	1.00	Over a length of 2.7 km, the Danube received a new, near-natural riverbed.The new riverbed is up to 2.5 m higher than in the previous recessed state. It was connected with a chute to the lower reaches. By means of land removal, a new river bed was created, which still changes its shape duringflood events. The floodplain is left to natural succession and morphological self-development.	finished	Project Baden-Württemberg
DE	ith gravel on the Danube nearDuenzing	restoration	renaturation/ revitalisation	Danube	-	L = 250m	-	On the left bank of the Danube near Duenzing, a structured gravel bank waspoured into the Danube in June / July 2018. This is intended primarily to create gravel spawning grounds for stream-loving fish species. The gravel bank is about 250m long and inclines with a gradient of about 1:25 about 15m to the middle of the river and is in terms of height in the middle low tide. A basic structure of water blocks serves the stability of the gravel bank andoffers a certain erosion protection. For the gravel beds approx. 3,000 m³ ofexisting Danube gravel was used.	finished	Project Bayern
DE	Lateral tributary above Neustaedter Bruecke	restoration	renaturation/ revitalisation	Danube	-	L = 250m	-	At the Danube in the district of Pförring, a 250 m long lateral tributary was created and connected to the Danube upstream and downstream. Above all, the habitat conditions for typical fish species are improved with the current through the tributary. The newly developed island area was removed over a large area. The improved bank dynamics create habitats fora variety of endangered pioneer species today, such as the sandpiper. The successive dismantling of the bank protections also promotes the water beddynamics and structure formation. The measure is also an important contribution to achieving good ecological status on the Danube in accordance with the EU Water Framework Directive.	finished	Project Bayern
DE	ation on the Danube nearPförring	restoration	renaturation/ revitalisation	Danube	-	L = 1 km	-	In the area of Pförring in the district of Eichstätt, the left bank of the Danube was rebuilt in August 2015 over a length of approx. 1 km and remodeled close to nature. With the removal of the massive bank paving anatural channel development and formation of water body structure becomes possible again. The installation of flowed stone groynes promotes the development of theriversides and increases the structural diversity for rheophilic (flow-loving)fish species and other aquatic organisms. Flat gravel banks offer a habitatfor pioneering species such as the little ringed plover and create attractive access to the Danube.	finished	Project Bayern

DE	tablishment at the Paar nearNörzhausen	restoration	renaturation/ revitalisation	Paar (tributary)	-	L = 90m	-	In August 2015, a new, about 90 m long oxbow was created at the couplenear Hörzhausen. The shore of the new oxbow was variably designed with shallow water zones and steep banks. The oxbow is connected via a pool, which is flowed through at higher streamflow at the Paar. The erosion surfaces are left to natural succession. On the surfaces subject to change inhumidity an typical floodplain vegetation on silting areas is to develop.	finished	Project Bayern
DE	nsformation of the Große Labernear Puchhof	restoration	renaturation/ revitalisation	Große Laber (tributary)	-	L = 1 km	-	In the approximate one-kilometer stretch between the engine at Puchhof and the county boundary to the Straubing-Bogen district, in autumn 2015 the Regensburg Water Resources Office removed the concrete slabs on theright bank and flattened the bank (this was not possible on the left bank because of a flood dike). In addition, the existing gravel in the water was loosened and in the riverbed various deadwood structures such as rhizomes and tree groynes were installed at about 30 places. Also some islands and groynes from water bricks were introduced. In spring 2016 about 130 trees were planted on the south bank. The aim of the measures is a dissolution of the riparian shorelines, the settlement of bank shrubs and above all a self-dynamic river development,which ensures a permanent improvement of the water structure and a continuous rearrangement of the bed load.	ongoing	Project Bayern
DE	Near-natural remodeling of the Isar estuary	restoration	partly reconnected FP	Danube / Isar	8.7	0	29.26	Change of plants to typical floodplain forests with periodic flooding, changeof agricultural land to grassland, reconnection and reservation of the floodplain forests and also reservation of cultural landscapes. Removal of rocky banks, creation of "soft banks" for widening and heterogenisation of the water body profiles. Retention, if necessary adaptation of the bed load to compensate for bedload deficits due to barrages. Reconnection and reactivation of side channels, (partial) removal of bank stretches. Reconnection of oxbows and restoration of backwaters. Area protection and area expansion for important cultural landscape biotopes, safeguardingof the necessary management and care. Further area securing and area expansion in core areas, in particular dike forelands, Polder area, water protection area and low moorland areas for the protection and development of highly endangered floodplain habitats. Investigation of a possible relocation of a dike. Implementation of special auxiliary measuresfor selected species. Measures for water level protection or -increase in the Isar, if necessary.	ongoing	DRBMP / Donauraum strategie

DE	Living Vils near Schönerting	restoration	renaturation/ revitalisation	Vils (tributary)	-	L = 15,5 km	-	Former channels and cut-offs are rejoined to the Vils at a length of 15.5 km. This allows a regular watering of the floodplain again. For the rural area around Schönerting, the planned transformation of the Vils and its floodplain will create a high-quality, natural water landscape with valuablehabitats. This unites the concerns of recreation and nature.	planned	Project Bayern
DE	Model projects for ecological Optimisation of the Danube between Straubing and Vilshofen	restoration	revitalisation and (partly) connected FP	Danube	2329	2249	27.50	Possible measures include in particular the deconstruction and near-naturaldesign of the built-up banks, the preservation or restoration of the scour, or desedimentation and reconnection of oxbow rivers.	planned	Donauraum strategie
DE	n between Ingolstadt and Weltenburg	restoration	renaturation/ revitalisation and partly reconnected FP	Danube	2455	2420	27.80	Preservation and restoration of natural river dynamics, preservation andimprovement of undisturbed, undeveloped or unpaved bank zones with natural flooding regime, natural bank design processes and undisturbedconnection to the adjacent biotopes. Preservation and restoration of oldwatercourses, securing and restoration of the continuity between the Danube and tributaries (cross-linking), preservation and improvement ofthe zones of changing water, preservation of the typical Waters, Sedimentation and riparian vegetation. Safeguarding and restoring of pioneer fauna along the valley flanks as well as on the burning sites. Thereby protecting the special habitats for endangered plant and mollusc species. Preservation or restoration of forests. Riverside restoration and structuring. Creation and development of new Danube tributaries.	planned	Donauraum strategie
DE	Licca liber - The Development of the Lech from barrage 23 to the estuary at the Danube	restoration	renaturation/ revitalisation	Lech (tributary)	56.8	0	40.84	Implementation of the FFH management plan with measures to improve water body morphology, discharge dynamics, groundwater dynamics, connectivity and connection of alluvial waters to the Lech.	planned	Donauraum strategie
DE	ynamisation of the Danube floodplains between Marxheim and Stepperg	restoration	renaturation/ revitalisation and partly reconnected FP	Danube	2498	2485	12.00	Creation of outflows and reinjections with naturally fluctuating outflows.Creation of a continuous stream to bypass the Bertoldsheim barrage. Reconnection of old watercourses and flood channels. Redynamisation and structural improvement of riparian zones and floodplain habitats (removalof slope protection and the insertion of disturbing elements). Developmentof site-specific forms of use in the project area.	ongoing	Donauraum strategie

DE	River development mid Isar	construction	dike relocation	Isar (tributary)	142.9	78.25	-	Opening of existing dikes and construction of new dikes at a greater distance from the river, the alluvial forest in between can thus be floodedmore frequently and the retention volume is used. Expansion of the restraint space, some areas are purchased and partial compensation for affected persons.	ongoing	HW-Aktionsprogramm 2020
DE	ervation area "Donauwiesen" betweenRiedlingen and Munderkingen	restoration	renaturation/ revitalisation	Danube	2650	2623	6.00	Conservation, facilitation and development of cultural imprinted flood plaints. The predominantly naturally structured oxbows and river banks show regional and cross-regional significance for breeding and resting areas of birds. Renaturation measures implement the generation of side channels, expansion of river bed, creation of flood plains. Conservation area is divided into two parts: Donauwiesen 1 (Riedlingen to Zwiefaltendorf (km 2639));Donauwiesen 2 (Zwiefaltendorf (km 2639)to Munderkingen)	ongoing	Project Baden-Württemberg
HR	truction and construction of the PSPodunavlje water gates	construction	partly reconnected FP	Danube, Drava	-	-	-	Release of Danube river floodwaters into the landside of the Danube-Dravaflood protection dike, i.e. area of a former fishpond and maintenance of water surfaces of a retention basin for the protection of biodiversity of the Kopački Rit Nature Park.	ongoing	Water Management Plan
HR	mental restoration of the Boroš Dravaand Aljmaški rit side arms	restoration	renaturation/ revitalisation	Drava	0	12	-	Revitalization of the flood zone on the right Drava riverbank.	ongoing	Water Manageme nt Plan
HR	Restoration of a Mura River side arm	restoration	renaturation/ revitalisation	Mura	-	-	0.20	The purpose of a hydraulic solution consisting of the improvement of the entry into the side arm, removal of mud from the bottom, partial removalof trees and small vegetation along the banks is to create a permanent water surface aimed at improving the ecological status of the area and establishing recreational areas.	ongoing	Water Management Plan
HR	de arms within DRAVA LIFEProject	restoration	renaturation/ revitalisation	Drava	-	-	-	The restoration of the Drava river side arms will enable better flood protection within the existing floodplains, i.e. contribute to the local decrease of water levels during high floods, as well as to relieving the pressure from the watercourse in urban areas. The project will also have apositive impact on groundwater resources since the side arm restoration will improve the infiltration of river water into groundwater aquifers, whichwill help stabilize the status of lowered groundwater levels.	ongoing	Water Management Plan
HU	Sustainable use and management rehabilitation of flood plain in the MiddleTisza District (SUMAR)	restoration	habitat rehabilitation, increase biodiversity, dike relocation, new wetlands	Tisza	312.4	323.2	5.50	The task of the project is to demonstrate on the typical section of the floodplain that the ecological approach to the floodplain rehabilitation canbe realized, so that by preserving and educating the natural values both the retention capacity of the affected area and the flood protection safety	finished	FRMP/ DRBMP

								increase.		
HU	Beregi complex project: decrease flood peakand floodplain revitalization development (KEOP-2.1.1/2F/09-2010-0007)	restoration	emergency reservoir, floodplain revitalization	Tisza	681	706	60.00	Construction of an emergancy reservoir and related facilities in Bereg, withthe help of which the peaks of the flood waves can be cutted in the most critical section of the Tisza Tivadar. With the implemented system, the Bereg water replacement can be solved. At the extension of the reservoir a rural development program has also started that would enable an adaptive land use where there would be less flood damages in case of filling up the reservoir and also there would be benefits of the regular small scale filling of the reservoir - measure 5.1.4.: 2,3) -. The reduced damages on the area are not known but could be a smalldegree, compared to possible flood damages in the effected flood bays.	finished	FRMP/ DRBMP
HU	Tisza floodplain: Improving the capacity of theriverbed in Middle-Tisza between Szolnok andKisköre. (KEHOP-1.4.0-15-2016-00017)	restoration	dike relocation, land use change, forest regulation (invasive), demolotion ofdepots, reef and summer dike demolotion	Tisza	335	403	-	Improving flood safety and reducing flood risks. Decrease: flood wave, flood risk. Increase: floodplain area, biodiversity, birds habitat, wetlands habitat, ecosystem services. Improve conveyance capacity. This project is a continuation of the SUMAD (Sustainable Use and Management of AlluvialPlains in Diked River Areas) international project, with Bavarian, Austrian and Hungarian partners. In the course of this project, the necessary measures and guidelines of SUMAD have been implemented into the legal framework in Hungary, but interventions have been completed in Bavariatoo. WWF HU doesn't support some parts of the project (especially the approach and the forest management).	ished/ongo	FRMP
HU	Vasarhelyi Plan: Development of floodplain in the Middle-Tisza. Target area: Szolnok-Csongrád Tisza river section. (KEHOP-1.4.0-15-2016-00014)	restoration	flood control channel, dike relocation, land usechange, forest regulation(invasive), demolotion ofdepots, reef demolotion	Tisza	247	335	-	Improving flood safety and reducing flood risks. Decrease: flood wave, floodrisk. Increase: floodplain area, biodiversity, birds habitat, wetlands habitat, ecosystem services. Improve conveyance capacity.	ongoing	FRMP
HU	Dike relocations in Tisza catchment	restoration	dike relocation, new floodplain area, new wetlands area	Tisza, Zagyva, Sebes-Körös, Fekete-Körös	-	-	-	Dike relocation of the left and right riverbank. By relocating the dike, the floodplain is broadened, providing more space for floodwater downstream.(eg.: Zagyva 19.7-22.2; Tisza 122.87-125.28, 255.4-260.2, 270-284.4, 290.9-294.8, 298-304.2, 342.7-360, 409.1-412; Sebes-Körös 2.9-3.1,22.35-22.55, 45.9-46.5; Fekete-Körös 0.8-4,9.8-10.1 rkm)	planned	FRHMP

HU	Modifying vegetation or land use in floodplainarea in natural conservation and ecological aspects in Tisza catchment	restoration	Modifying vegetation or land use in floodplain area in natural conservation and ecological aspects	Tisza, Zagyva, Hernád, Túr, Szamos, Kraszna, Bodrog, Berettyó, Maros	-	-	-	Removing run-off barriers, supression of high density vegetation. In particular, suppressing invasive species at the shrub level. This will help to increase runoff and maintain native biodiversity. Modify land-use to reduce the floodrisk.. Taking in count aspects: ecological status, nature conservation, reduction of sediment and nutrition. (e.g. Tisza 159-164.1, 198- 206, 252-412, 435-437, 443-462, 472-483, 486-491, 517.6-519.9, 536.9-537.1, 539.9-541.1, 542.3-542.7, 543.6-744.9; Zagyva 0-87.7; Hernád 9.3-9.7, 21.9-22, 65.5-76.5; Túr 18.5-19.5; Szamos 0-50.2; Kraszna 1.3-10, 17-17.7, 30.5-33, 33.4-36.5, Bodrog 28.8-29.6, 37.3-38, 42.3-43.9, 46-46.5, 48.5-49; Brettyó 53.3-55.3; Maros 0-49.5 rkm) In case of eradication of the vegetation, aspects of protected habitats and natural values should be taken into account. It should be given the possibility for the native flora to settle as much as possible - this can hinder spreading of invasive species. Connection between the watercourses and the active floodplains should be improved, to maintain as much water as possible in case of low-water stands as well	planned	FRMP
HU	Sustainable land usage in Tiszatarján	restoration	shrub control, increase biodiversity	Tisza	470	-	0.90	Cutting Amorpha fruticosa and grazing of the area by buffalos. Using Amorpha as biomass, for heating. Cleaning the floodplain to increase watercarrying capacity.	ished/ongo	WWF
HU	Integrated (Multi-level inundation) water management system in the Borsodi-mezőség	restoration	floodplain revitalization	Csincse-channel	-	-	-	The project applied a 'FOK' (natural depression in a flood plain) water regulation system and a proper land use system by establishing a natural water supply in the Borsodi mezőség area.	finished	LIFE Project
HU	Bátai-Holt-Duna	restoration/construction	reconnection of asidearm	Danube	1465	1471		construction of a sluice and dredging - improved water supply of the "Címer-fok" and the sidearm, also good for taking bigger water discharges in case of floods	finished	DRBMP
HU	Mocskos-Duna	restoration/ construction	reconnection of asidearm	Danube	1440			construction of a bottom weir to retain more water in the sidearm by lowwater stand, also good for taking bigger water discharges in case of floods	finished	DRBMP
HU	Restoration of the conveyance capacity andecological conditions of the floodplain water supply system and the Old-Danube riverbed in the Szigetköz region	restoration	renaturation/ revitalisation	Öreg-Duna (Szigetköz)	1850	1810	-	Szigetköz has a potential for complex rehabilitation measures in many different locations. HU party have closed, ongoing and planned projects aswell. The main issues are rejoining separated sidearms, modification of regulatory structures and establishment of **conveyance lines**.	d/ongoing/f	FRMP (NMT) RBMP (VGT6.2, 6.3, 6.7, 6.8)

HU	Restoration of the conveyance capacity andecological conditions of side-arms in the Danube floodplain ("Vének", "Erebe")	restoration	renaturation/ revitalisation	Duna	1800	1785	1,86	Rehabilitation of "Véneki" and "Erebe" side arm systems, decreasing the heights of local training structures, re-joining shallow sections, improvingthe conditions of the mouth of the "Cuhai Bakonyér" river if necessary, vegetation management	planned	FRMP (NMT) RBMP (VGT6.2, 6.8)
HU	Restoration of the conveyance capacity andecological conditions of side-arms in the Danube floodplain ("Szőnyi", "Monostori", "Neszmély-Mocsi")	restoration	renaturation/ revitalisation	Duna	1784	1744	2,56	Ecological water supply and rehabilitation of "Szőnyi", "Monostori", "Neszmély-Mocsi" sidearms, decreasing the heights of local training structures, re-joining shallow sections, vegetation management	planned	FRMP (NMT) RBMP (VGT6.2, 6.8)
HU	Restoration of the conveyance capacity and ecological conditions of side-arms in the Danube floodplain ("Táti", "Prímás", "Dédai", "Törpe")	restoration	renaturation/ revitalisation	Duna	1728	1710	1,83	Better ecological water supply and rehabilitation of "Táti", "Prímás", "Dédai", "Törpe" sidearms, re-joining shallow sections, vegetation management, forming **conveyance lines** in the islands. Including the opening of the "Körtvélyes" sidearm and development of wetland habitats	planned	FRMP (NMT) RBMP (VGT6.2, 6.8)
HU	Restoration of the "Kompkötő szigeti" side arm	restoration	renaturation/ revitalisation	Duna	1686	1682	-	Restoration of the "Kompkötő szigeti" side arm	planned	FRMP (NMT)
HU	Rehabilitation of the "Adonyi", "Rácalmási", "Szitányi szigeti" side arms	restoration	renaturation/ revitalisation	Duna	1601	1567	-	Rehabilitation of the "Adonyi", "Rácalmási", "Szitányi szigeti" side arm	planned	FRMP (NMT) RBMP (VGT6.2, 6.8)
HU	Restoration of the "Solti" side arm	restoration	renaturation/ revitalisation	Duna	1564	1560	-	Restoration of the "Solti" side arm	planned	FRMP (NMT)
HU	Re-establishment of the meandering character of the river and expansion of the wetted perimeter with rehabilition of the disconnected side arms	restoration	renaturation/ revitalisation	Rába	86	0	-	Rehabilitation of side arms, water level provision with small submerged dams at the end of the side-arms, vegetation management, opening conveyance lines	planned	FRMP (NMT)
HU	Point-wise extension of the floodplain to remove narrow sections that obstructs flood	construction	dike relocation	Rába	-	-	-	Due to the narrow floodplain dike relocation is a potential local measure at82-80 rkm, 55 rkm and 49 rkm.	planned	FRMP (NMT)

	conveyance									
HU	Removal of artifical obstacles from the floodplain	construction	summer dams relocationin the floodplain	Mura	50	23	-	Demolish of so called "summer dams" (local polders) fro mthe floodplain	planned	FRMP (NMT)
HU	Rehabilitation of the "Adhini", "Kisinci", "Mailáthpusztai", "Piskói", "Lajos-tanyai", "Drávasztárai" side arms	restoration	renaturation/ revitalisation	Dráva	118	83	-	Rehabilitation of the "Adhini", "Kisinci", "Mailáthpusztai", "Piskói", "Lajos- tanyai", "Drávasztárai" side arms	planned	FRMP (NMT)
RO	Wetland resoration on river sector Bratovoieşti- Dobreşti	restoration	partly reconnected FP	Jiu	Centroid X=23.90203 Y=43.993644	-	0.80	wetland restoration measures.	ongoing	RBMP FRMP
RO	Wetland restoration on river sector Filiaşi - Argineşti – râul Jiu	restoration	partly reconnected FP	Jiu	Centroid X=23.440742 Y=44.559591	-	0.50	wetland restoration measures.	ongoing	RBMP FRMP
RO	Wetland restoration on WB Hârtibaciu Izvoare - confl. Cibin	restoration	totally reconnected FP	Hartibaciu	Centroid Retis Reservoir X=487756,745 Y=507978,588 Centroid Alţâna wetland X=457875,756 y=494964,073	L = 265,6m	Retis = 0,45 Alţâna = 1,90	The wetland is proposed in the Retis temporary reservoir. 2 phases have been proposed . 1-st phase is the development of the Retis river dam upstream enclusure, toghether with a water supply sytem . The 2-nd pahase comprise in fish and macrophite population. The surface of restored wetland is approximately 7 ha.	ongoing	RBMP FRMP
RO	Reconnect old arm on the Stefanesti - Romanesti area	restoration	totally reconnected FP	Baseu	Centroid x=668252.01 y=696790.54	L = 22 km	-	Restoration of the flow on the old basin of the River Baseu on a length of ~19 km upstream of the confluence with the Prut river. The restoration workswill follow the old route of the Baseu River from Stefanesti and up to the Prut on the distance of about 22 km and will be designed for a maximum flow of 2 m/s. Rehabilitation works are required on a length of approximately 19 km.	ongoing	RBMP FRMP
RO	Restoration of meanders / secondary branches in the area of Cotul Morii - Teiva Visina	restoration	totally reconnected FP	Jijia	Centroid x=695045.1 y=650617.6	L = 12,5 km	-	Reconstruction and restoration of flooded meadow and remediation ofwater flow Jijia.The Cotu Morii area at Frasuleni will feed the natural reserve Teiva - Visina	ongoing	RBMP FRMP
RO	Reconnect old arm in the right bank Jijia,Victoria-	restoration	totally reconnected FP	Jijia	Centroid x=70223.00 y=644699.2	L = 51 km	-	Reconstruction and restoration of flooded meadow and remediation ofwater flow Jijia	ongoing	RBMP FRMP

	Golaesti									
RO	Restoration of the left bank Jijia meandering, Bosia	restoration	totally reconnected FP	Jijia	Centroid x=70966.9 y=638989.8	L = 13,5 km	-	Reconstruction and restoration of flooplain and remeandering of water flowJijia. The area from Bosia to Ungheni is 13.5 km long and is a meander on the left bank of Jijia.	ongoing	RBMP FRMP
RO	Restoration of the left bank Jijia meandering, Cristeşti	restoration	totally reconnected FP	Jijia	Centroid x=706886.7 y=633622.7	L = 3,2 km	-	Reconstruction and restoration of flooplain and remeandering of water flow Jijia. The area from Bosia to Ungheni is 13.5 km long and is a meander onthe left bank of Jijia.	ongoing	RBMP FRMP
RO	Create new wetlands on Tur River - downstream of Negresti Oas	restoration	partly/totally reconnected FP	Tur	-	-	2.00	Increasing the mitigation capacity of Calinesti reservoir and transit the floodflows to the border with the Hungarian Republic. The wetland is proposed on the left bank of the Tur River, upstream of the confluence with the Talna River - Satu Mare County.	planned	FRMP
RO	Create new wetlands on Tur River - downstream of Negresti Oas	restoration	partly/totally reconnected FP	Tur	-	-	3.00	Increasing the mitigation capacity of Calinesti reservoir and transit the floodflows to the border with the Hungarian Republic. The wetland is proposed on the right bank of Tur River, in the area of Gherta Mica locality - Satu Mare County.	planned	FRMP
RO	Reconstruction and restoration of floodplainon Tur River - downstream of Negresti Oas	restoration	partly/totally reconnected FP	Tur	-	-	0.50	Increasing the mitigation capacity of Calinesti reservoir and transit the floodflows to the border with the Hungarian Republic. Restoration of the flood plain on the Tur River, downstream of Calinesti reservoir.	planned	FRMP
RO	Create new wetlands on Crişul Negru River– downstream of Poiana locality	restoration	partly/totally reconnected FP	Crişul Negru	-	-	10.00	Creation of wetlands on the Crişul Negru river for improving the drainage in high water condition, Bihor County	ongoing	FRMP
RO	Create new wetlands on Râul Negru - downstream of Lemnia locality	restoration	partly/totally reconnected FP	Râul Negru	-	-	-	Maintaining the wetland in the Mestecanesti area (ROSCI 0111) by works which stop lowering the groundwater level	planned	FRMP
RS	Obedska bara	restoration	partly reconnected FP	Sava	-	-	98.95	Implemented and supported several measures (periodical dredging and land and vegetation clearing/removing, widening and deepening of inland channels and the Sava River connecting canal) in order to improve waterregime and ecology (revitalization of wet meadows and pastures). Building/rehabilitation of the stone/earth dam on the side channel aimed toslow down discharge from the area.	ongoing	DRBMP
RS	Carska bara	restoration	partly reconnected FP	Begej	-	-	47.26	Periodical silt dredging of Stari Begej canal, construction of silting basin, desilting of connecting canal with the Stari Begej River aiming to enable fish spawning.	ongoing	DRBMP

RS	Gornje Podunavlje	restoration	partly reconnected FP	Danube	-	-	193.86	Implemented and supported several measures (periodical swamp dredging and connection) in order to improve water regime and ecology.	ongoing	DRBMP
SI	Identification, establishment and preservation of retention areas of high water	preservation	renaturation/ revitalisation	Krka	62	76	37.00	Regular activities - control of water streams banks, removal of excessivevegetation	ongoing	State Flood Directive, DFRMP
SI	Drava River - Mala vas	restoration	Restoration of side channel	Drava		L=2 km	-	Restoration of side channel on the Drava River close to Mala vas (near Slovenian – Croatian border). Side channel will improve hydromorphological conditions of Drava River and reduce the water level up to 10 cm. In case of high-water level (Q5) 5 %of the entire water would flow through the channel. Within restored side channel, also river pools, natural spurdykes and fallen trees are foreseen.	ongoing	FRMP
SI	BIOMURA	restoration	Reconnected Floodplain & Restoration of side channels	Mura		L = 11 km	15.00	Because of intensive water use, activities in the water area and change of land use in the Mura basin, the floodplain forests along Mura received everless water. The water dynamics in oxbows, side branches and in the groundwere decreasing. Between Bakovci and Mota, old side channels were reconnected to the Mura river. The former oxbows were restored. Natural river bed widening (lateral erosion) was established. This way, the connection between surfacewater and groundwater was renewed. The floodplain forests are now naturally flooded more often and not just during extreme water levels.	finished	Nature Protection Project
SI	DRAMURCI 11-mill canal	restoration	Reconnected Floodplain	Mura		L=17 km	-	The Mura river is known to have deepened its river bed up to 1.5 m becauseof intense use for hydropower and narrowed river channel. In this project, the river bed of the Mura river, at the 11-mill canal, has beensignificantly widened to allow deposition of sediments and therefore to stabilise the river bed. Former side channels that have been dry for decades have also been reconnected to the Mura water body at this section.		European Territorial Cooperation
SI	Polhov Gradec	preservation	Protection of Floodplain	Gradaščica				Floodplain along the Gradaščica river protected under municipality land use plan upstream of Ljubljana.	finished	FRMP
SI	Horjul	preservation	Protection of Floodplain	Horjulka				Floodplain along the Horjulka river protected under municipality land use plan upstream of Ljubljana.	finished	FRMP
SI	Grosuplje	preservation	Protection of Floodplain	Grosupeljščica				Floodplain along the Grosupeljščica river protected under municipality land use plan.	ongoing	FRMP

SK	Right side diked retention area beside of weirHrušov-from year 2002 Protected area "Dunajské ostrovy"	preservation	totally reconnected FP	Danube	1859.5	1856	-	The Polder/dry reservoir is formed in the area between the right side dikeof the pool and the Danube river bank at the end of the upper backwater between Danube River km 1859,5 to 1856,0. The Polder/dry reservoir itselfserves to protect forests in the km 4,5 - 12,0 dike of the pool. The intake structure is built in the polder/dry reservoir dike at rkm 1856,0.The polder/dry reservoir begins to fill at a flow rate of over 4 000 $m^3.s^{-1}$ in the period from March to July, if the required flows in the period does not occur, the polder/dry reservoir will not be flooded. The Polder/dry reservoir is filled about 10 hours with a flow of 48 $m^3.s^{-1}$, thevolume of the polder/dry reservoir is about 1.7 mil. m^3. Water from the polder/dry reservoir is discharged in an amount of up to 8 $m^3.s^{-1}$ to the channel of Hrušov weir.	finished	Temporary handling regulation for SVD G-N
SK	Weir/Stupeň Čunovo + former Danube channel+stream branches + Weir/Stupeň Gabčíkovo	preservation	totally reconnected FP	Danube	1851.75	1811	-	By constructing of the "SVD (system of water structures) Gabčíkovo- Nagymaros" in the territory of the Slovak Republic, the positive effect of theDanube left-side branch system can be used during increased flow in the Danube River. At flow more than 5 700 $m^3.s^{-1}$, a part of the flow can be released through the Čunovo stage into the old Danube channel. With the redistribution of a part of the flood flow into the old Danube channel, a decreasing of the flood wave and time shift can be achieved (slowing theflow of the split flow through the branch system to the confluence of thewaste canal and the Danube River). Before moving of the part of the floodflow to the old Danube channel in a quantity that is already pouring out from the riverbed, about 2 800 $m^3.s^{-1}$, is necessary to flood the branch systems on both sides (flooding of the branch system is provided by handling regulations). Before starting to fill the branch system, a warning is given to people moving in the branch system and in the adjacent villages Dobrohošť, Vojka nad Dunajom, Bodíky and Gabčíkovo.	ongoing	Temporary handling regulation for SVD G-N
SK	Restoration of Natura 2000 sites in cross-border Bratislava capital region" LIFE+ Project	restoration	partly reconnected FP	Danube	1872	1879.7	2.30	Reconnection of Devinske and Karloveske branches (Danube), constructionof inflow structure, reconstruction of barrier in Devinske branch (bridge), removal of bank pavement, dredging of sediments	finished	LIFE Project
SK	Danube Floodplain rehabilitation to improve flood protection and enhance ecological values of the river in	restoration	totally reconnected FP	Danube	1799	1809.5	8.20	Reconnection of Medvedov-Klucovec main branches (Danube), reconnection of small transversal side branches, construcion of inflow structures, construction of deflectiver structures, removal of groins on the outflow from the Klucovec branch, adjustment of groins	planned, partly ongoing	DRBMP

	section between Sap and Szob (DuReFlood) SK-HU Cross-border cooperation Project							elevation (lowering) in the Danube channel, removal of sediments between the groins		
SK	Danube birds conservation - Conservation of Endangered Bird Species Populations in Natural Habitats of the Danube Inland Delta; Restoration and management of Danube floodplain habitats LIFE+ Project	restoration	partly reconnected FP	Danube	1780.5	1786	3.50	Reconnection of Velkolelske main branch (Danube), reconnection of small transversal side-branches, removal of barrier in the main branch, building ofa bridge, removal of sediments (inflow, outflow, branch), reconnection of wetlands on the islands with the branch to ensure more often local floodingof the island, sustainable grassland management on Veľkolélsky island	finished	LIFE Project
SK	DANUBEPARKS CONNECTED Interreg DTP Project	restoration	partly reconnected FP	Danube	1730	1732	0.66	Reconnection of Muzla branch with the Danube	planned	Interreg Project
SK	Bilateral General Project Morava (BGM II) - Common management of hydro ecological &water management measures prepared in harmony with EU WFD and other Environmental Directives; The Morava RiverRestoration: Plan of measures prepared in agreement with EC Water and Nature Protection Directives (MoRe) SK-AT cross border cooperation projects	restoration	partly reconnected FP	Morava	0	69	46.00	Development of restoration scenarios to enhance ecological improvement in line to the EU WFD and Environmental Directives and maintain water management functions, development of sustainable plan of restoration measures for pilot section, feasibility study including cost estimation, prior -implementation monitoring of morphological and ecological status; measures such as bank pavement removal, lowering of banks to enable lateral connectivity of the river and floodplain, restoration of straightenedreaches by integration of cutt-off meanders into the river system, reconnection of meanders etc.	planned	DRBMB

III. Activity 3.3: Floodplain assessment on selected tributaries

Introduction

The Activity 3.3 of the DFP aims to identify and evaluate the active and potential floodplains and their reconnection on six Danube tributaries. Namely, tributary watersheds have an important role in floodplainanalysis, assessment and management, especially in the context of ensuring the holistic approach to waterand flood risk planning. Besides restoration, a significant floodplain management aspect is the preservation of floodplains through spatial plans considering environmental, economical, societal and land development issues.

The methodology for delineation and evaluation of active and potential floodplains was developed and applied on the Danube River, as well as on six tributaries: Krka (Slovenia), Morava (Czech Republic, Slovakia), Tisza (Hungary, Serbia), Sava (Croatia, Serbia), Desnăţui (Romania) and Yantra (Bulgaria) (Figure48). In addition, possible restoration measures to activate potential floodplains have been identified.

DRSV coordinated the Activity and the project partners (PPs) for the evaluation of floodplains on selectedtributaries. Project partners (DRSV, MRBA, KOTIVIZIG, USZ, JCI, CW, MWF, NARW, NIHWM, DRBD) have:

- identified active and former floodplains and associated measures on their selected tributaries,
- reviewed FEM (Floodplain Evaluation Matrix) ranking method and cooperated in its adaptation formultiple-criteria floodplain evaluation,
- defined criteria and classified floodplains on their selected tributaries considering specific nationalconditions,
- cooperated in preparation of recommendations for floodplain evaluation on tributary floodplainsbased on knowledge exchange that will be incorporated in WP5 deliverables.

The following is the report of the Activity 3.3 (Floodplain assessment on selected tributaries), consisting of three deliverables:

- D 3.3.1 Map of floodplains on selected tributaries,
- D 3.3.2 List of floodplains, their characteristics restoration/preservation potential and associatedmeasures,
- D 3.3.3 Recommendations for floodplain assessment on tributaries including the description ofimplemented methods and classification criteria.

Figure 48: Danube river basin with the six selected tributaries

In this report, the process of floodplain assessment on the tributaries is given, including the implementedmethods and classification criteria. The results for any given tributary are based on the data contributed by the project partners.

Deliverable 3.3.1 Map of floodplains on selected tributaries

8. Methodology

The methodology for identification of active and potential floodplains on tributaries is based on the experience of the PPs from the Danube river and the selected tributaries. At the beginning of the project,the PPs faced some obstacles in the process due to different background of water management, data availability, and legislation in their countries. Several meetings were organised to harmonize the specific backgrounds of the PPs with the demands of the project. Nevertheless, the wide pool of knowledge and experience helped create the methodology that proved useful and efficient, which resulted in common approach and comparability of the results among different countries and rivers. Its flexibility and adaptability overpassed the restrictions which could stem from different size of the watercourses and their floodplains. It will help rise awareness of the importance of the floodplains, their integration in the process of water and flood risk management, and overall better transnational water management in the Danube river basin.

The document summarises the results on the selected tributaries. Extended reports on each tributary areavailable on the FTP site. The evaluation of the tributaries is based on commonly agreed procedures between the project partners on tributaries and on the Danube.

8.1. Krka

The Krka river basin was chosen for the Danube floodplain project mainly due to increased flood risk present in some areas, and because several floodplains had been identified within the catchment. The aim was to delineate and evaluate the floodplains from the point of view of their suitability for the purposeof flood risk management.

OVERVIEW

The Krka Sub-basin has an area of 2,315 km^2 with approximately 120.000 inhabitants. From administrativepoint of view 23 municipalities are positioned on its territory. It is a tributary of the Sava river to which the Krka river discharges just some 11 km upstream the cross section where Sava discharges from Sloveniato Croatia. Beside the main watercourse of the river in the length of 94 km its tributaries and springs in the upper part of the river basin are mainly karstic, as shown on 2 with absence of surface watercourses.

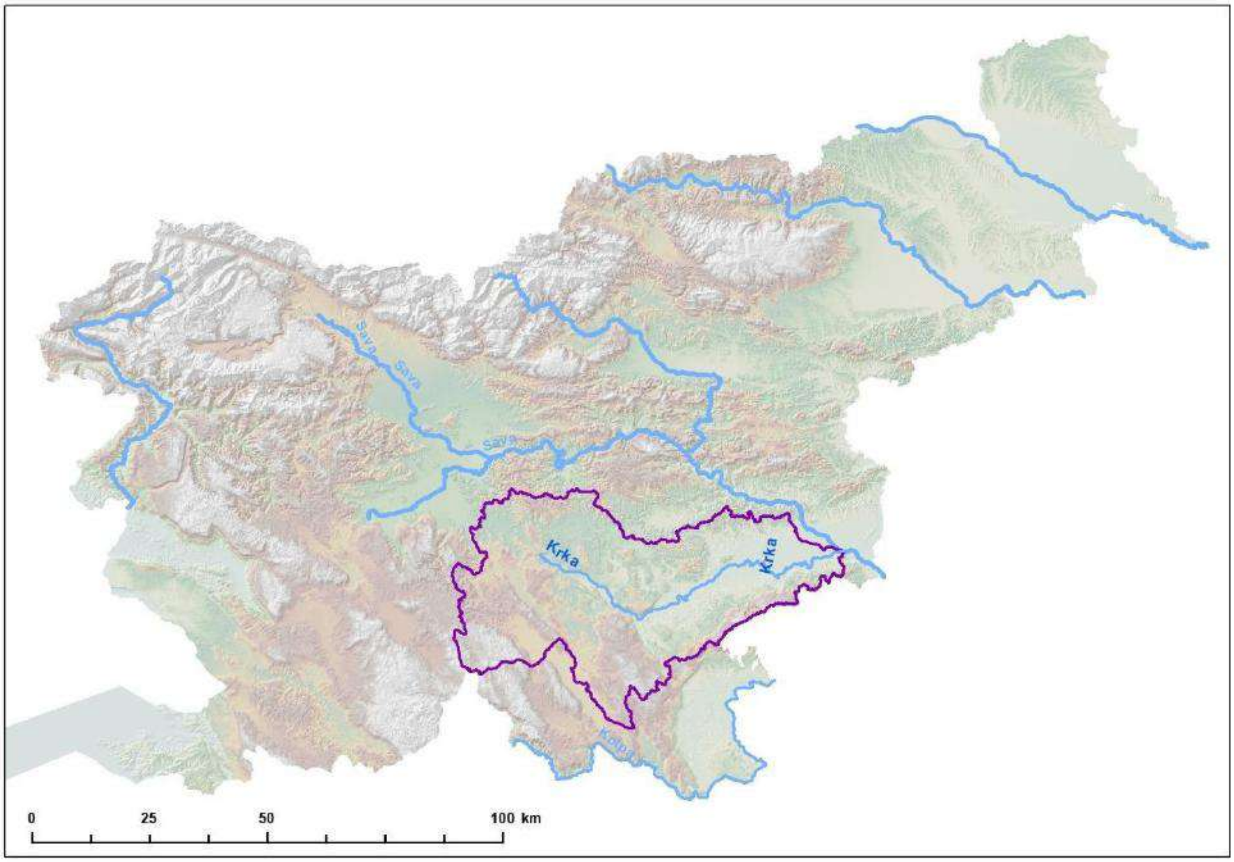


Figure 49: Krka river basin

Comparison between the historical map (1829-1835) – Second military survey of the Habsburg Empire[3] and LIDAR DEM of 2014 shows historical development of the Krka river and the observed floodplains. It can be observed that in almost 200 years the watercourse topology has not changed much, nor were anydykes constructed along the river. Turbidity does occur, but due to the prevailing karstic springs, there islittle bedload transport. A special characteristic of Krka is its natural tuft weirs that can be found in the river bed.

Krka river features very long propagation times and hence long flood waves for a catchment of its size. Observed and calculated hydrogrpahs show flood waves of more than 10 days (300 hours) at a 100-year flood event. This specific characteristic is again defined by the mainly karstic character of the river basin. During flood events, the water is retained on karst fields and underground for an extended period of time, before reaching the Krka springs. The water is then gradually discharging to Krka river over several days, thus extending the flood event.

[3] https://mapire.eu/en/

2-D MODEL

Hydrologycal study of the Krka river basin had been finished in 2019. The results were used as input for the hydraulic model designed within the project. Additionally, eight gauging stations are managed withinthe catchment by the Slovenian Environment Agency. The data from the stations were used for calibrationof the models.

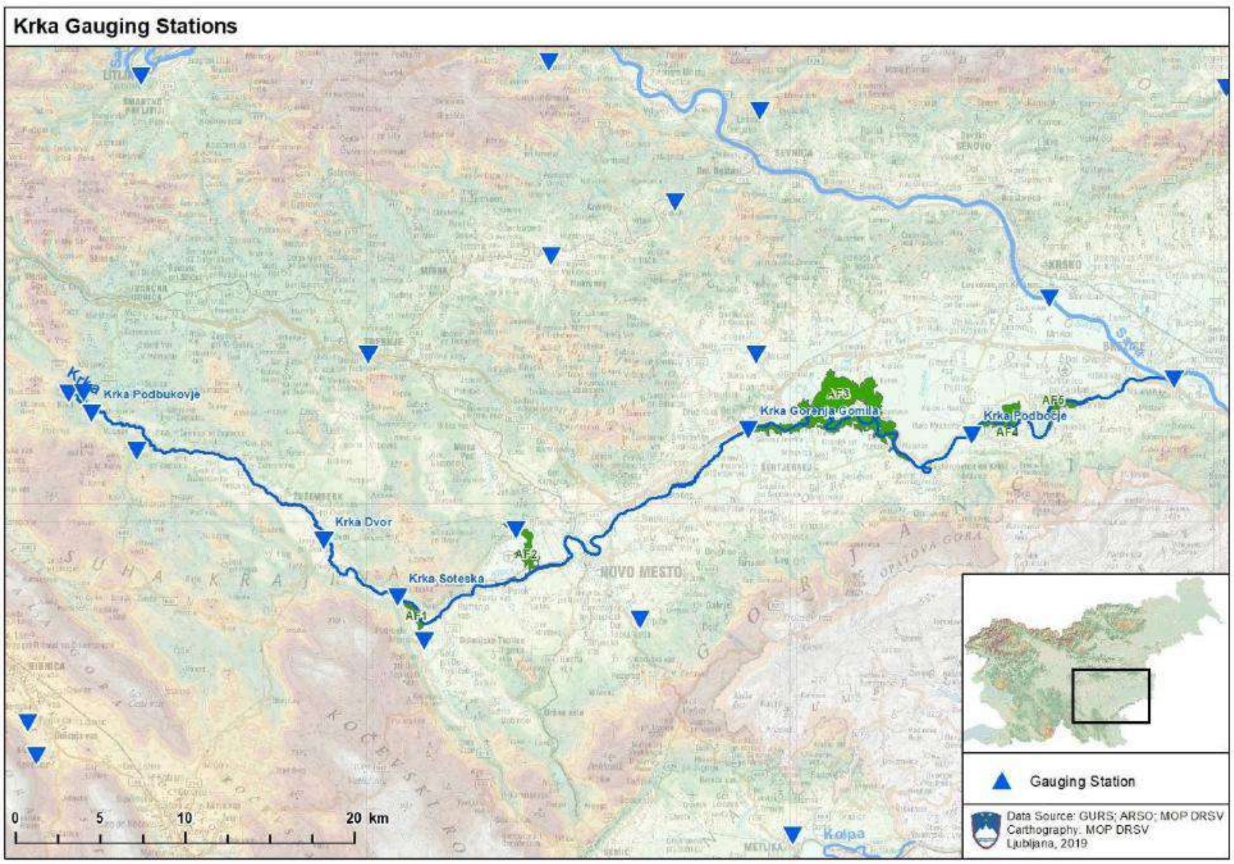


Figure 50: Krka river basin Gauging stations in the Krka river basin

For the purpose of identification of active floodplain, HQ100 (100-year return period) was used. Except for occasional slightly elevated roads, there are no major dykes along the Krka river which could be subject to removal for the purpose of defining potential floodplains. Therefore, we used the HQ500 hydrologicalscenario to define the extent of potential floodplain.

On Figure 51, main karstic sub-terrain flows are indicated. It could be observed that the upper part of the river basin is characterized by karstic phenomena, while on the lower part of the river basin mainly regular,surface runoff could be observed.

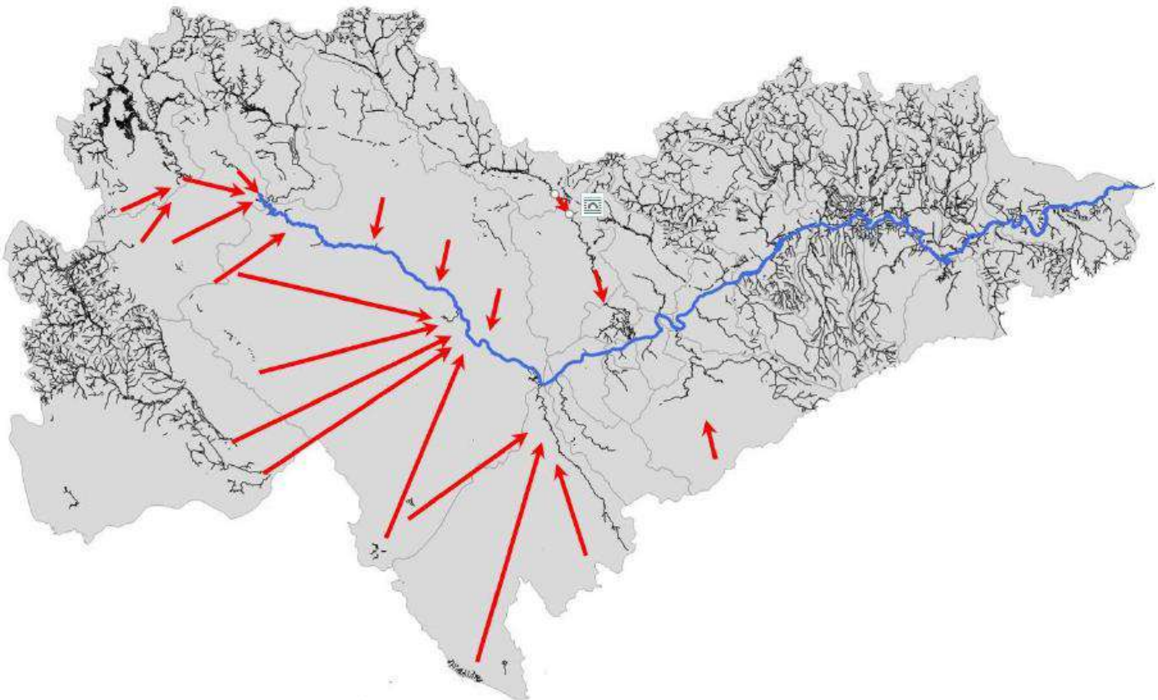


Figure 51: Hydrography of the Krka river basin with indicated main directions of subsurface karstic flow

Floodplains larger than 100 ha were identified in the middle and lower part of the Krka river basin, wherethe river is already running over quartarian and tertiarian alluvium (see Figure 3). For all five listed floodplains, hydraulic model was developed and hydrological data were analysed in order to properly delineate them. In the upper part of the catchment, the river mainly flows through hilly karstic terrain, featuring gorges and canyons, and thus no floodplains have been identified there.

Two 2-D hydraulic models were developed for the purpose of floodplain delineation, one for the upper part and one for the lower part of the river.

Modelling domain 1: Floodplains: 1-Soteska, 2-Prečna Scenario: Actual Floodplains:

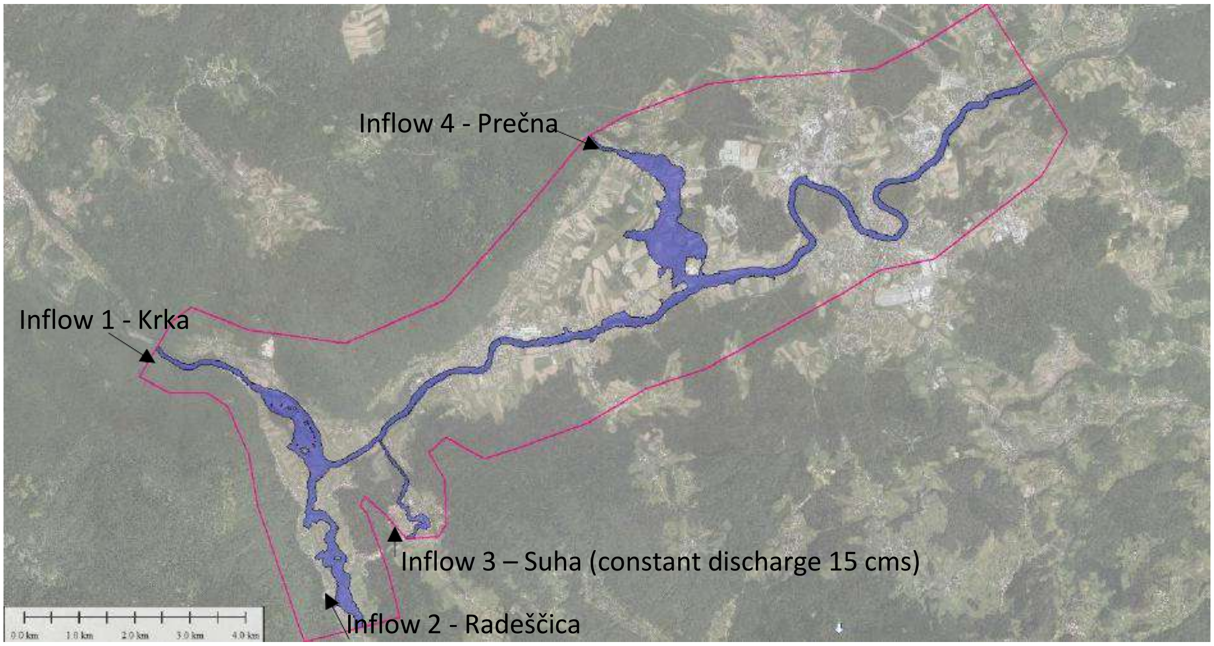


Figure 52: Locations of applied hydrographs for the modeling domain 1 – Floodplain SLO1 (Soteska) and Floodplain SLO2 (Prečna)

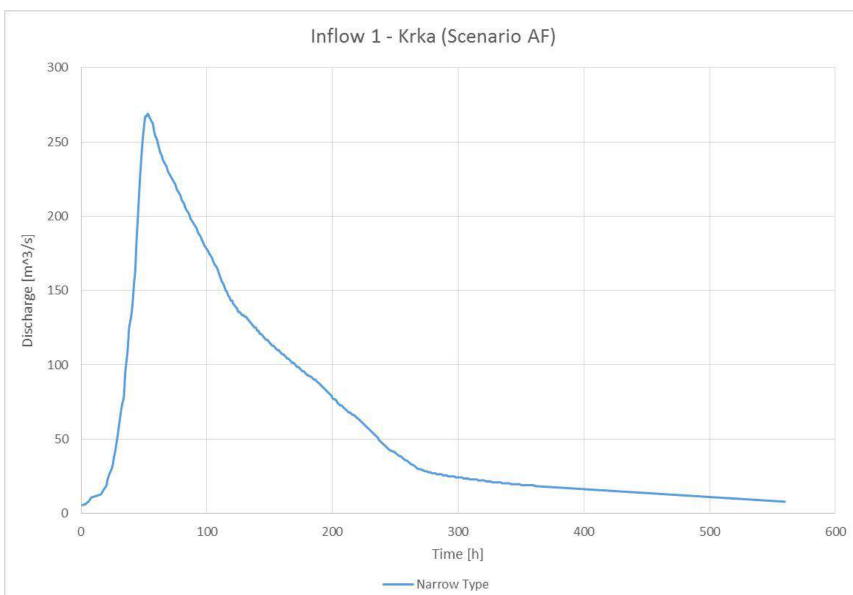


Figure 53: Applied hydrograph for the inflow 1 – Soteska – Krka, actual flood plains (AF) (Qn100) – narrow type (small volume) flood wave was used

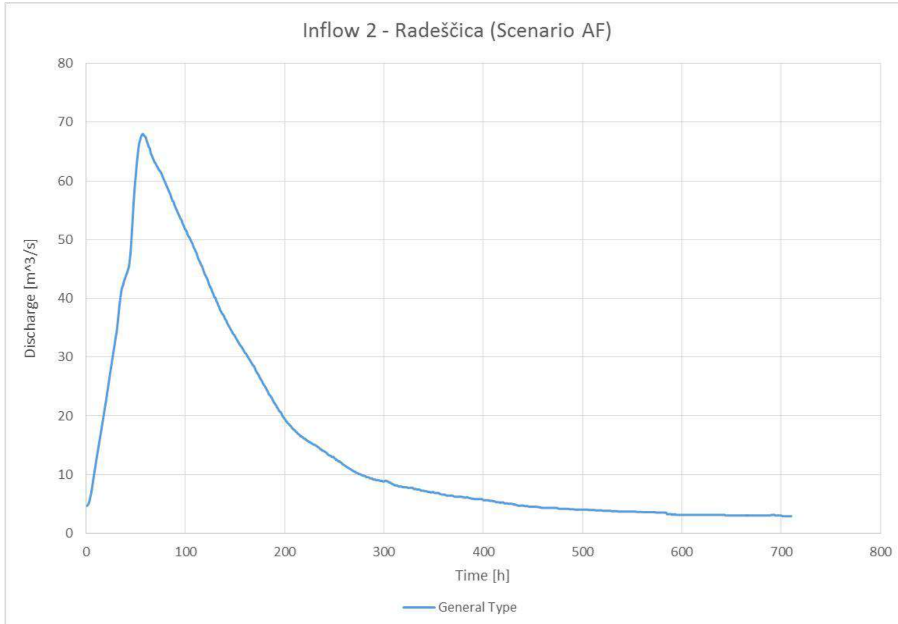


Figure 54: Applied hydrograph for the inflow 2 – Radeščica, actual flood plains (AF) (Qn100) – narrow type (small volume) flood wave was used

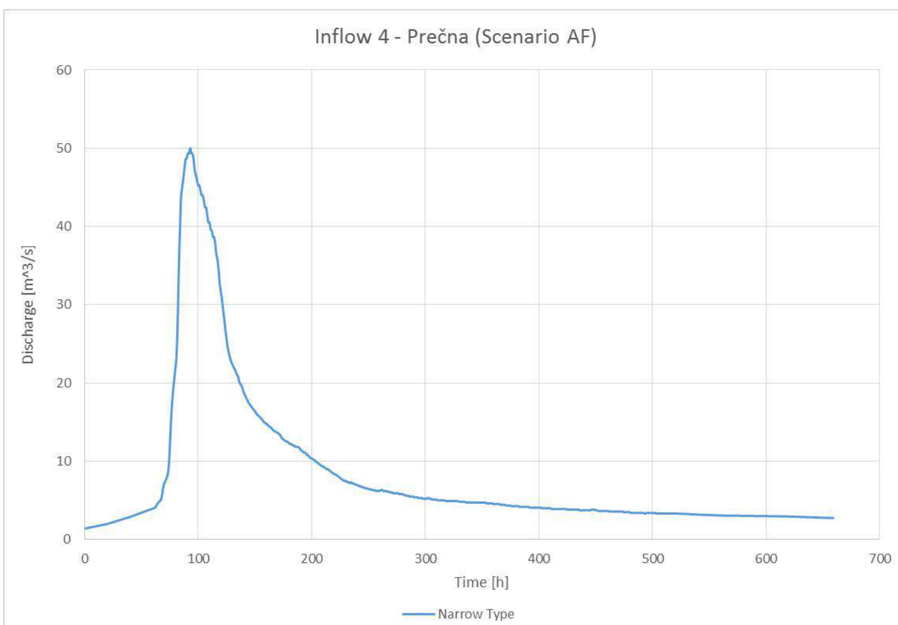


Figure 55: Applied hydrograph for the inflow 3 – Prečna, actual flood plains (AF) (Qn100)– narrow type (small volume) flood wave was used

Scenario potential floodplains (PF) – Krka modelling domain 1, floodplains: 1-Soteska and 2-Prečna:

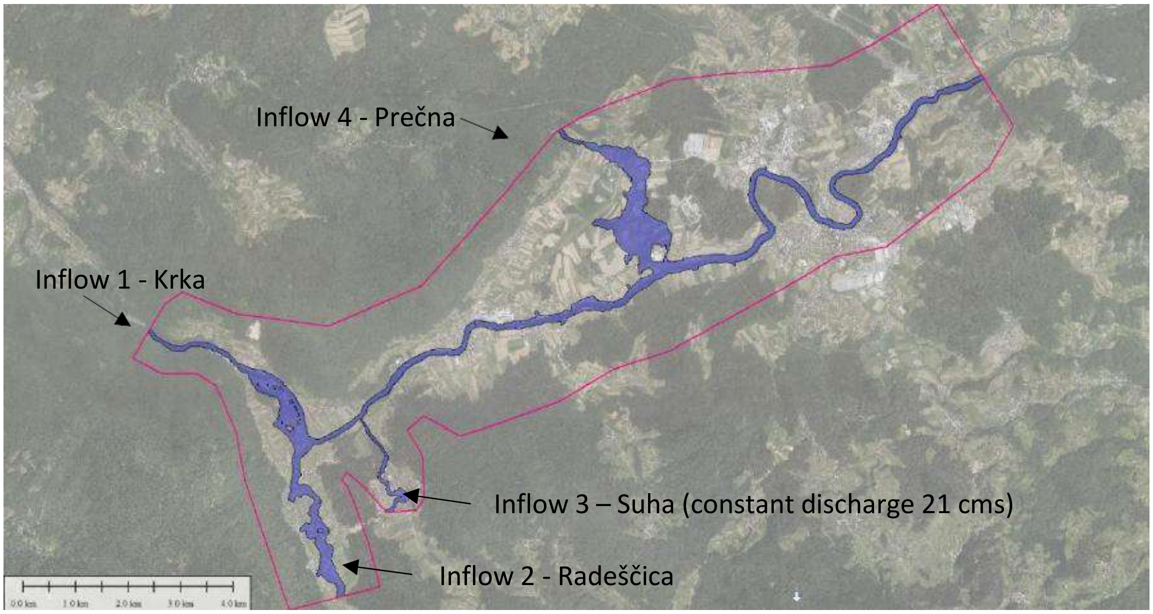


Figure 56: Locations of applied hydrographs for the modeling domain 1 – Floodplain SLO1 (Soteska) and Floodplain SLO2 (Prečna) – FF

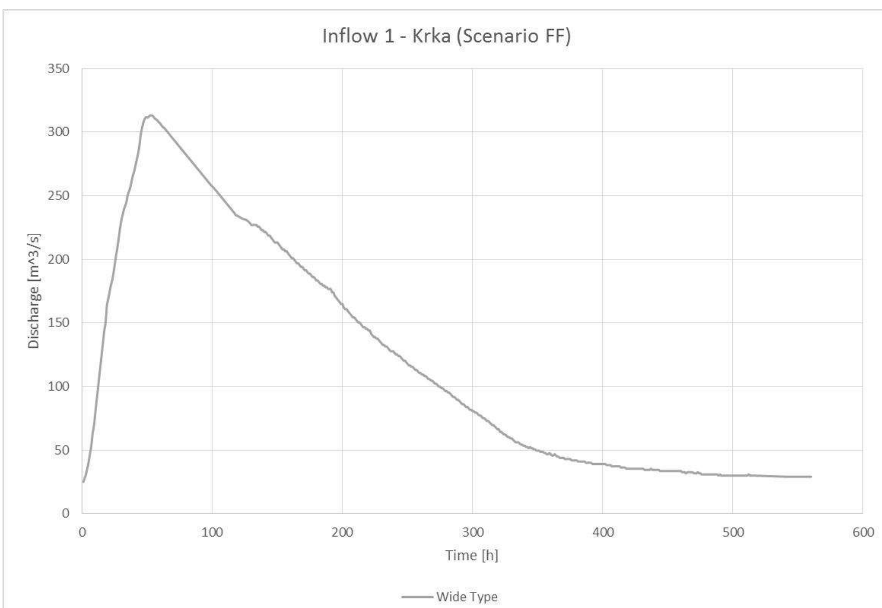


Figure 57: Applied hydrograph for the inflow 1 – Soteska – Krka, future flood plains (AF) (Qn500)– wide type (large volume) flood wave was used

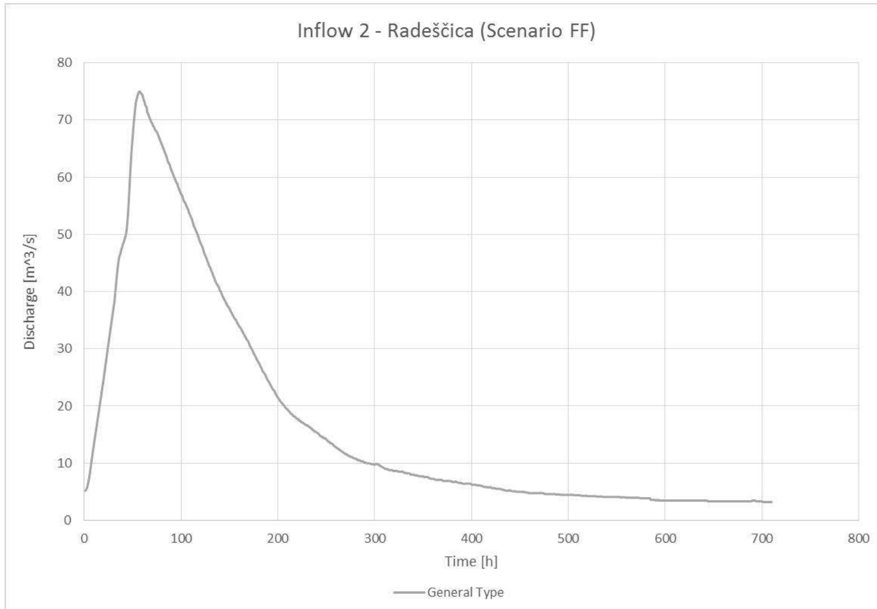


Figure 58: Applied hydrograph for the inflow 2 –Radeščica , future flood plains (FF) (Qn500)– regular type (mid volume) flood wave was used

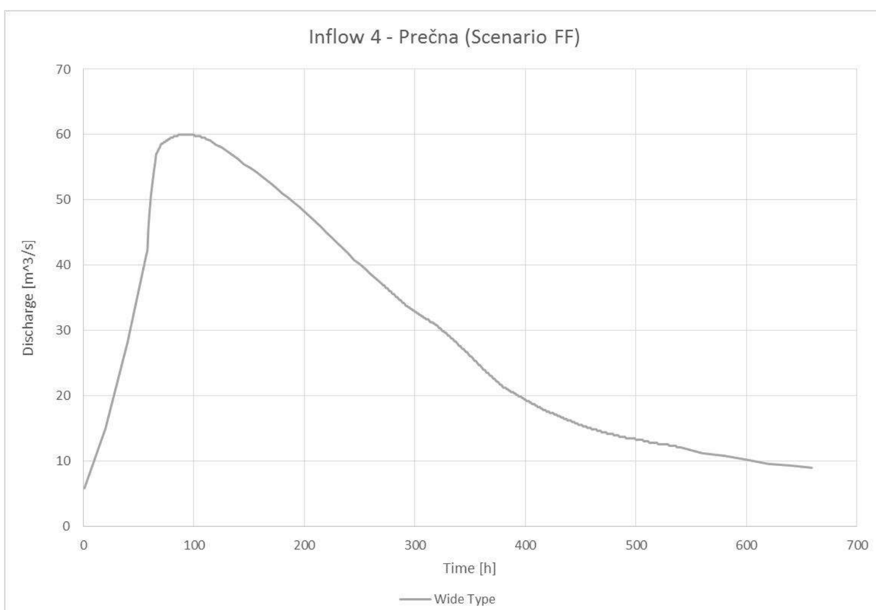


Figure 59: Applied hydrograph for the inflow 3 –Prečna , future flood plains (FF) (Qn500)– wide type (large volume) flood wave was used

Modelling domain 2: Floodplains: 3-Kostanjevica– river Sava, 4-Podbočje, and 5 – CerkljeScenario actual flood plains (AF):

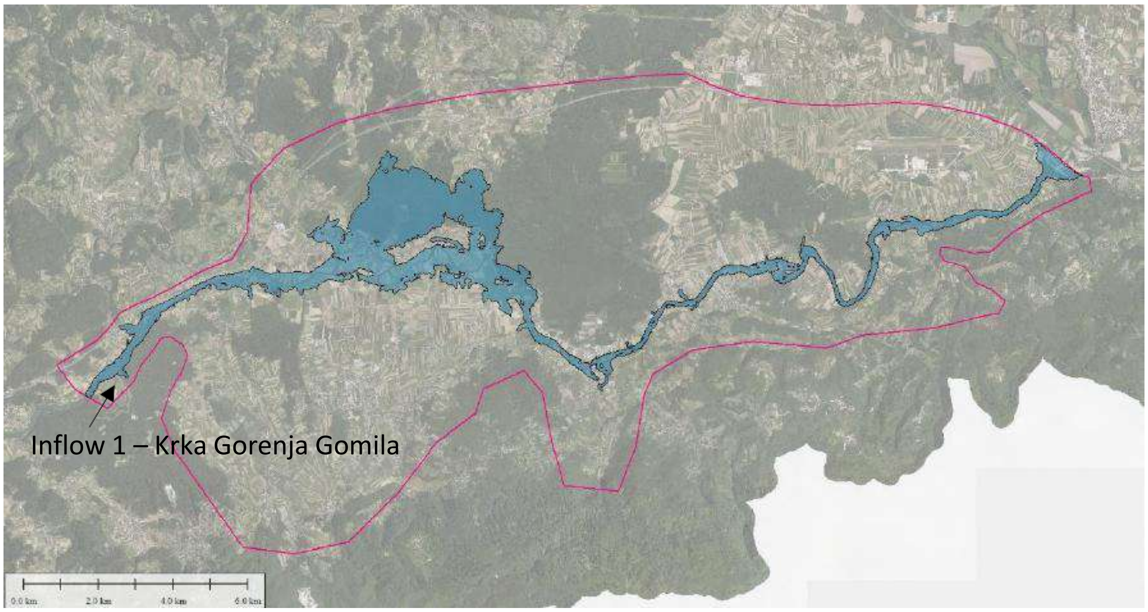


Figure 60: Locations of applied hydrographs for the modelling domain 2 – Inflow 1

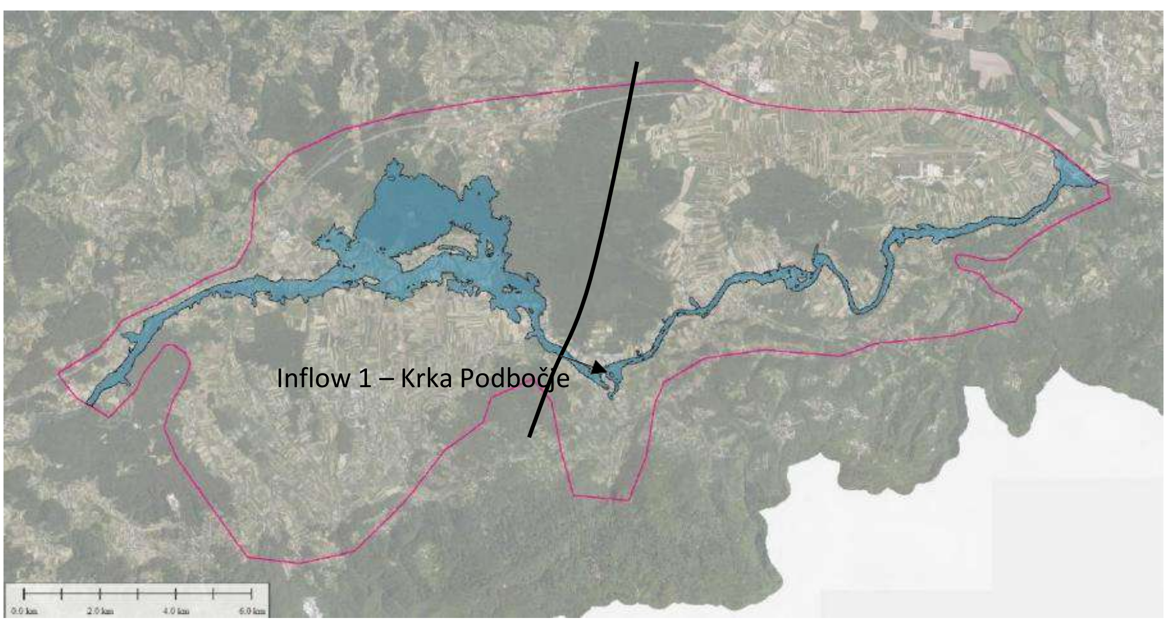


Figure 61: Locations of applied hydrograpsh for the modelling domain 2 – Inflow 2

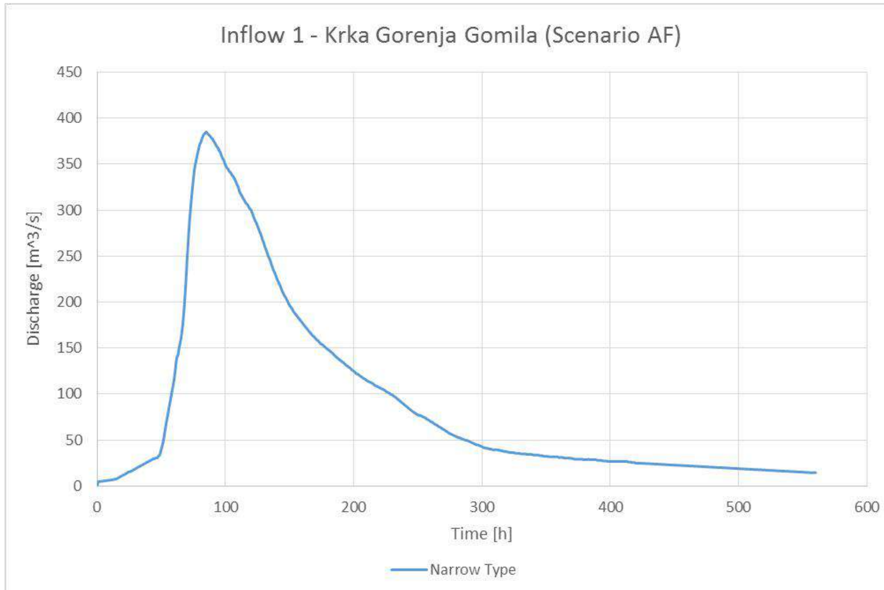


Figure 62: Applied hydrograph for the inflow 1 – Krka G. Gomila, actual flood plains (AF) (Qn100) – narrow type (small volume) flood wave was used

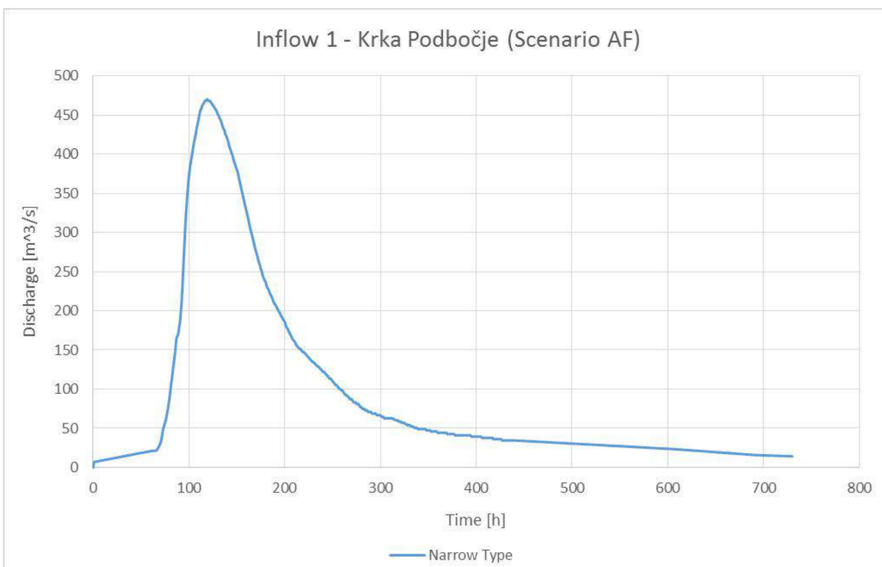


Figure 63: Applied hydrograph for the inflow 2 – Krka Podbočje, actual flood plains (AF) (Qn100)– narrow type (small volume) flood wave was used

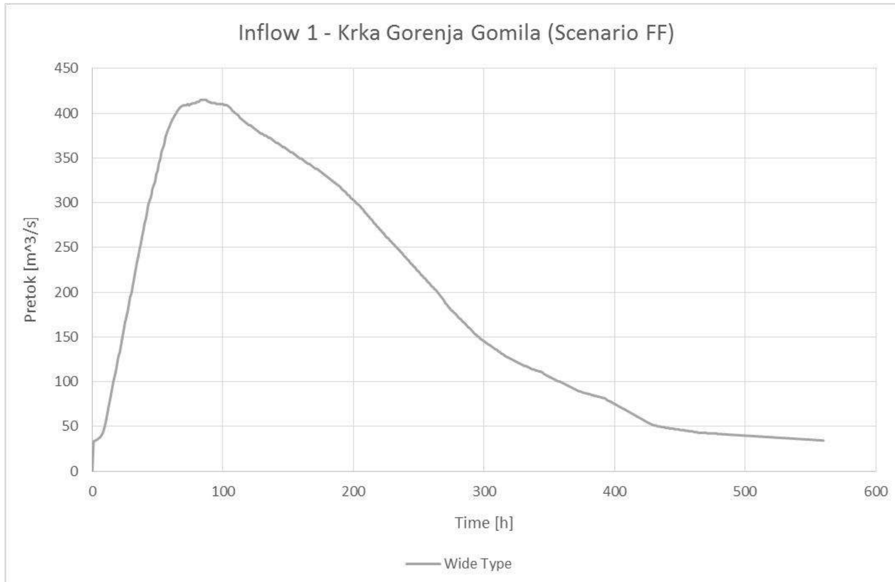


Figure 64: Applied hydrograph for the inflow 1 – Krka G. Gomila, future flood plains (FF) (Qn500)– wide type (large volume) flood wave was used

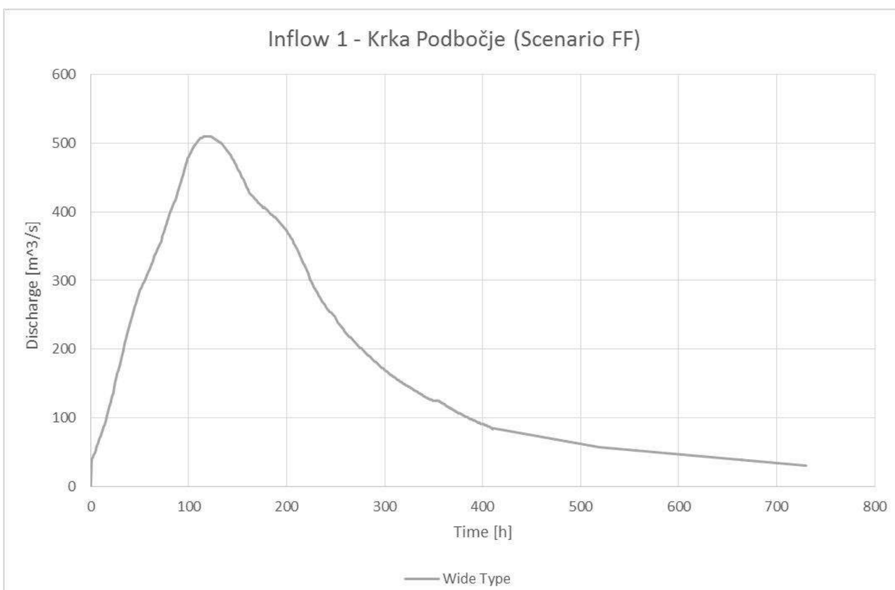


Figure 65: Applied hydrograph for the inflow 2 – Krka Podbočje, future (potential) floodplains (FF) (Qn500)– wide type (large volume) flood wave was used

8.2. Yantra

- The methodology for identification of active and potential floodplains was applied to the main course of the Yantra River. This study identifies floodplains along the main Yantra River course. Due to the relatively identical way of determining the active and potential floodplains, they were assessed together.

- The Yantra River is 223.5 km long and has a catchment area of 7 862 km2. The river originates from the Shipka part of the Balkan, east of Hadji Dimitar (Buzludzha) Peak 1439.8 m. It crosses the Predbalkan andthe Danube Plains and flows into the Danube River near the village of Krivina (Russe), east of Vardim Island. The catchment area of the Yantra River is fan-shaped - with an extended southern part and a narrowed northern one. The river receives three large tributaries, whose catchment area is equal to nearly70% of the total catchment area of the Yantra River - Rositsa River (left tributary - 28.6%), Belitsa River (right tributary - 9.4%) and the Lefedzha River (30.9%).

- The identification of the geomorphologic floodplain was made for the entire course of the Yantra River by slope-based analysis. The boundaries of the delineated floodplains were refined using large-scale topographic maps and geological maps. Due to their small scale (1: 100,000), the geological maps were only applicable in the lower course of the Yantra River, where the river forms wide floodplains. Defining the floodplains beginning and end places was made on the basis of the accepted criterion for the ratio between the width of the floodplain and the width of the water mirror to be greater than 1. On this basis,22 floodplains were determined along the main course of the Yantra River - 12 active and 10 potential.

- The floodplains definition is based on the results of a non-stationary two-dimensional hydraulic model. The hydraulic model SRH-2D was used. Models are defined using an unstructured network of triangular and quadrangular elements, varying in size to minimize defects in the digital terrain model.

- The hydraulic model was built on the basis of a digital elevation model with a cell size of 8 m. Due to its poor quality (in some places it is a digital terrain model), the model was processed with data from large scale topographic maps, in order to print the riverbed in it. Thus, the exact location and altitude of the hydrotechnical facilities has been incorporated into the DEM. Such kind of information is not available indigital format at the responsible institutions and cannot be used.

- Based on the current cadastral data, an adjustment was made of the floodplains defined so far, namely the urban and industrial territories were removed. For territories for which no up-to-date cadastral data are available, a visual inspection of the aerial photo was made.

- All hydrological and hydraulic parameters were assessed, except the parameter “bottom shear stress” (due to the very low quality of the available DTM and the presence of local elevations and reductions in the riverbed, the bottom tangential stresses calculated from the model are incorrect).

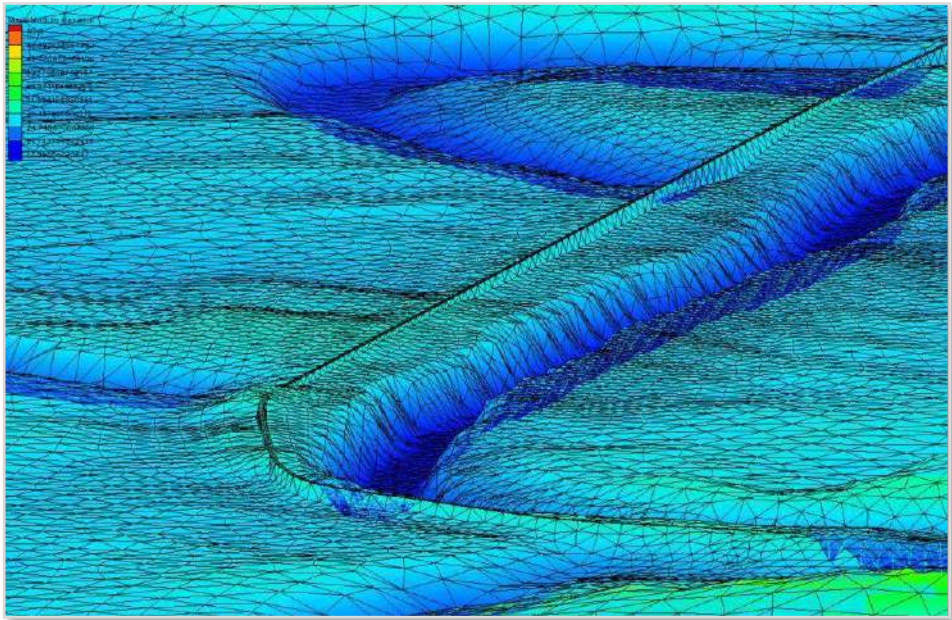
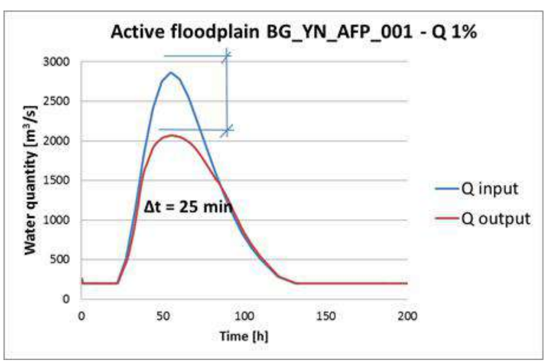
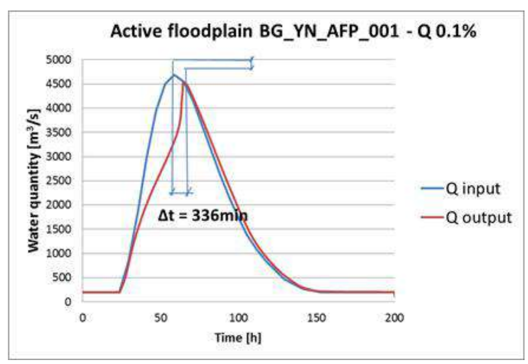
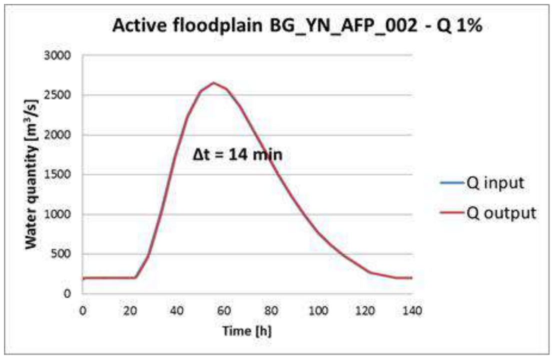


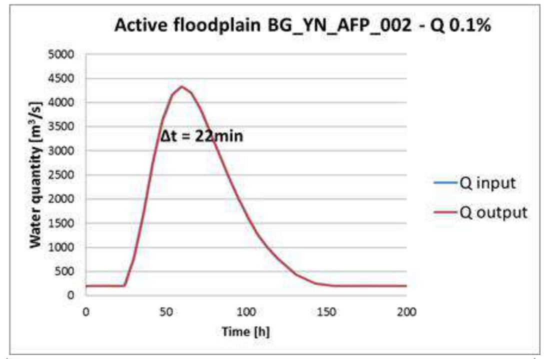
Figure 66: Computing network based on digital elevation model with dykes and riverbed

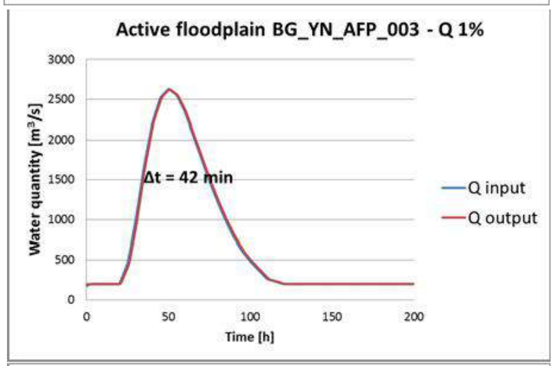
- The poor quality of DEM is the reason for serious numerical instabilities in the computational model, which makes it impossible to determine the flow parameters and by this reason no further assessment has been performed for three of the identified geomorphologic floodplains.

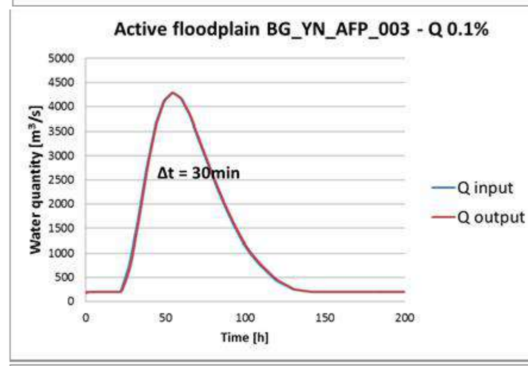


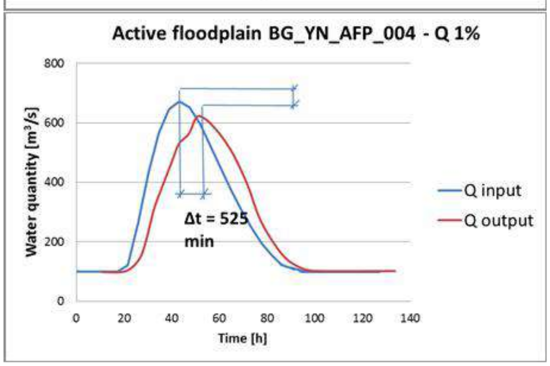


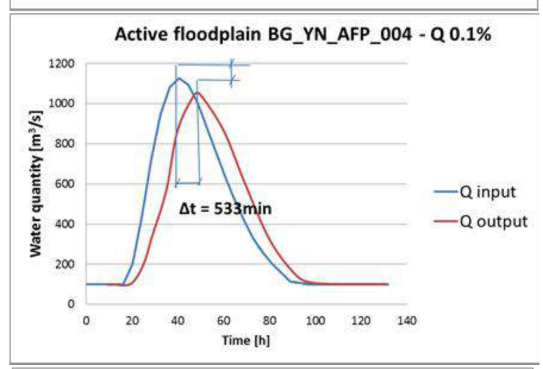

Active floodplain BG_YN_AFP_002 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 14 min
Q input
Q output

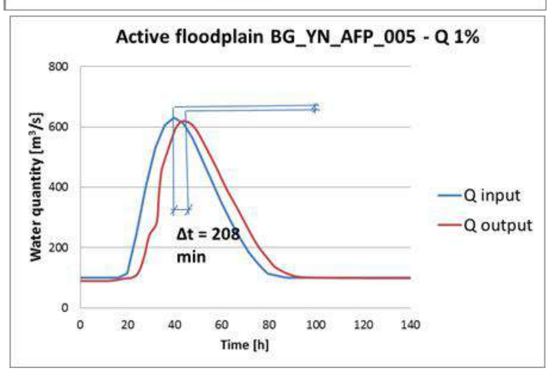

Active floodplain BG_YN_AFP_002 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 22min
Q input
Q output

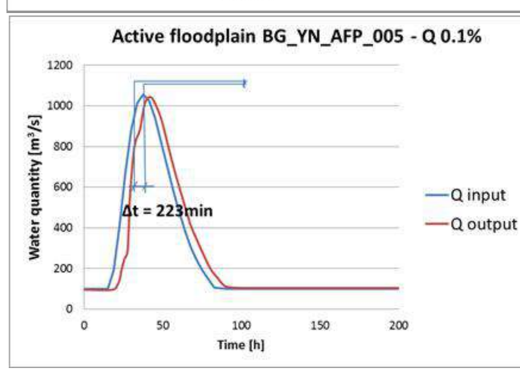

Active floodplain BG_YN_AFP_003 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 42 min
Q input
Q output

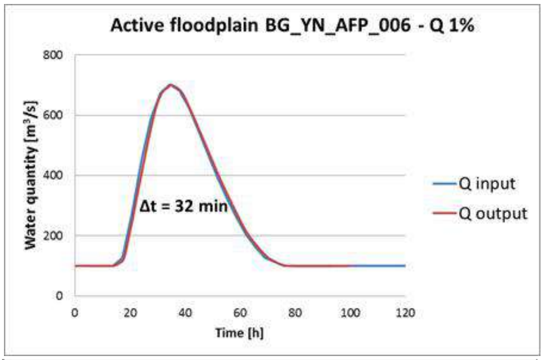

Active floodplain BG_YN_AFP_003 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 30min
Q input
Q output

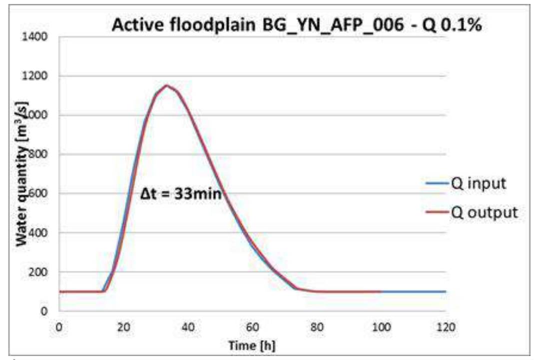

Active floodplain BG_YN_AFP_004 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 525 min
Q input
Q output

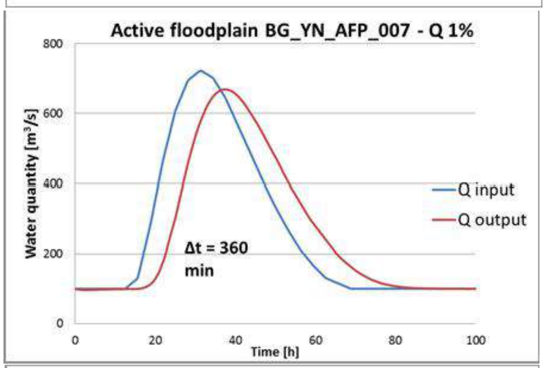

Active floodplain BG_YN_AFP_004 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 533min
Q input
Q output

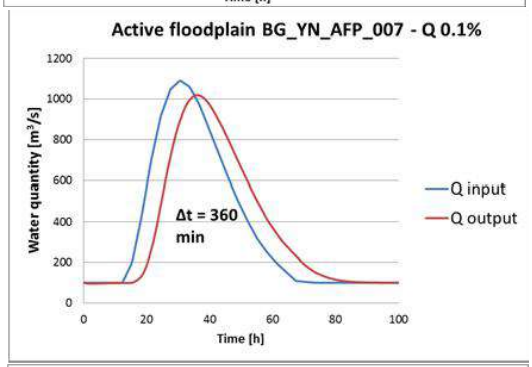

Active floodplain BG_YN_AFP_005 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 208 min
Q input
Q output

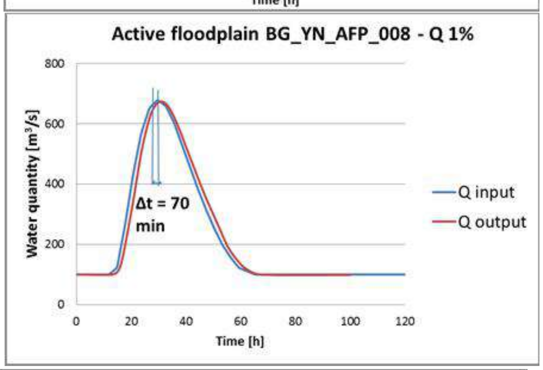

Active floodplain BG_YN_AFP_005 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 223min
Q input
Q output

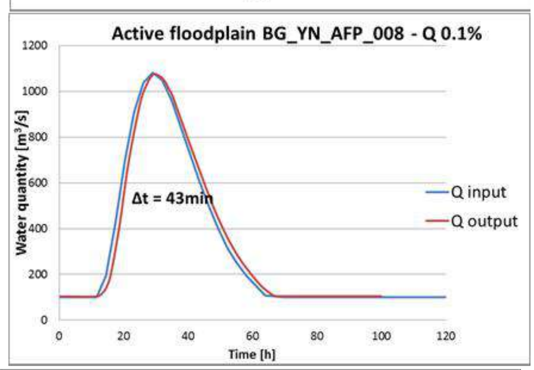

Active floodplain BG_YN_AFP_006 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 32 min
Q input
Q output

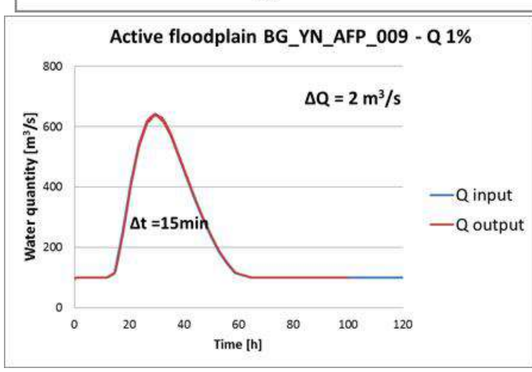

Active floodplain BG_YN_AFP_006 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 33min
Q input
Q output

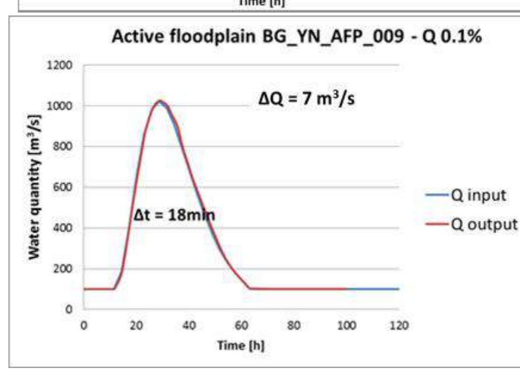

Active floodplain BG_YN_AFP_007 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 360
min
Q input
Q output

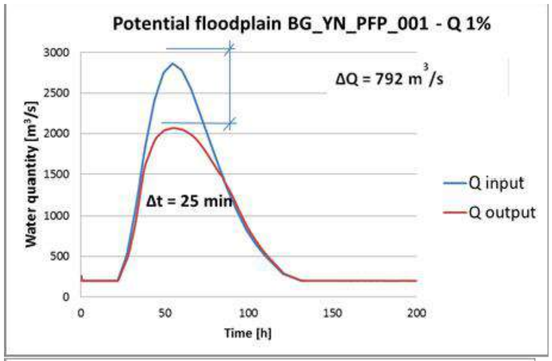

Active floodplain BG_YN_AFP_007 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 360
min
Q input
Q output

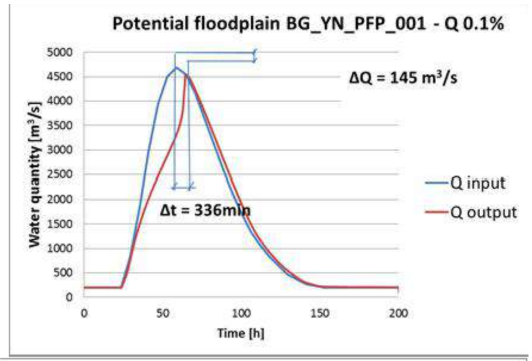

Active floodplain BG_YN_AFP_008 - Q 1%
Water quantity [m³/s]
Time [h]
Δt = 70
min
Q input
Q output

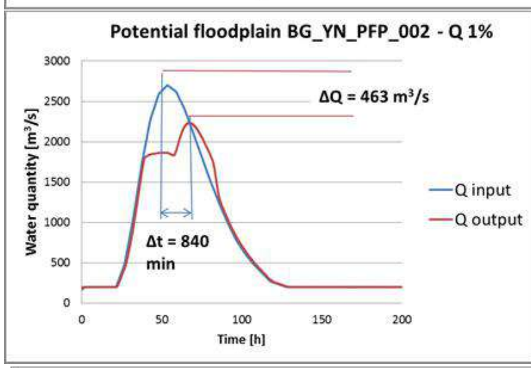

Active floodplain BG_YN_AFP_008 - Q 0.1%
Water quantity [m³/s]
Time [h]
Δt = 43min
Q input
Q output

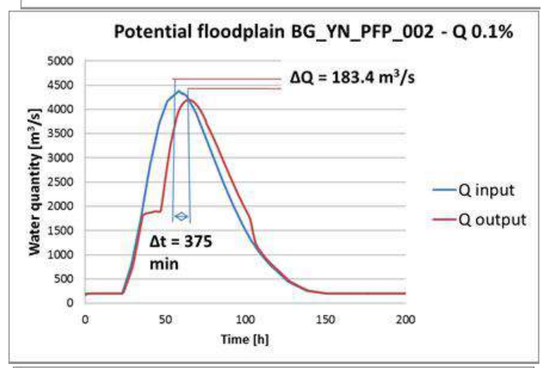

Active floodplain BG_YN_AFP_009 - Q 1%
Water quantity [m³/s]
Time [h]
ΔQ = 2 m³/s
Δt =15min
Q input
Q output

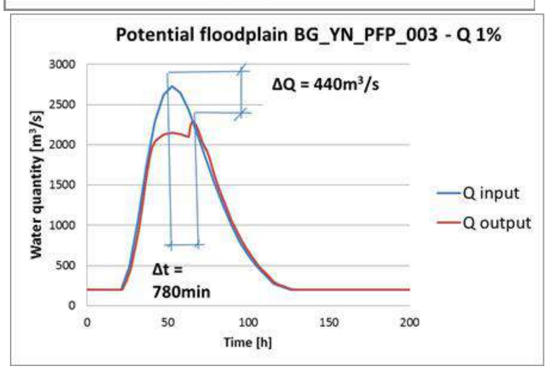

Active floodplain BG_YN_AFP_009 - Q 0.1%
Water quantity [m³/s]
Time [h]
ΔQ = 7 m³/s
Δt = 18min
Q input
Q output

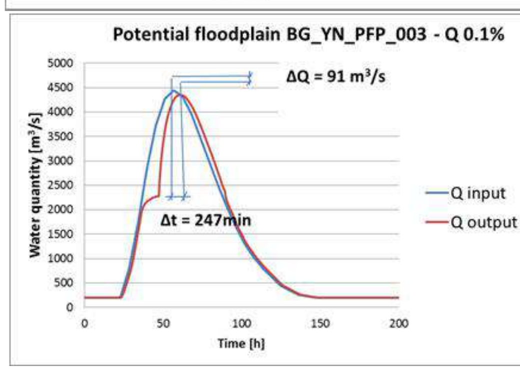

Potential floodplain BG_YN_PFP_001 - Q 1%
ΔQ = 792 m³/s
Δt = 25 min
Water quantity [m³/s]
Time [h]
Q input
Q output

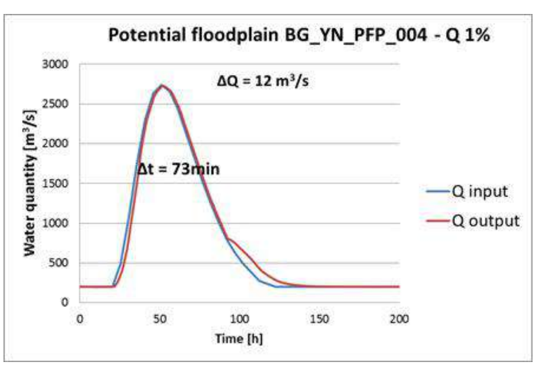

Potential floodplain BG_YN_PFP_001 - Q 0.1%
ΔQ = 145 m³/s
Δt = 336min
Water quantity [m³/s]
Time [h]
Q input
Q output

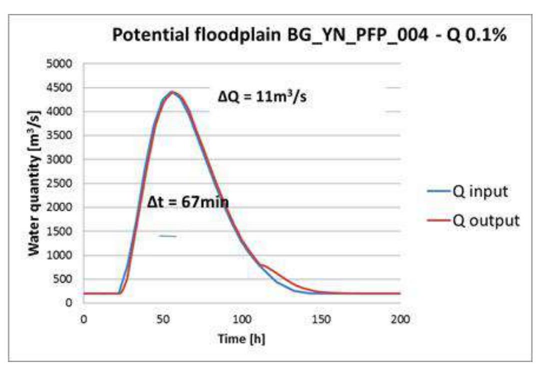

Potential floodplain BG_YN_PFP_002 - Q 1%
ΔQ = 463 m³/s
Δt = 840 min
Water quantity [m³/s]
Time [h]
Q input
Q output


Potential floodplain BG_YN_PFP_002 - Q 0.1%
ΔQ = 183.4 m³/s
Δt = 375 min
Water quantity [m³/s]
Time [h]
Q input
Q output


Potential floodplain BG_YN_PFP_003 - Q 1%
ΔQ = 440m³/s
Δt = 780min
Water quantity [m³/s]
Time [h]
Q input
Q output


Potential floodplain BG_YN_PFP_003 - Q 0.1%
ΔQ = 91 m³/s
Δt = 247min
Water quantity [m³/s]
Time [h]
Q input
Q output


Potential floodplain BG_YN_PFP_004 - Q 1%
ΔQ = 12 m³/s
Δt = 73min
Water quantity [m³/s]
Time [h]
Q input
Q output


Potential floodplain BG_YN_PFP_004 - Q 0.1%
ΔQ = 11m³/s
Δt = 67min
Water quantity [m³/s]
Time [h]
Q input
Q output

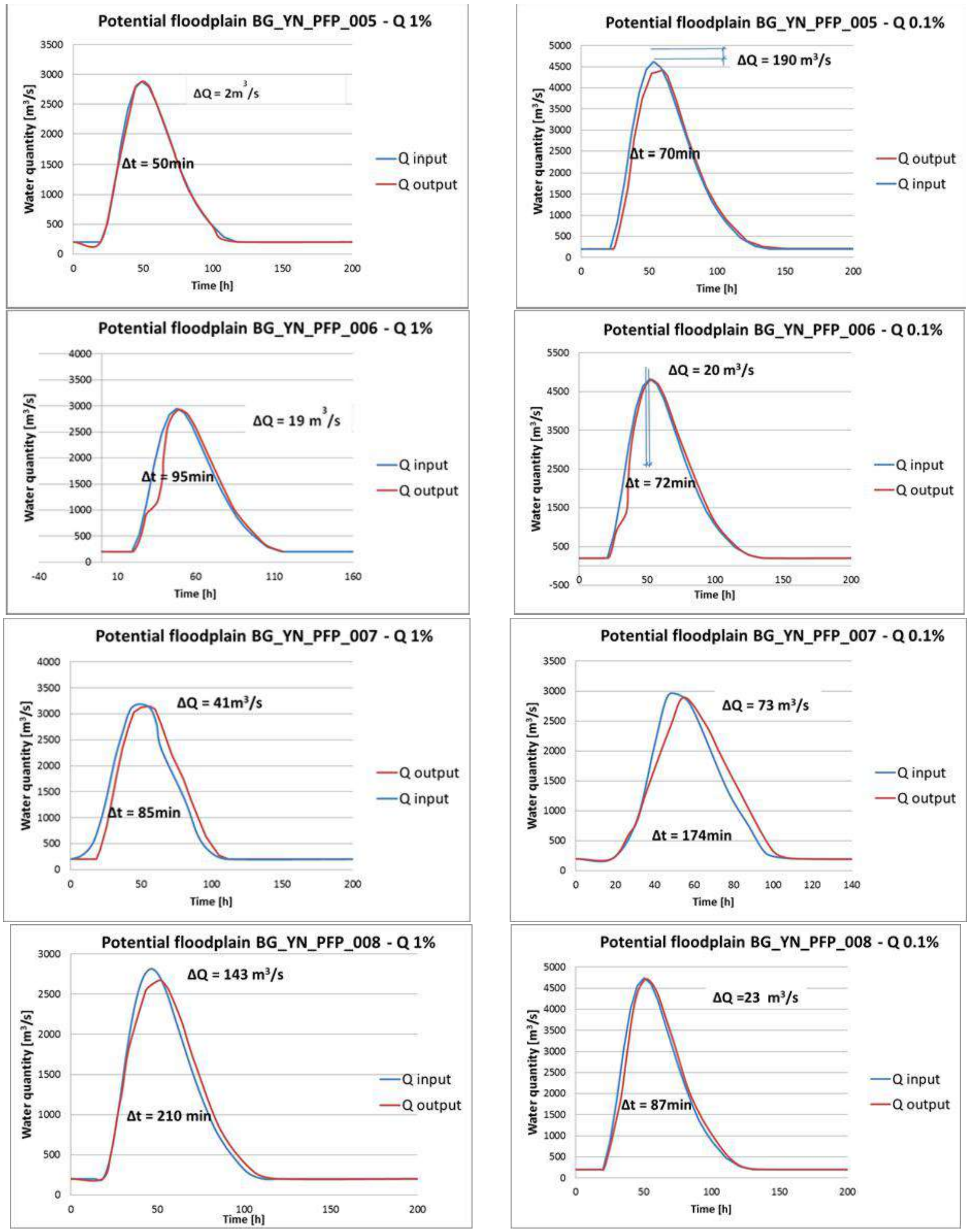


Figure 67: Hydrographs for evaluated floodplains on Yantra River floodplains

8.3. Desnăţui

- The Desnăţui River, a direct tributary of the Danube, is a small plain river, which is located in the south ofRomania and is 115 km long, with an average altitude of 129 m and an area of 2015 km2. It springs from an altitude of only 260 m in the Bălăciței Plain, with an initial flow direction from NV to SE, so that near the confluence with Terpezita River, at the exit of the Fântânele Reservoir, it will change its direction of flow towards the south, having the discharge into Bistreț Lake. The Desnăţui River has 12 main tributaries(figure 21), the most important are: Terpezita, Baboia and Valea Rea river, the total length of the water courses on the catchment area being 516 km (River Basin Management Plan, 2009 source; Water CadastreAtlas, 1992).

- The Desnăţui River, a direct tributary of the Danube, was selected in the Danube Floodplain project mainly because of the identification of large flood areas (APFSR no.16 – declared in Flood Risk Management Planof Jiu River Basin Administration) and risks of floods, where damage reduction measures are envisaged - (PMRI BH JIU source), but also due to technical considerations of connection with the pilot area on the Danube river.

- The hydrological data which have been updated at the level of 2019 (NIHWM source) show the high capacity of Fântânele Reservoir to mitigate the flood with probability of occurrence of 100 years, this being almost 93% (from 280 m^3/s to 20 mc/s). In table 1, the flows along the Desnăţui River for different probabilities of occurrence are presented.

- From the administrative point of view 76 settlements are located on its territory (1 urban and 75 rural localities) with approximately 91,000 inhabitants.

- For Danube Floodplain Project was considered the sector located in the lower part of the Desnățui river basin, downstream of Fântânele Reservoir, with the length of the 62 km and a catchment area of 1 589 km2.

Figure 68: Desnăţui River basin considered for Danube Floodplain Project

- In order to delineate flooded area an unsteady 1D hydrodynamic model was elaborated on the river sectorbetween Fântânele Reservoir and Bistreţ Lake, about 60 km length, using as input data measured cross- sections and LIDAR DTM obtained at the level of 2011, for drawing up the hazard and risk maps at nationallevel.

- **The calibration of the hydraulic model** aimed that the calculated levels for the maximum flows transited through both the minor and major channel, as well as the through major channel in the sections of the gauging stations, to overlap over the levels indicated from the rating curve of the respective gauging stations. In this case, the model calibration has mainly achieved using the existing rating curve at the Goicea gauging station from the Desnațui River.

- Mainly this calibration has achieved by changing the values of the coefficients of Manning roughness from the minor and major channels. The roughness coefficient, adopted in accord with „HEC - RAS – River Analysis System – Hydraulic Reference Manual" recommendation, taking into account the characteristics of the study area and based on orthophotoplans, had values between 0.035 and 0.04 in river channel and between 0.065 and 0.070 in floodplains.

- The downstream boundary condition used in the hydraulic model was considered the normal depth and the actual slope of the Desnăţui River in the downstream area, which is less than 1 ‰.

For the purpose of the evaluation of the FEM the hydrological models were using following assumptions:

- Definition for the Actual Floodplain (AFP): 100 year return period was used using actual floodplainsand their geometry.
- Potential floodplains (PFP):200 year return period was used.
- Former floodplains (FFP): 1000 year return period was used.

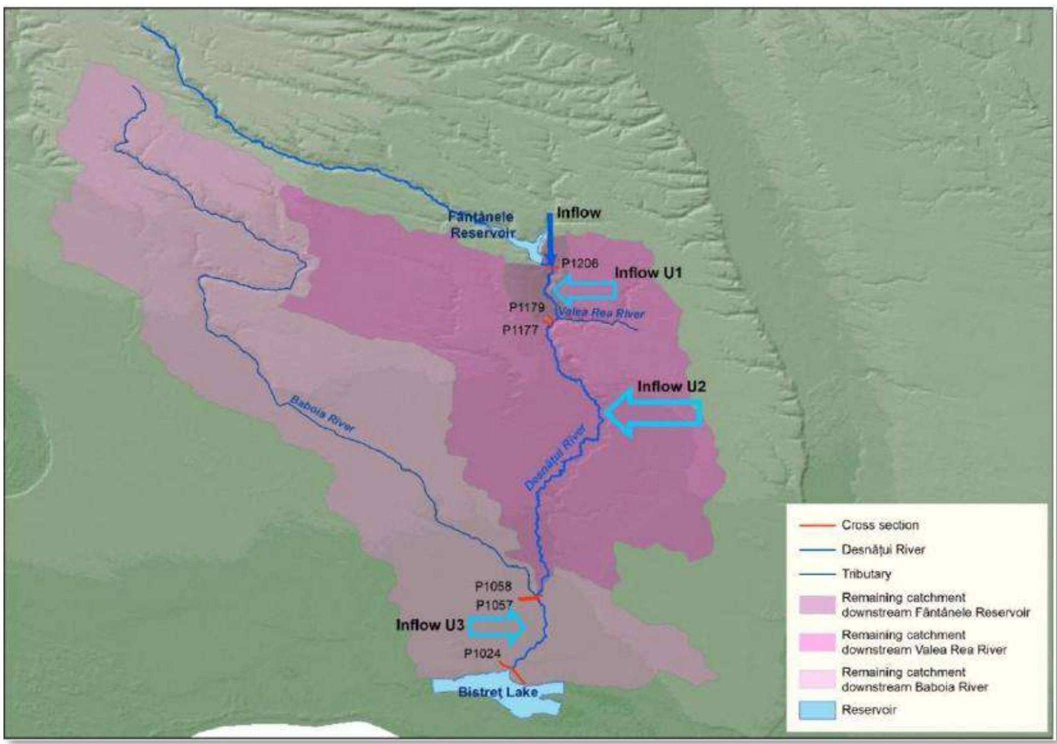


Figure 69: The distribution of inflow hydrographs and Locations for applied inflows for modelling actual floodplain (AFP) Q100

8.4. Morava

Morava River Basin is located in the North of the Danube River Basin and spreads across three countries – Czech Republic, Slovakia and Austria with the total area of around 27.000 km2 (Figure 23). Morava River with its total length of 329 km is a leftside tributary of the Danube River with confluence near Bratislava-Devín. The Morava River creates natural border between Czech Republic and Slovakia and Austria and Slovakia.

Figure 70: Morava River basin and the DanubeFloodplain pilot reach

- Pilot area of the Danube Floodplain project is Morava river reach from km 69 to 100 on the border between Czech Republic and Slovakia. The 2D modelling was performed at the area of 147 km2 (Figure 24). Morava in this section is a typical lowland river, originally strongly meandering (Figure 25). Since the 19th century, extensive river training works were performed, such as straightening of the river channel with a uniform cross-section profile, bank protection in long reaches, construction of flood protection dykes, cutting off meanders, construction of weirs and sills. River training has led to significant reduction of original floodplains as well as interruption of longitudinal continuity.

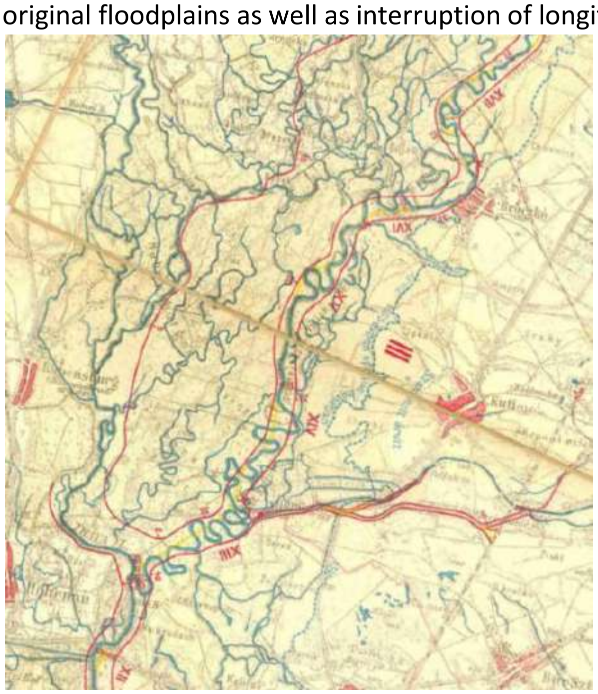


Figure 71: Original Morava river channel on the map from the beginning of 20th century

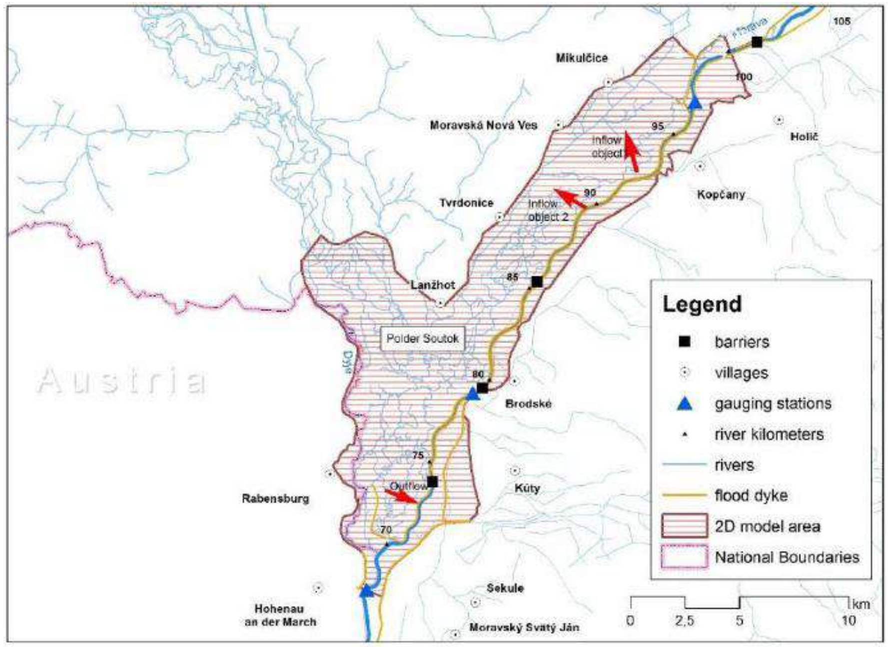


Figure 72: Morava river pilot area evaluated by 2D modelling

- Former flood plains in the pilot area were cut-off and the current floodplain within the dykes on both sides of the river is very narrow, namely only approx. 130 m. Current floodplain widens only in the lower reach of the pilot area on the Slovak side to approx. 600-1100 m (floodplain forest – Natura 2000 site).

Figure 73: Morava River between the dykes – photos taken at bankfull discharge, June 2020 (Author: VUVH)

- During flood events, large retention area Polder Soutok at Morava and Dyje confluence is used for releasing flood discharges. The retention area is behind the flood protection dyke on the right bank (Czech republic). Two inflow and an outflow object in the Morava dyke are used to release discharges higher than 600 m3/s. Water is released to the floodplain forest (Natura 2000 site).

Figure 74: Inflow object to the retention area behind the flood protection dyke (Author: VUVH)

- There are no settlements directly in the modelled floodplain area.
- Proposed restoration measures within DanubeFloodplain project were focused on improvement of flow conditions and water regime in the floodplains with respect to flood protection and nature protection, as well as improvement of conditions for fish migration and diverse biotopes in the area. For FEM analysis, Restoration scenario RS2 was evaluated with proposed measures: relocation of flood dykes (to include cut-off side arms), reconnection of oxbows, lowering of barriers (weirs, sills) in the channel (medium discharge), renewal of river pattern – design of a meandering channel.
- 1D and 2D model of the pilot area were set-up, calibrated and verified to analyse hydraulic conditions of the current state and evaluate the effect of proposed restoration measures. Hydrological data from stations Lanžhot, Kopčany and Moravský Svätý Ján were used (1 hour step). Real floodwaves of 2009 and 2010 were simulated (HQ5, HQ10-30, HQ100).
- Only one active floodplain was identified within the pilot area at current state.
- 5 potential floodplains were identified (proposed) in case proposed measures are applied, the dyke shifting towards the former floodplains was inevitable.
- To estimate the FEM parameters according to the given methodology, 1D model results were used. The parameters were estimated in cross section profiles within the identified active and potential floodplains (at upstream and downstream boundary).

Figure 75: Cut-off side arm (Author: VUVH)

8.5. Tisza (HU)

The Tisza River Basin drains an area of 157,186 km². Five countries are sharing this largest sub-basin of the Danube River Basin (Romania, Ukraine, Slovakia, Hungary, and Serbia). The Tisza River is the longest tributary of the Danube (966 km), and the second largest by flow, after the Sava River.

The Tisza River Basin can be divided into two main parts:

The mountainous Upper Tisza and the tributaries in Ukraine, Romania and the eastern part of the Slovak Republic,

The lowland parts mainly in Hungary and in Serbia surrounded by the East-Slovak Plain, the Transcarpathian lowland in Ukraine and the plains on the western fringes of Romania.

The Tisza River itself can be divided into three main parts:

- **The Upper Tisza** upstream from the confluence with the Somes/Szamos River,
- **The Middle Tisza** in Hungary which receives the largest right-hand tributaries: the Bodrog and Slaná/Sajó Rivers together with the Hornád/Hernád River collect water from the Carpathian Mountains in Slovakia and Ukraine, and the Zagyva River drains the Mátra and Bükk, as well as the largest left-hand tributaries: the Szamos/Somes River, the Körös/Crisuri River System and Maros/Mures River draining Transylvania in Romania,
- **The Lower Tisza** downstream from the mouth of the Maros/Mures River where it receives the Begej/Bega River and other tributaries indirectly through the Danube – Tisza – Danube

Canal system.

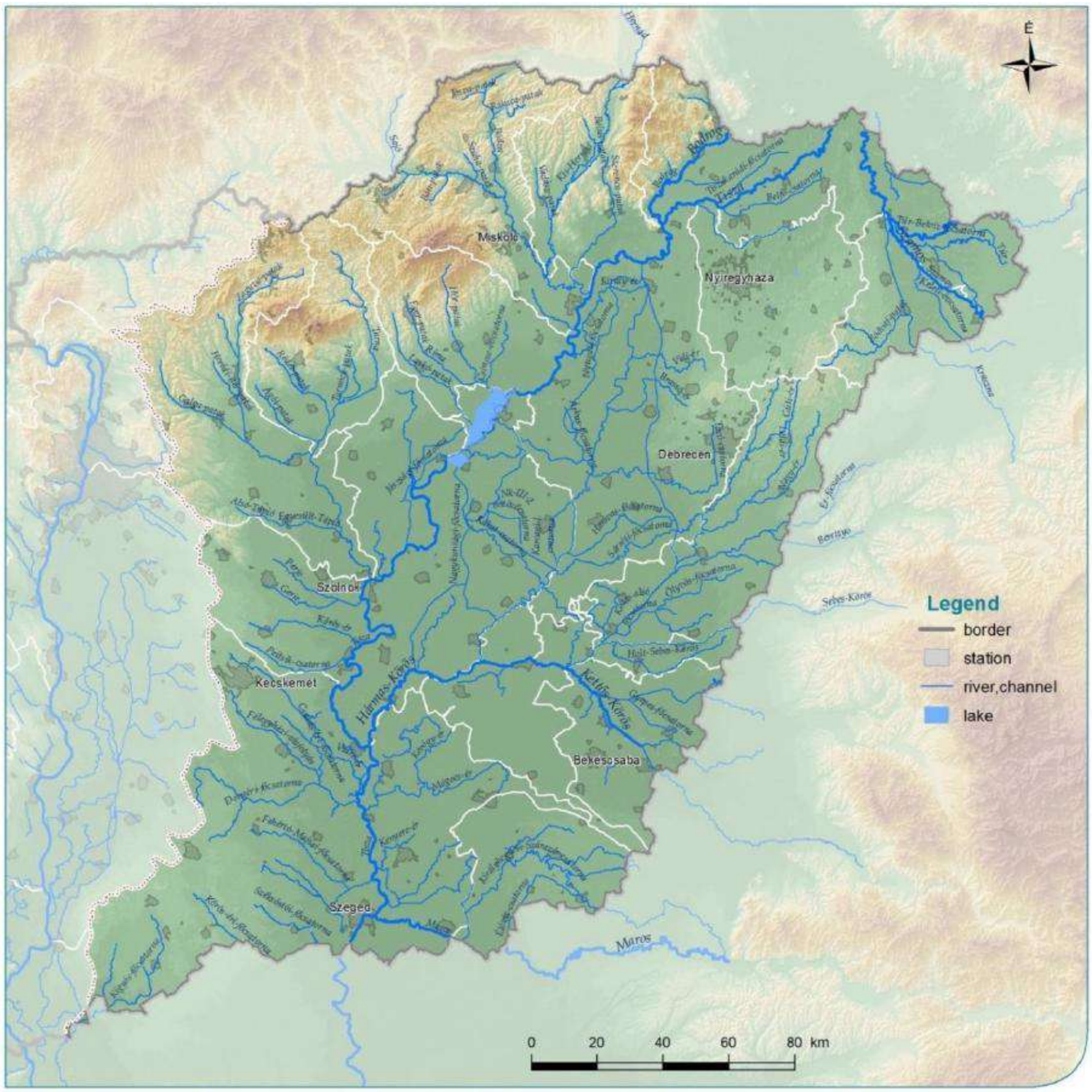


Figure 76: Tisza River Network in Hungary

Over the past decades, several extraordinary floods have drifted off the rivers in the Danube River Basin,especially in 2000, 2002, 2006, 2013 and 2014. Each of the flooding levels that emerged were one of the 100-year return waves that caused significant human and economic damage in the affected countries.

To handle increasing flood risks within the European Union the No. 2007/60/EK Directive requires almostall river basin districts to identify areas where is a significant potential flood risk or likely to occur. The identified flood risks are needed to be reduced as much as possible to ensure greater human and material security. In addition to recognize and reduce risk factors, the Water Framework Directive states, that all surface and groundwater in the EU Member States in a good condition must be kept sustainable and waterstatus deterioration must be prevented.

The primary objective of the project is to examine the Danube and its main tributaries, to identify the potentially recoverable active and potential floodplains and to describe the necessary measures, in whichflood-peak interventions are identified, and most importantly to have an ecologically positive impact. Theriver basin was selected for the Danube floodplain project mainly due to large identified floodplains and identified flood risks in some of them where flood damage reduction measures are anticipated.

In the Hungarian section of the river Tisza, 17 active and 7 potential floodplains were identified in this project.

For the active floodplains the delineation criteria were:

- Min area: 500 ha
- Hydraulically connected area
- Ratio factor 10:1 of Width of floodplain / Width of river

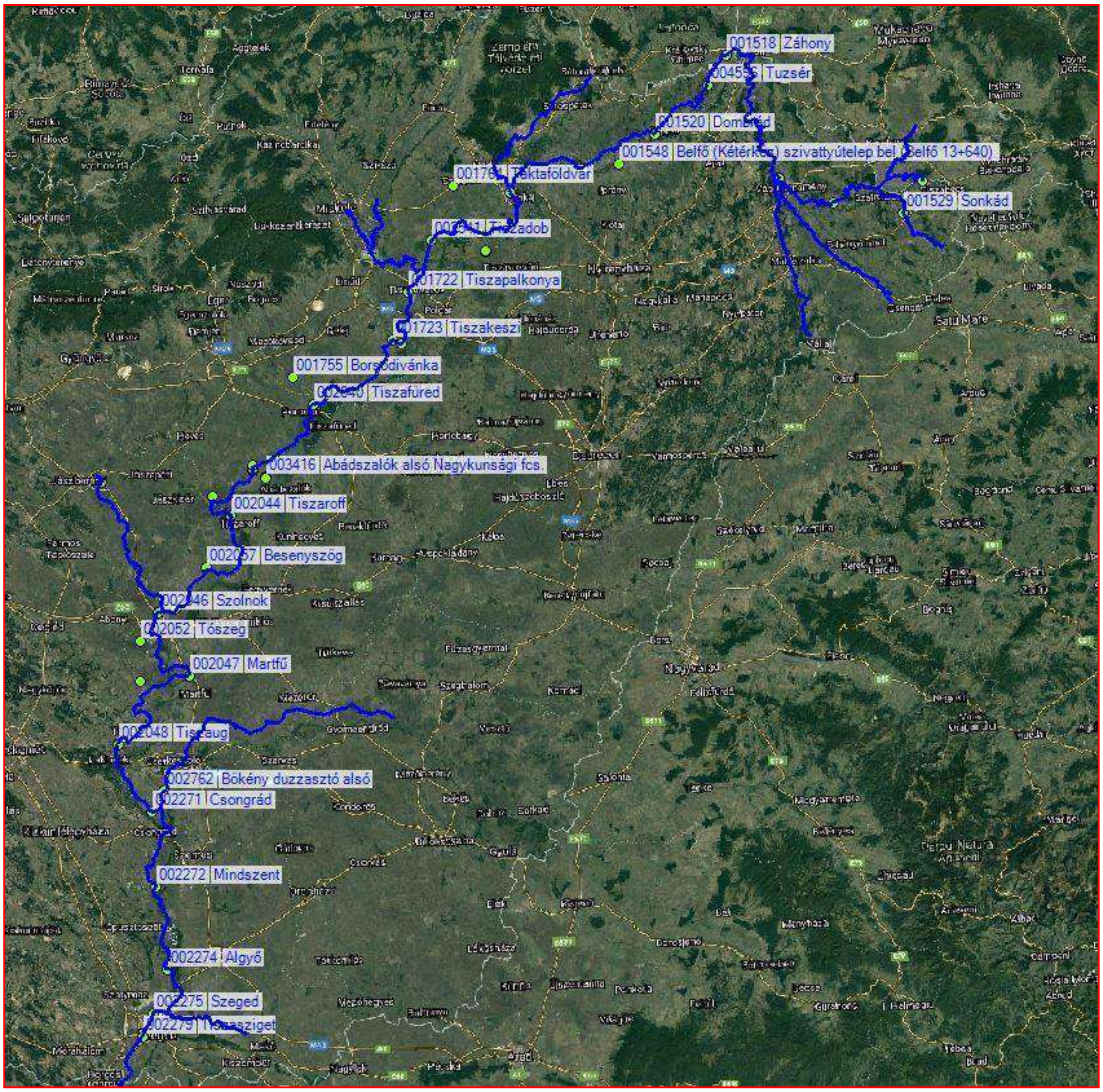


Figure 77: Most important hydrological measurement stations along the Tisza river (highlight only the Hungarian section)

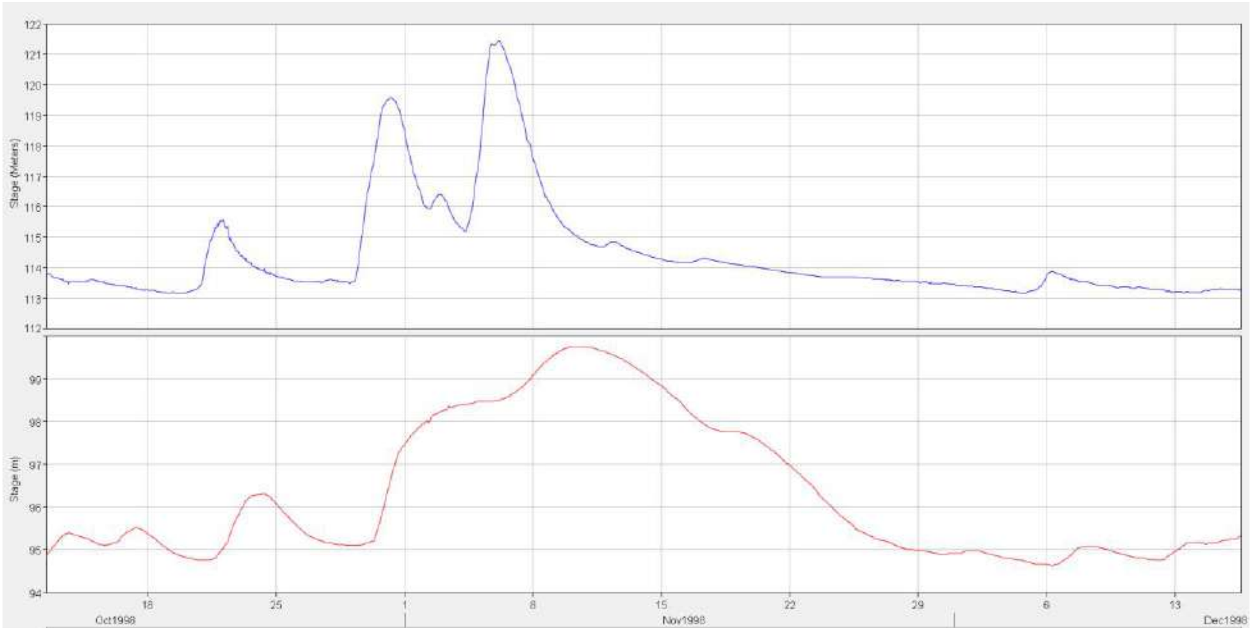


Figure 78: Applied boundary conditions time series on Upper Tisza model domain (Flood event 1998 -HQ100)

8.6. Tisa (RS)

The Tisza/Tisa River Basin drains an area of almost 160.000 km². The average discharge of the Tisa River at the mouth to the Danube is about 800 m^3/s. Five countries are sharing this largest subbasin of the Danube River Basin (Ukraine, Romania Slovakia, Hungary, and Serbia). The Tisza River is the longest tributary of the Danube (966 km), and the second-largest by flow, after the Sava River.

Serbian part belongs to the Lower Tisza downstream part starting from the mouth of the Maros/Mures River where it receives the Begej/Bega River and other tributaries indirectly through the Danube – Tisa –Danube Canal system and ending at the confluence with the Danube River near the village of Slankamen.

Flood protection along the Serbian section of the Tisa River (Figure 32) is based on the 296 km long leveelines along both riverbanks. The first levees were constructed in the XVIII century and in the period that followed they were heightened and improved after every large flood. However, such levees were not safeenough and additional efforts were required to ensure flood defence. After a long-lasting, hard, and costlyflood defence in 1970, a systematic approach was applied to ensure a secure flood protection system. Reconstruction of the existing and erection of some new, reallocated levees were grounded on equal standard - to enable the protection from 1% probability floods, with 1 m additional freeboard above the design flood level. The last section of an old levee was reconstructed after a demanding flood defence in 2006. The conditions of floodwater conveyance were also considerably improved by engineering works in the riverbed (enlargement and shortcutting) and on the floodplains (correction of levee lines). Along someriver sections "summer dikes" protect cultivated floodplains from 10% probability floods. There are somevulnerable points on the levees, where pumping stations and drainage outlets exist, or the levee line crosses abandoned riverbed.

Flood hazard and flood risk maps show that in the case of overtopping and breach of levees floods may endanger many settlements, some of which were built right next to the river. They host the inhabitants and their property, public institutions, economic activities, cultural heritage, infrastructure (within and between settlements). Flood hazard area also encompasses several protected areas while its largest portion is used for agricultural production.

Figure 79: Overview of the flood defence system at the Tisa River and main tributaries in Serbia

Riparian land of the Tisa River is mostly agricultural (around 50%) while forests are presented with around 25%. There are several significant industrial centres, Kanjiža, Novi Kneževac, Senta, Novi Bečej, and somesmaller settlements mostly dedicated to agricultural production.

The most significant protected areas along the Tisa River are Special nature reserve “Ritovi Donjeg Potisja”and Nature park “Stara Tisa kod Bisernog ostrva” (Old Tisa near the Pearl island).

The special nature reserve "Ritovi donjeg Potisja" includes eight old meanders and a belt of floodplain forests in the Tisa foreland located on the area between the Nature Park "Stara Tisa" near the Pearl Islandand the Special nature reserve "Titelski breg". They are located on the left and right of the present courseof the Tisa river and connected by a continuous to a large extent preserved forest complex. The basic characteristics of this protected area are preservation and diversity of original orographic and hydrographic forms of marshes (meanders, shallow and deep depressions and ponds) in the Tisa floodplain, preservation of ecosystem diversity characteristic for the large river's floodplains of the floodplain of the large plains and preservation and representativeness of native plant communities of marshes. This protected area belongs to the IUCN Category IV, it is a part of the Tisa River international ecological corridor and will be nominated as Natura 2000 area in the Republic of Serbia based on CouncilDirective 92/43/EEC.

The Nature park “Stara Tisa kod Bisernog ostrva” is especially important from the hydrological point of view due to its uniqueness and preservation. The length of about 24 km makes it the longest Tisa River oxbow. The Old Tisza has preserved its natural values from the 19th century, when it was cut off from itscourse. The most important characteristics of natural habitats are determined by the geographical position, geomorphological and hydrological characteristics of the area. The mosaic of aquatic, marsh, meadow, and salt marshes habitats, with the presence of a large number of rare and endangered species, is a unique complex important for protection not only nationally but also internationally. This protected area belongs to the IUCN Category V, it is a part of the Tisa River international ecological corridor, it was declared as the international Important Bird Area (IBA) in 1997 and will be nominated as Natura 2000 area.

In addition to these, there is also the area Mrtvaje Gornjeg Potisja that is planned for protection as a Nature Park. This area is located in the upper part of the Serbian stretch of the Tisa River. It belongs to the IUCN Category V, it is a part of the Tisa River international ecological corridor and will be nominated as Natura 2000 area. The area consists of 4 oxbow lakes that represent one of the preserved aquatic habitats due to the presence of numerous rare species characteristic for marshes, meadows, salt marshesand steppe habitats.

Given that the Tisa River in Serbia have all characteristics of large lowland rivers, the same approach for the identification of the active floodplains (AFP) was used as for the Danube River:

- the inundation outlines of an HQ100 identify active floodplains; for the Tisa River locations ofdikes and/or high terrain defines the inundation,
- the ratio factor 1:1 of Widthfloodplain / Widthriver is used for AFP delineation,
- the AFP area is larger than 500 ha,
- defined floodplains have to be hydraulically connected.

Based on applied criteria, three AFPs were identified on the Tisa River in Serbia.

No PFP were identified on the Tisa River in Serbia. The decision is made based on the “Study on possibilities for water retention in the Tisa River riparian zone”, Jaroslav Černi Water Institute, Belgrade, 1992, and supported by the fact that recent national strategic and planning documents related to the flood protection don't foresee measures of flood retention along the Tisa River in Serbia. The study examined only the Tisa river reach upstream of the Novi Bečej dam, given that flood retention would haveno effects at the most downstream part near the confluence with the Danube. Three potential areas for flood retention were identified based on volume capacity, land use, topography, and existing infrastructure. The Study concludes that only the simultaneous use of all of them would be effective but probably not economically feasible.

8.7. Sava (RS)

The Sava River Basin is one of the most significant sub-basins of the Danube River Basin with a total areaof almost 98,000 km^2. The average discharge of the Sava River at the mouth to the Danube is about 1700 m^3/s. The basin area is shared among six countries: Slovenia, Croatia, Bosnia and Herzegovina, Albania, Montenegro and Serbia. The Sava River is very important for the Danube River Basin for its biological andlandscape diversity. It hosts the largest complex of alluvial wetlands in the Danube Basin and large lowlandforest complexes. The Sava River is a unique example of a river with some of the floodplains still intact, thus supporting the flood alleviation and biodiversity.

The lowest part of the Sava River belongs to the territory of the Republic of Serbia. It is about 210 km long,stretching from the HR-RS state border near the village of Jamena to the confluence with the Danube River in Belgrade. At this section, the Sava flows through a distinct plain area and has all the characteristics of an alluvial river (deformable bed, meandering course, etc.). It receives many tributaries and the most significant are the Bosut at the left and the Drina and the Kolubara at the right bank.

The flood defence system along the Sava River section in Serbia is not continual. There are still natural floodplains capable to store and attenuate a part of flood wave.

The history of flood protection system development along the Sava is very long and related to the establishment of numerous settlements and agricultural development. The levee reconstruction to so-called "Sava levee profile" was initiated after extremely complex and expensive flood protection activitiesin 1974 and 1981. Reconstruction of the flood defence lines along the Sava and its tributaries in the mouth sections has not been completed so far and some works are currently ongoing, as described in the following text.

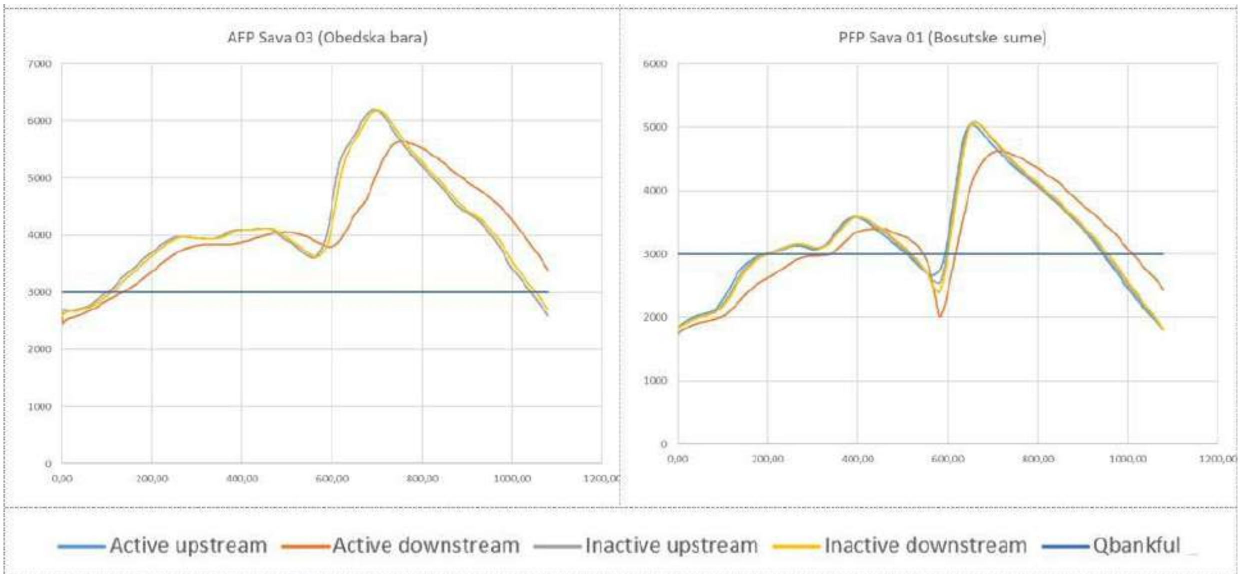


Figure 80: Hydrographs for the Sava River FPs

The left-bank levees of the Sava River protect the lowland area of Srem. The defence line is not continuous,and three different sections can be distinguished:

From the Sava mouth into the Danube River to Kupinovo village, a 51.3 km long protection line is continuous, protecting around 13,000 ha of agricultural land, 1,300 ha of urban territory including the Belgrade area, and a few villages. Densely populated area of New Belgrade is protected by 8.5 km of the quay wall and by the levee on a short section. One part of these structures is below the design protectionlevel.

Riparian lands between the Kupinovo village and the city of Sremska Mitrovica are not protected, excepttwo short stretches by the villages. The terrain is low, and high waters inundate 12,000 ha. Nature reserve“Obedska bara” is located in this area (near Kupinovo).

From Sremska Mitrovica to the state border with Croatia a 70 km long levee protects around 48,000 ha offertile agricultural land and forests, city of Sremska Mitrovica and numerous smaller settlements, traffic infrastructure and industry. Drainage water from dense channel network is discharged into the Sava Riverby gravity or pumping.

Flood protection line on the right bank of the Sava River also has three specific sections:

From the Sava River mouth to Skela (km 0 to km 55.1) flood protection line is interrupted by numerous smaller and larger tributaries. The protected area is thus divided into several flood cells protected by levees along the Sava and its tributaries. Quay walls and levees protect the central Belgrade area. Levees upstream of the Kolubara mouth protect 12,000 ha of agricultural land, numerous settlements, and part of Obrenovac, industrial facilities and infrastructure.

Between Skela and the city of Šabac, only short levees are built to protect agricultural land and small settlements.

Between Šabac and the Drina River mouth, a 70 km long and continuous defence line protects the Mačvaregion. It extends 18 km along the right bank of the Drina River to Badovinci. Within protected area, thereis the city of Šabac and numerous smaller settlements, 30,000 ha of agricultural land, industrial facilities and infrastructure, and drainage systems.

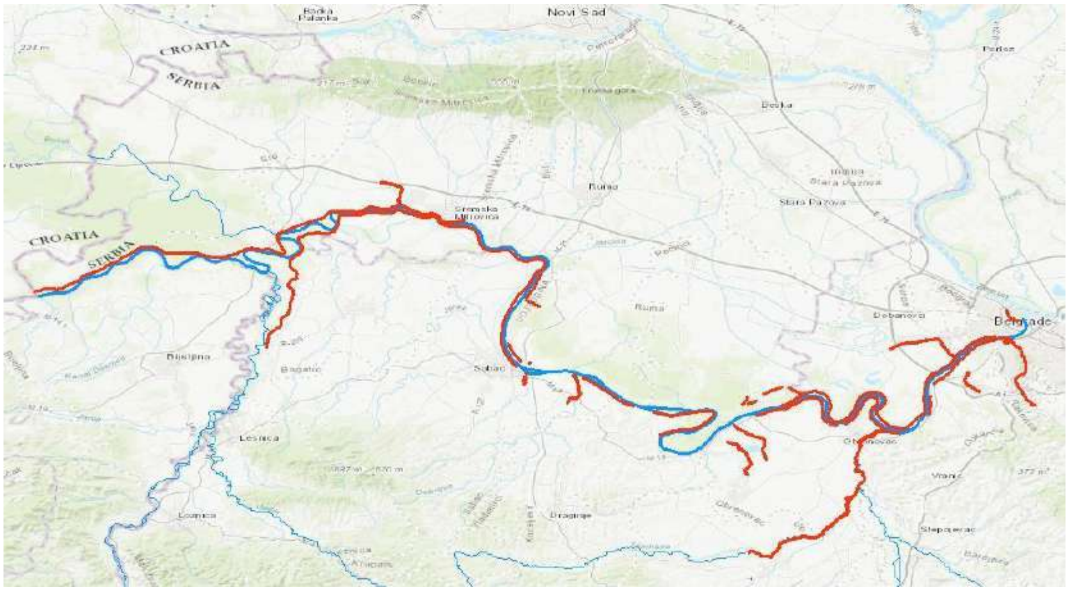


Figure 81: Overview of the flood system at the Sava River and main tributaries in Serbia

Forest land is dominating at the left while agricultural land is more represented at the right bank of the Sava River in Serbia. There are four significant industrial centres, Sremska Mitrovica, Šabac, Obrenovac and Belgrade and some smaller settlements mostly dedicated to agricultural production.

The most significant protected areas along the Sava River are the Special Nature Reserves Obedska bara (the Obed swamp) and Zasavica.

The greatest value of Obedska bara lies in its authentic combination of stagnant tributaries, ponds, pits, swamp vegetation, wet meadows, and forests with exceptional diversity of ecosystems and species, especially the endangered ones. It is one of the few remaining inundated marshes with distinctive features, such as hundred years old mixed English oak forests, waterfowl colonies and numerous naturalrarities. This swamp actually represents a remnant of the former meander of the Sava, located along its old riverbed. Obedska bara has been included in the Ramsar Convention list in 1977 and is the first protected site of such kind in Serbia. In 1989 it was declared the international Important Bird Area (IBA).

Zasavica is dominated by a reverie biotope of the Zasavica River. It is mosaic of aquatic and wetland ecosystems with fragments of flooded forests. The backbone of the Reserve makes canals, creeks and theZasavica river which is connected to the Sava River directly through Bogaz canal. The Zasavica River is alsosupplied by groundwaters from the Drina River. The whole system presents one of the few authentic andpreserved wetlands of the region. This area was put under protection in 1997 and is a part of a national network of Ramsar sites (wetlands protected according to the Ramsar Convention), and according to IUCNmanagement categories, it is Habitat and species management area – category IV.

Given that the Sava River in Serbia have all characteristics of large lowland rivers, the same approach for the identification of the active floodplains (AFP) was used as for the Danube River:

- the inundation outlines of an HQ100 identify active floodplains; for the Sava River locations ofdikes and/or high terrain defines the inundation,
- the ratio factor 1:1 of Widthfloodplain / Widthriver is used for AFP delineation,
- the AFP area is larger than 500 ha,
- defined floodplains have to be hydraulically connected.

Based on applied criteria, three AFPs were identified on the Sava River in Serbia.

Identification of the potential floodplains (PFP) on the Sava River is based on the extreme flood event in May 2014 when a three-months amount of rain fell onto the region in just three days. Enormous inflow lead to a fast increase of the Sava water levels, in the bordering sections between Bosnia and Herzegovinaand Croatia and in Serbia. On May 17, the Sava River breached left-bank levee at two locations, flooding several settlements in eastern Croatia, and water progressed over flat areas towards lower terrain in Serbia and flooded several settlements there as well (Figure 7, red hatch area). After this event, HR and RS initiated the Interreg Project called FORRET (https://www.interreg-croatia-serbia2014- 2020.eu/project/forret/) striving to significantly increase the disaster response capability related to the risk of disasters from floods in the area. One of the flood wave reduction options was the relieving a partof the flood wave into the transboundary natural forest retention areas of Spačva-Morović, covering approximately 38, 000 ha in Croatia and Serbia, while also improving the ecological status of the area. Atthe very beginning of the Danube Floodplain Project, the HR and RS partners decided not to examine thisarea as a common potential FP given that the same exercise should be done through the FORRET Project.The FORRET project failed in the meantime and JCWI decided to examine the RS part of the area (Figure 7, blue area) as a potential FP at the territory of Serbia as presented in Figure 5 (PFP Sava 01, Bosutske šume, aka Morović).

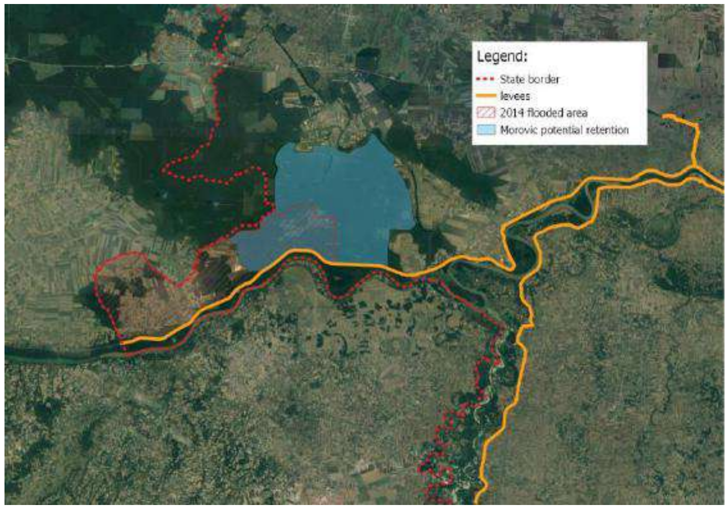


Figure 82: 2014 flood event impacted area on the Sava River left bank in HR and RS

9. Results

Maps of active and potential floodplains on the six selected tributaries are given in this chapter. Shapefilesof all identified floodplains and associated data will be available on the Danube Floodplain GIS server.

9.1. Krka

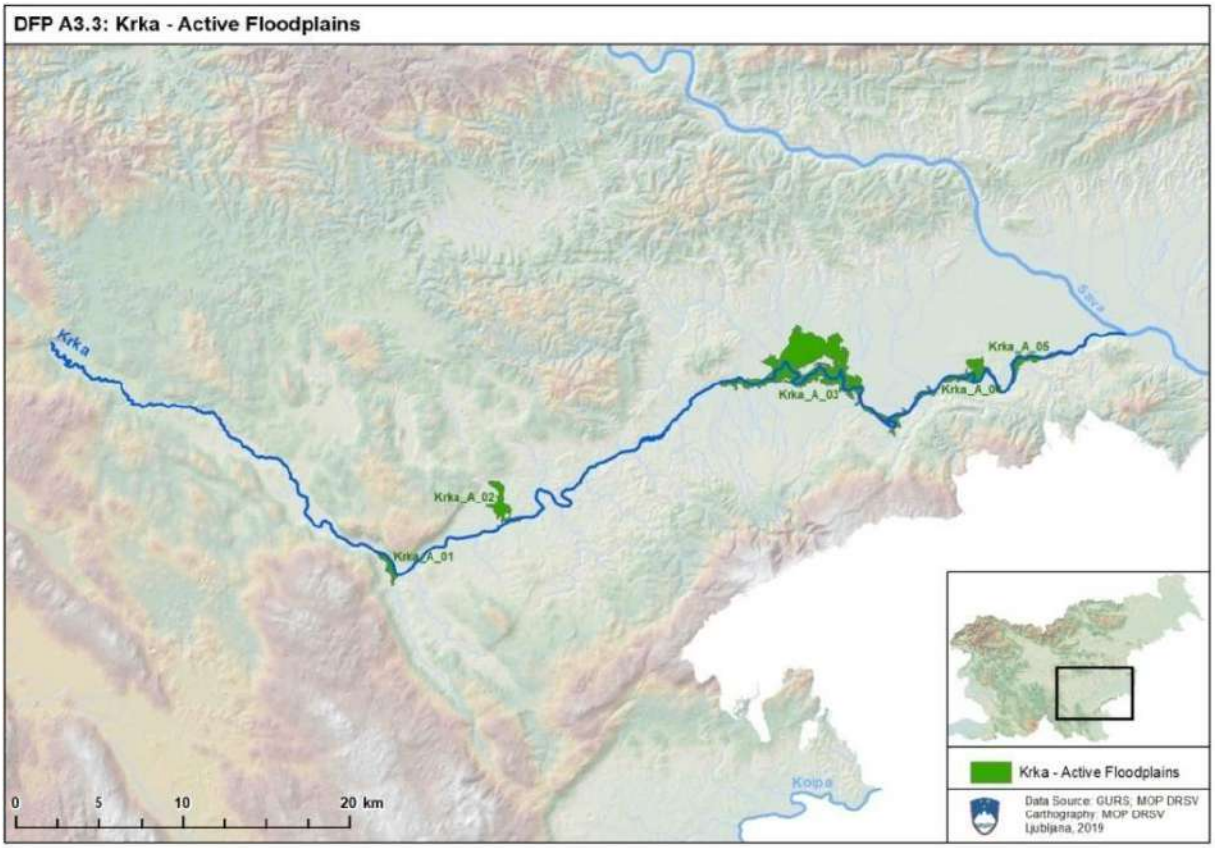


Figure 83: Extent and position of the Active floodplains identified on the Krka river

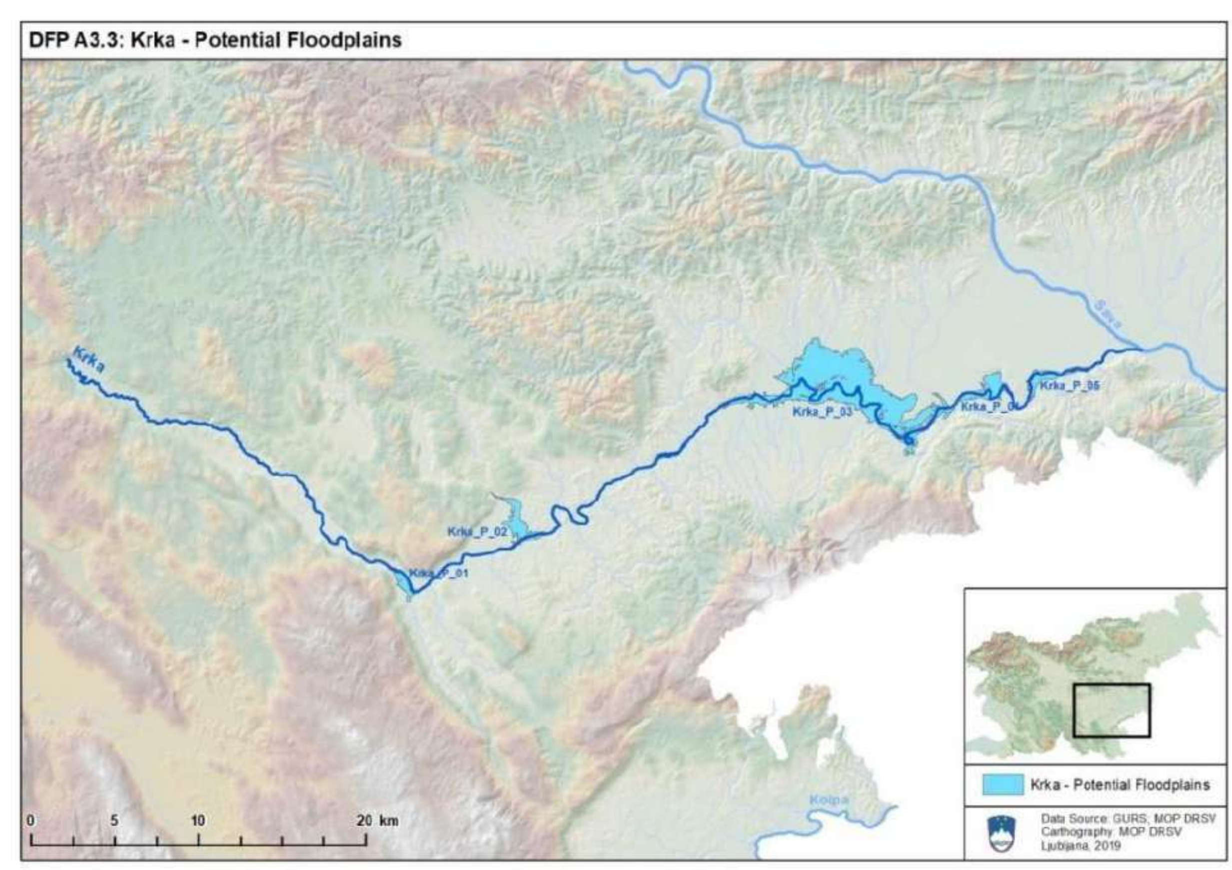


Figure 84: Extent and position of the potential floodplains identified on the Krka river

9.2. Yantra

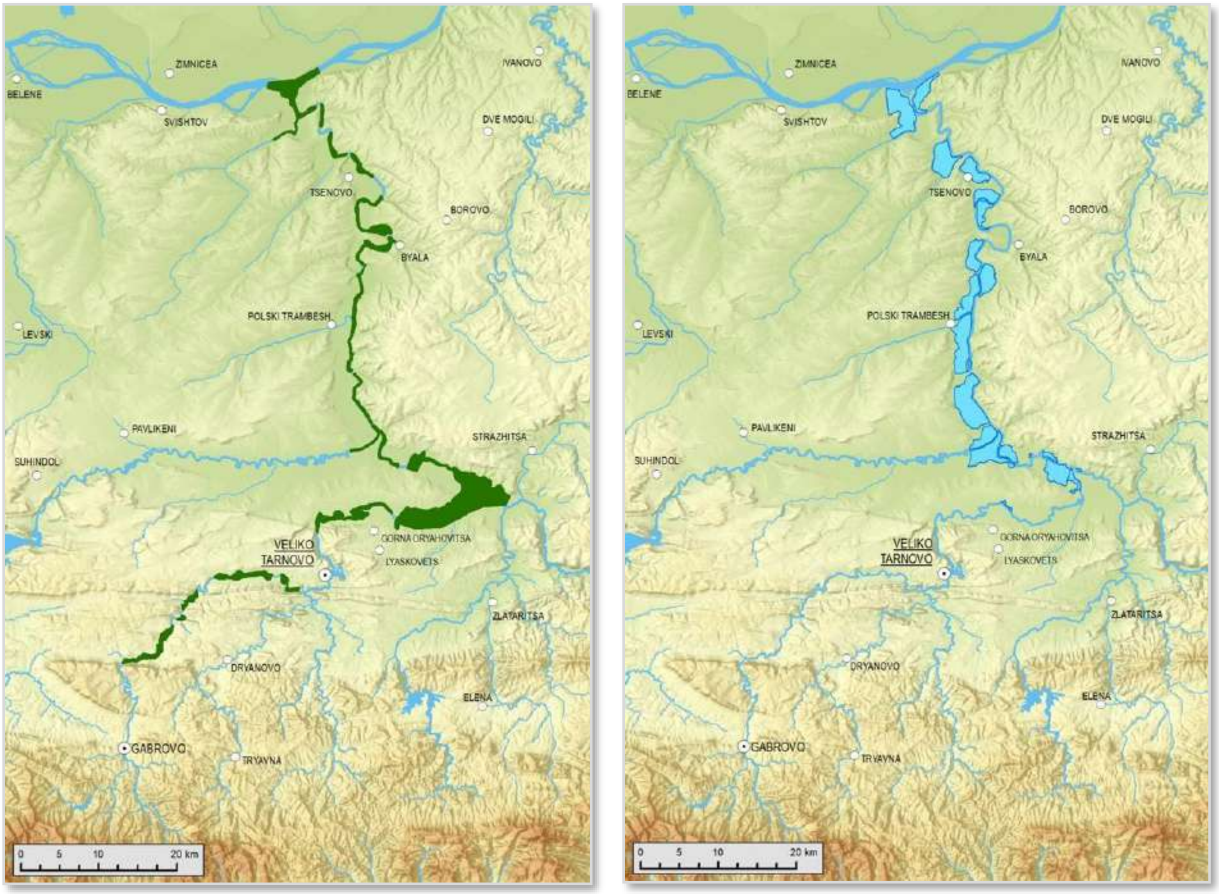


Figure 85: Extent and position of the Active and Potential floodplains identified on the Yantra river

9.3. Desnăţui

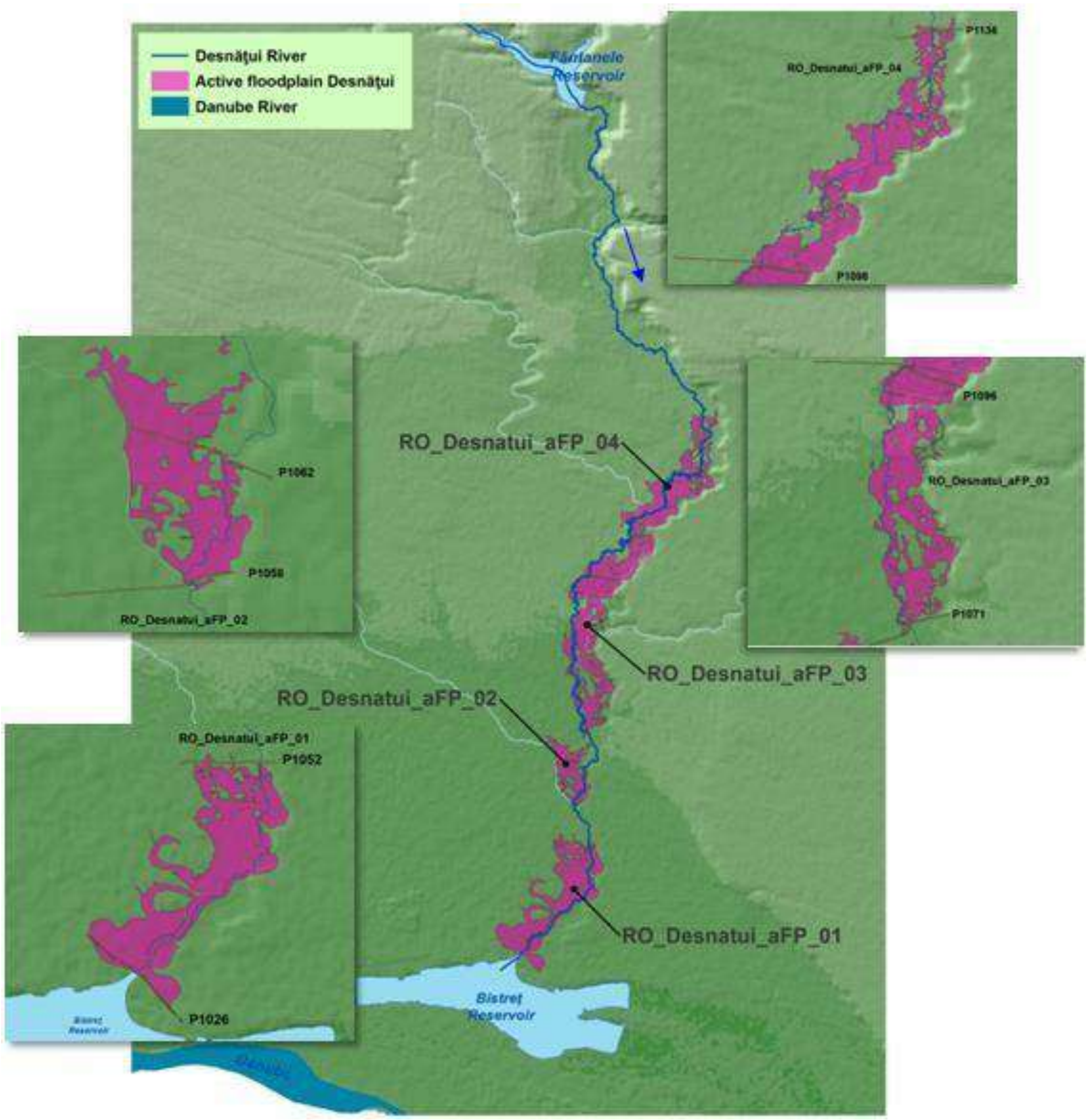


Figure 86: Extent and position of the active floodplains identified on Desnăţui River

9.4. Tisza (HU)

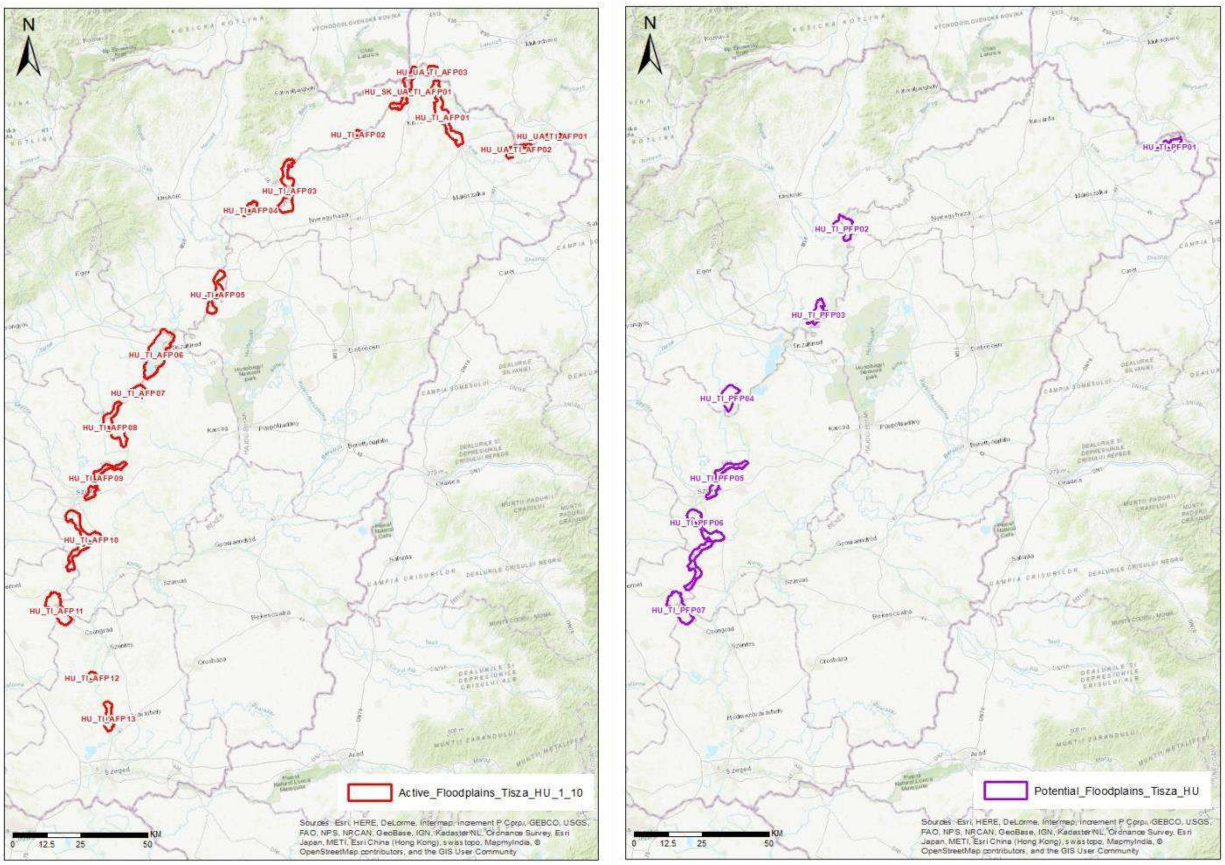


Figure 87: Extent and position of the Active floodplains identified on the Tisza river (HU)

9.5. Tisa (RS)

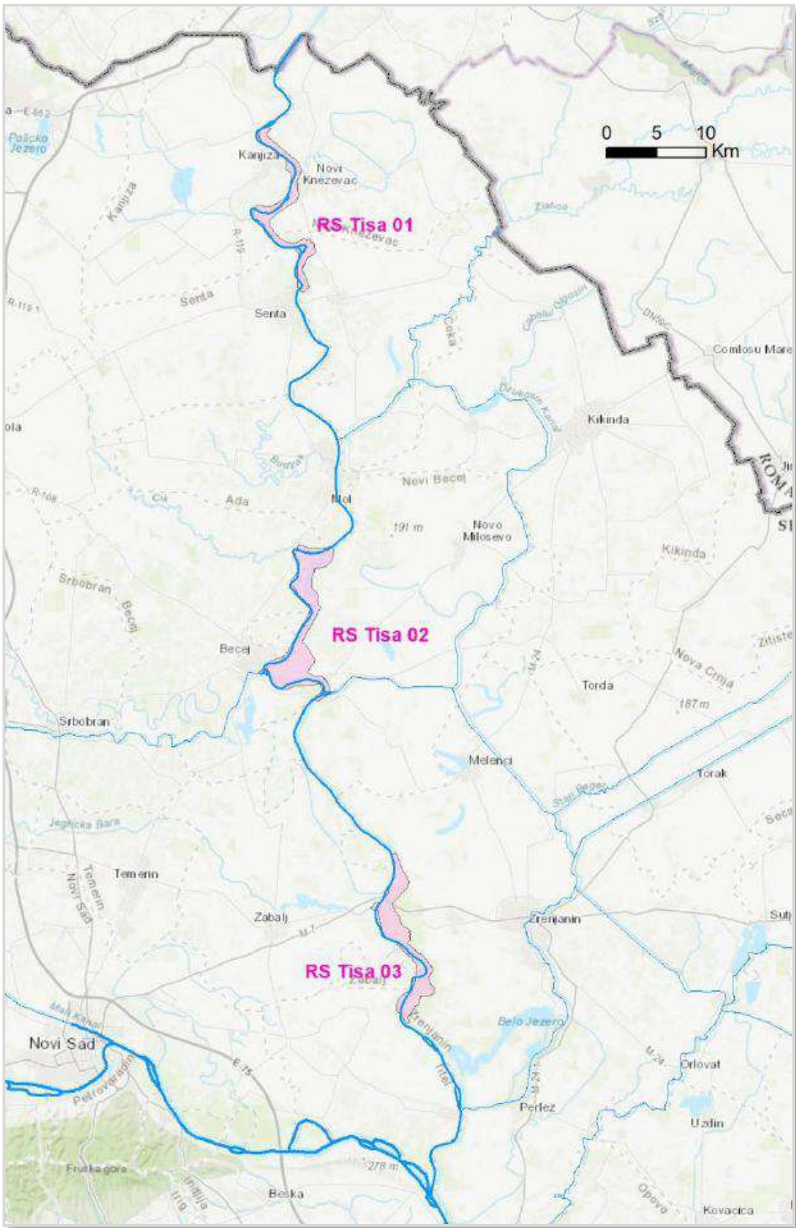


Figure 88: Extent and position of the Active floodplains identified on the Tisa river (RS)

9.6. Morava

Only one active floodplain larger than 500 ha was identified within the pilot area. At this locality, the flood protection dyke is further from the Morava river and the area is naturally flooded at higher discharges.

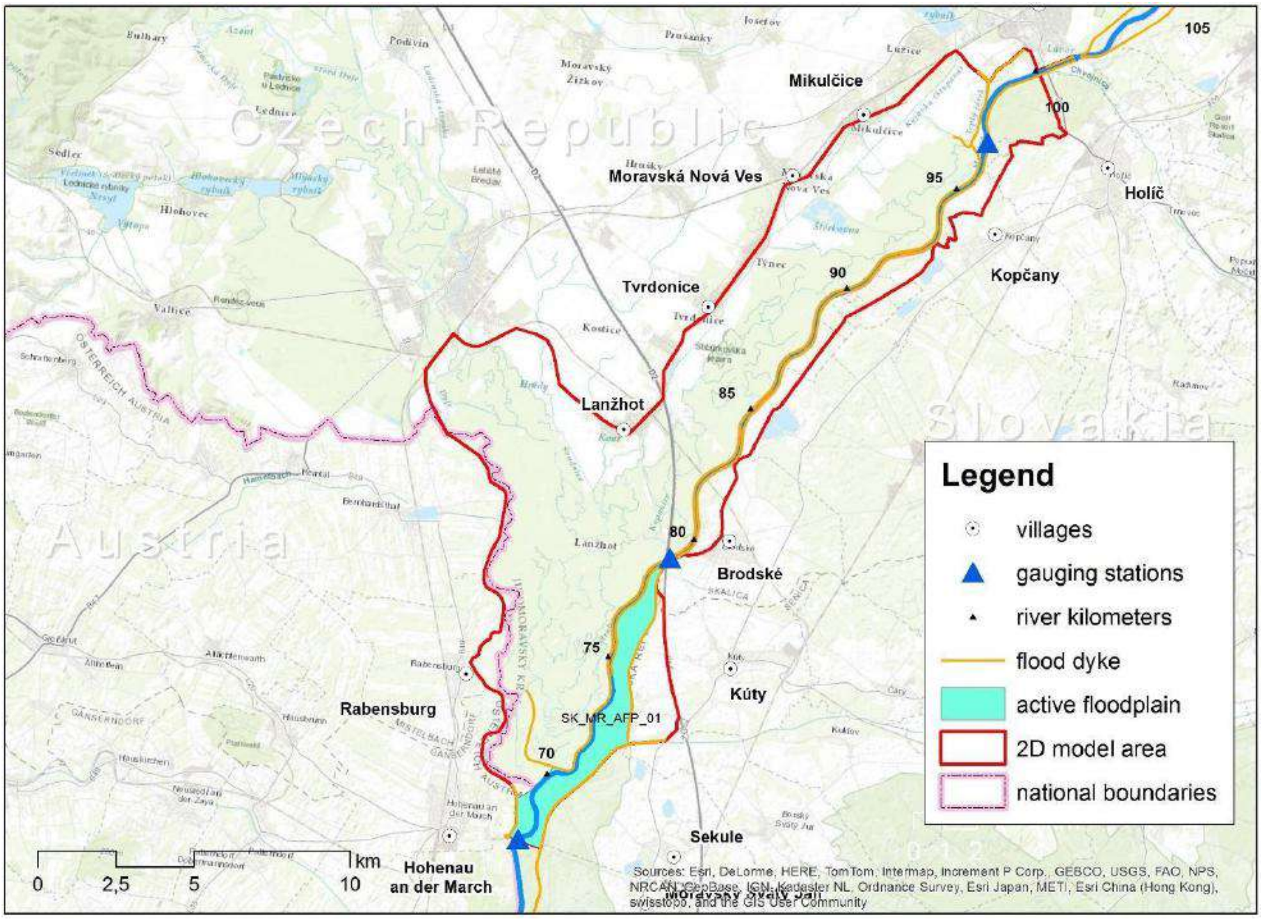


Figure 89: Extent and position of the active floodplain identified on the Morava river (CZ, SVK)

After the proposed measures are implemented, 5 potential floodplains could be created to communicatewith the main river course during floods. Dyke shifting on both sides of the border was proposed. Current active floodplain was proposed to be widened.

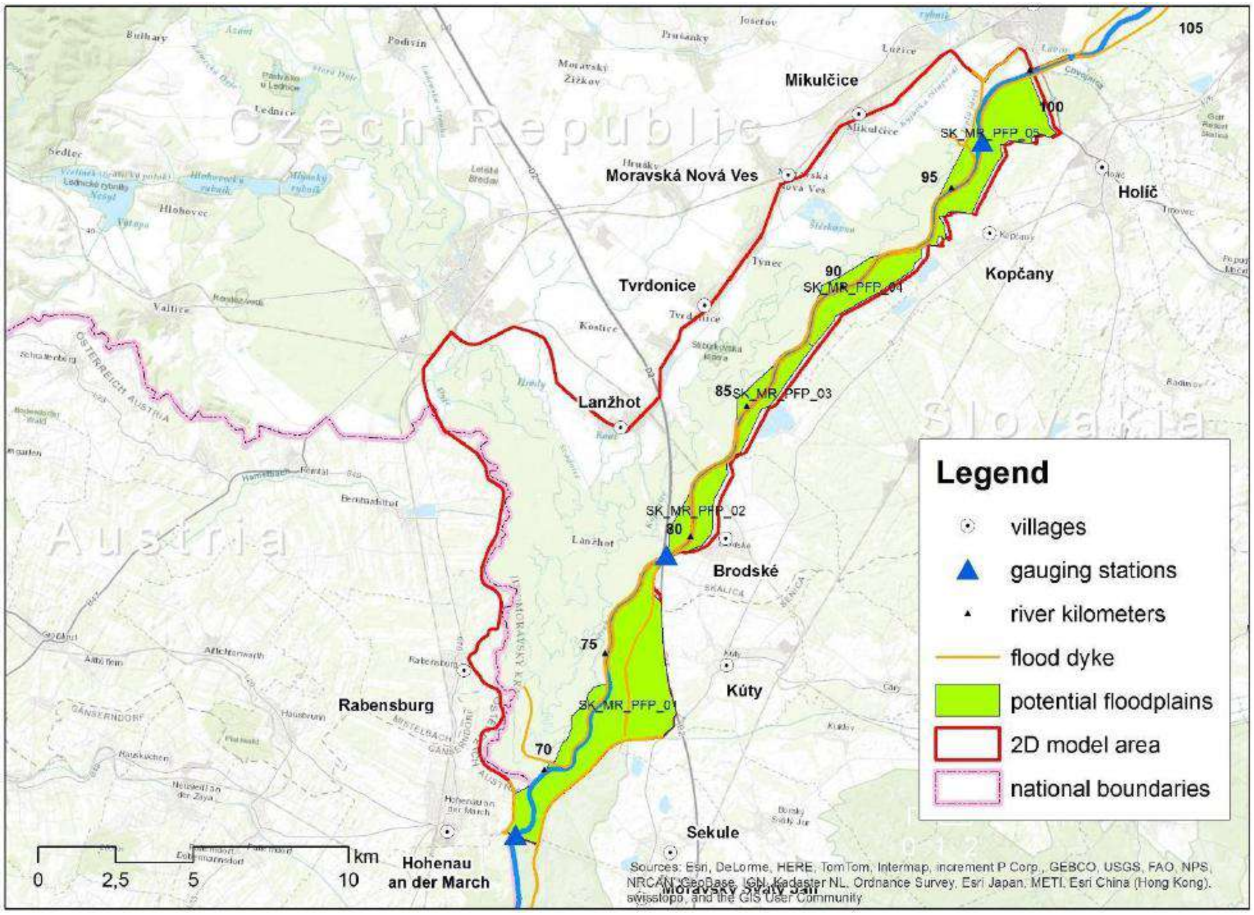


Figure 90: Extent and position of the potential floodplains identified on the Morava river (CZ, SK)

9.7. Sava (HR)

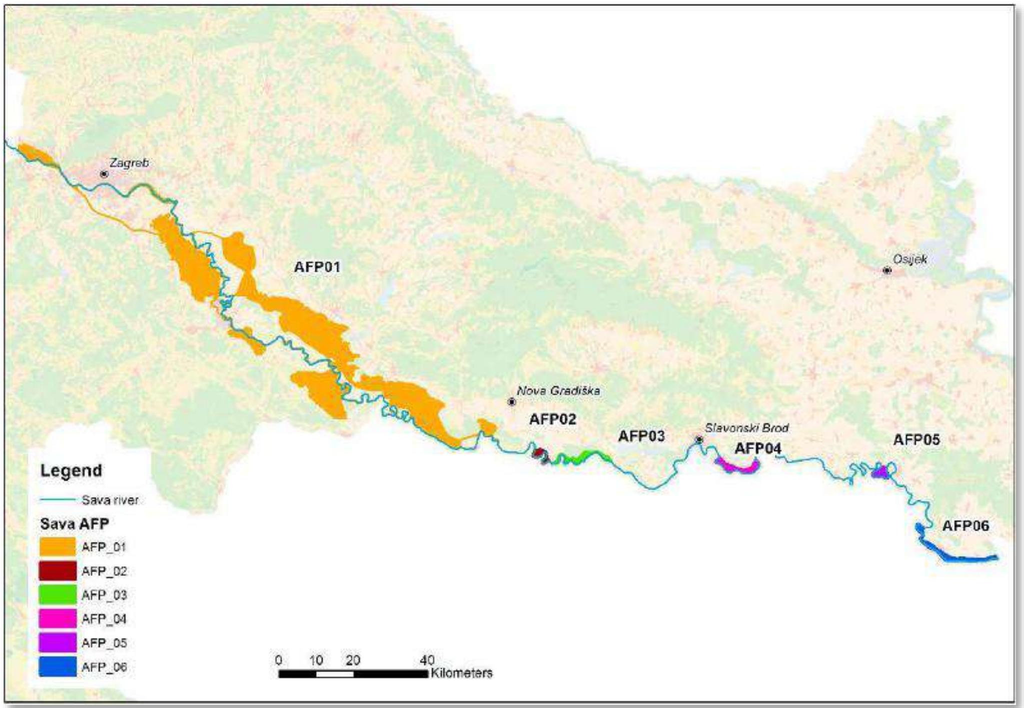


Figure 91: Extent and position of the Active floodplains identified on the Sava river (HR)

9.8. Sava (RS)

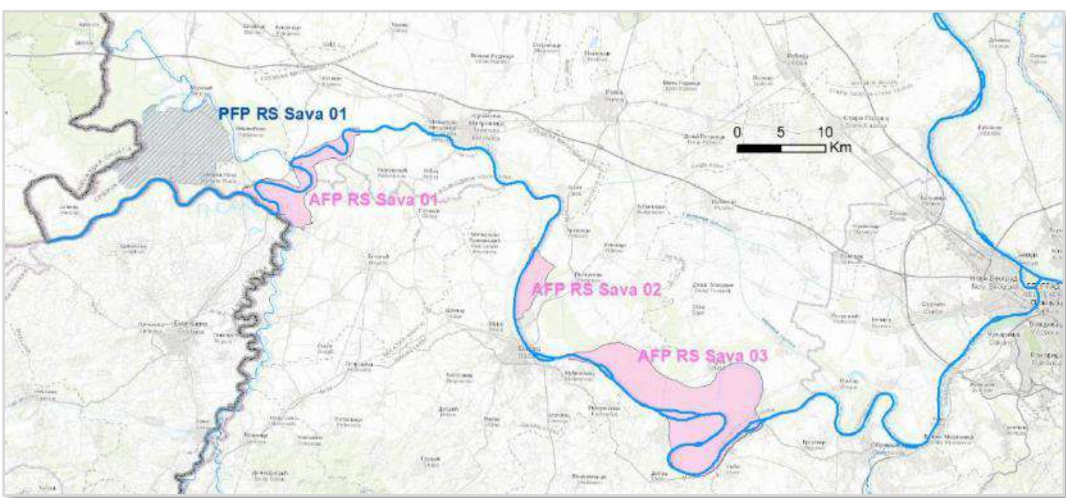


Figure 92: Extent and position of the Active floodplains identified on the Sava river (RS)

Deliverable 3.3.2 List of floodplains, their characteristics, restoration/preservation potential and associated measures

10. Methodology

The main activity objective is the evaluation of active and former floodplains along selected tributaries (or their river sections) with relevant multi-criteria decision analysis methods considering the FEM (Floodplain Evaluation Matrix) ranking method and results from Activity 3.2 and D3.3.1. The deliverable consists of:

- determining relevant parameters and indices for floodplain preservation and restoration suitabilityconsidering multiple objectives;
- determining relevant scale for each parameter to assess it;
- classification of floodplains according to each parameter by defining relevant thresholds;
- final ranking of floodplains.

The FEM priority ranking indicates where non-structural measures are most powerful with regard to hydromorphology, ecology and socio-economics and where effort should be made first.

Among the PPs working on tributaries, it was agreed that:

- For the identification of the former floodplains the historical maps should be used;
- For the identification of the active floodplains, the following conditions should be fulfilled:
  - a ratio factor of $width_{floodplain}/width_{river} > 2:1$[4];
  - a minimum floodplain size of 500 ha on larger (Tisza/Tisa, Morava, Sava), and 100 ha on
    smaller tributaries (Krka, Desnăţui and Yantra);
  - floodplain must be hydraulically connected and characteristic flow behaviour is given.

- For the purpose of the floodplain characteristic description, their evaluation and ranking, allof the FEM parameters from the Minimum set should be implemented:
  - Hydrology:
    - Peak reduction ΔQ
    - Flood wave translation Δt
  - Hydraulics:
    - Water level Δh

[4] The Hungarian section of the Tisza the Ratio factor of Width of floodplain / Width of river > 10:1

- Ecology:
  - Connectivity of floodplain water bodies
  - Existence of protected species
- Socio-Economics:
  - Potentially affected buildings
  - Land use

Hydrology	Hydraulics	Ecology	Socio-Economics
peak reduction ΔQ	water level Δh	connectivity of floodplain water bodies	Potentially affected buildings
flood wave translation Δt	flow velocity Δv	Existence of protected species	Land use
effects (pos./neg.) in case of extreme discharges	bottom shear stress	Existence of protected habitats	Precence of documented planning interests
		Vegetation naturalness	
		water level dynamics	
		Potential for typical habitats	
		ecological, chemical and ground water status	

Figure 93: Floodplain Evaluation Matrix - in blue: minimum set, in green: medium set, in yellow: extended set of parameters

During A 3.2 the FEM parameters were defined and agreed among all PPs. It was agreed which parametersshould be in the minimum set of parameters and are mandatory for all partners to be calculated. Amedium and extended set of parameters were also prepared, out of the favoured parameters by allpartners which serve as additional information in the Danube Floodplain GIS but will not be taken intoaccount for the ranking list. The results will nevertheless be a valuable information for decision makers. An Activity leader of A 3.2 (BOKU) responsible for methodological frame and support in implementationof FEM also coordinated the definition of the thresholds between the values of each parameter. Aftersome modifications and harmonization mostly with an Activity leader 3.3 (DRSV), the thresholds werepresented and agreed among PPs on the last expert meeting Bratislava. Here are the results (only for theparameters from the minimum set):

Thresholds $\Delta Qrel$		Thresholds Δt		Thresholds Δh	
1	< 1 %	1	< 1 h	1	< 10 cm
3	1 - 2 %	3	1 - 5 h	3	10 - 50 cm
5	> 2 %	5	> 5 h	5	> 50 cm

Thresholds protected species	
1	< 1
3	1 - 20
5	> 20

Connectivity of FP water bodies	
1	< 50 %
3	50 % - 80 %
5	> 80 %

Thresholds affected buildings	
1	> 5 [n/km²]
3	1 - 5 [n/km²]
5	< 1 [n/km²]

Thresholds land use	
1	< 2
3	2 - 4
5	> 4

Figure 94: Thresholds for the parameters from the minimum set

FEM-Ranking
High performance = 5
Medium performance = 3
Low performance = 1

Figure 95: Thresholds for the Ranking of parameters from the minimum set

11. Floodplain evaluation, classification and ranking on tributaries

Due to the fact that the methodology of the floodplains identification, delineation, evaluation, classification and ranking was agreed upon among the PPs, the process will be described with the emphasis on the Krka river, while all other details for the Krka river and for some other tributaries are in the reports attached.

As decided in our past expert meetings, the PPs should implement the FEM parameters from the minimumset. However, in a few cases the PPs also found adequate some parameters from the medium and extended set, in some cases even additional parameters were introduced – all in a view of getting as muchas possible good picture of the conditions on the specific flooplains. The data gained with those parameters can be used for better informing of stakeholders and for easier decisioning of responsible institutions.

11.1. Krka

The Krka sub-basin has an area of 2 315 km^2 with approximately 120 000 inhabitants. From administrativepoint of view, 23 municipalities are located on its territory. It is a tributary of the Sava river to which the Krka river discharges just some 11 km upstream the cross section where Sava flows from Slovenia to Croatia. Beside the main watercourse of the river in the length of 94 km its tributaries and springs in the upper part of the river basin are mainly karstic, as shown on Figure 96 with absence of surface watercourses.

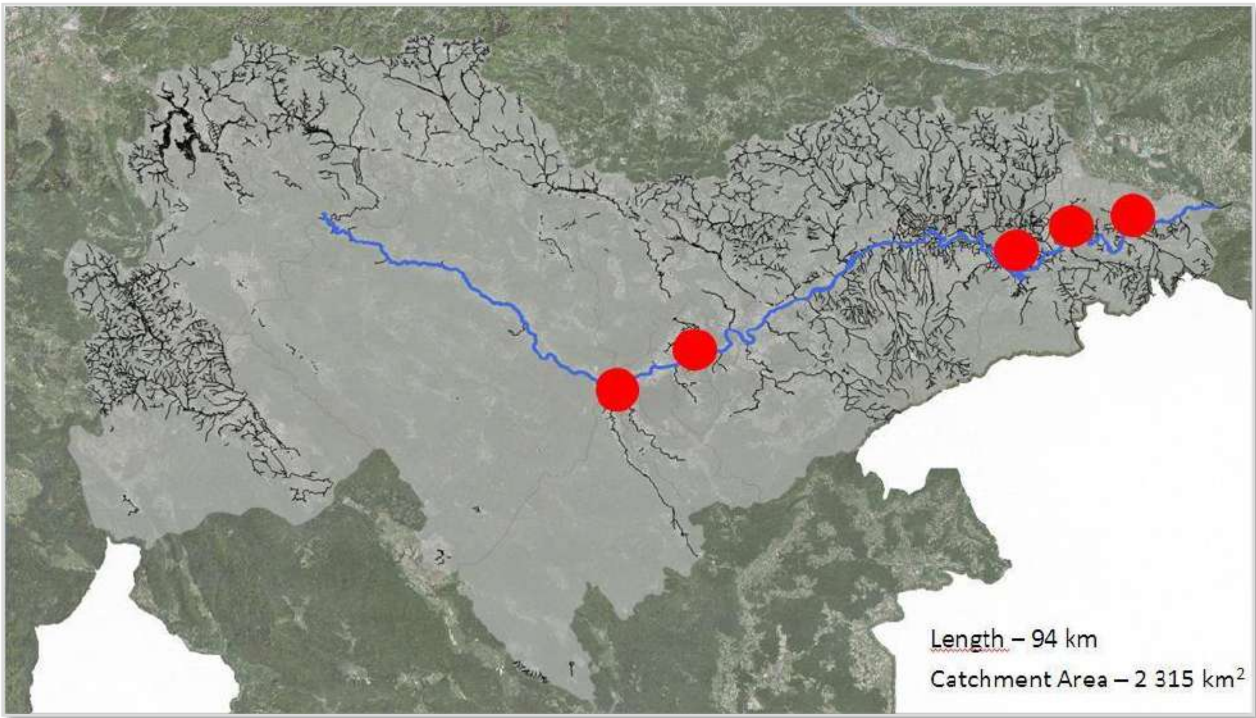


Figure 96: Overview of the Krka river basin with locations of the floodplains and indication of main watercourse and tributaries - not karstic watersheds with no surface runoff or formation of watercourses

The FEM priority ranking was implemented considering five identified floodplains on the Krka river.

a) Hydrology / Hydraulics
From this sections only the parameters from the minimum set were used:

- Peak Reduction ΔQ
- Floodwave Translation Δt
- Water Level Change Δh

For the purpose of FEM scenario analysis the hydrographs were applied in two developed hydraulic models (for two models). Δt and ΔQ were identified for the modelled floodplains. The using the FEM guidebook the shift in time and discharge downstreams was observed on different cross sections. The using of the FEM guidebook the shift in time and discharge were observed on different cross sections.

b) Ecology
From this sections the following parameters were assessed:
- Connectivity of Floodplain Water Bodies,

- Existence of Protected Species,
- Existence of Protected Habitats.

The analysed floodplains of Krka river are completely connected in the terms of longitudinal connectivitywith its historical floodplains. Therefore, the analysed scenarios are not subject of 2D modelling for this specific case:

1. mean water level (from gauging stations)
2. bankfull flow (1D/2D modelling)
3. above bankfull flow

The Connectivity determination is not applicable for the Krka floodplains as there are no oxbows and branches to define at which discharge the water bodies are connected.

For determination the "natural (historic)" status of water bodies on the floodplain historic maps were checked. There were noticed no major changes since the first mapping – more than 230 years ago. The condition: "If the river system is meandering, the connectivity is naturally beginning at bankfull dischargeso, if this is given, it gets the best rating (5) in the FEM and no further steps are needed." applies and all analysed floodplains are evaluated with 5 – High performance according to the FEM evaluation procedure.

Considering the floodplains with **Existence of protected species** FEM parameter, layers of Natura2000 and List of protected species data were used. Sticking to the stipulation that a floodplain is valuable and should be preserved if red list species or species and habitats (recognized by Natura2000) are found on the area, we evaluated all five AFP and PFP as valuable. According to our classification (see DRSV, 2020. A 3.3 – Floodplain assessment on selected tributaries - Results. Ljubljana) and presence of the protected species on the floodplains, all five floodplains are evaluated as 5 – High performance.

The **Existence of protected habitats** FEM parameter shows what part of the floodplain area isdesignated as protected area according to the Natura 2000 or other documents about protected species of habitats – the higher the share of protected areas, the more "valuable" is the floodplain.All five floodplains are partly (in two cases even mostly) in Natura2000 zone (see Figure 49).

c) Socio – Economics

From this section, the following parameters were assessed:

- Land Use,
- Potentially Affected Buildings,
- Presence of Documented Planning Interests.

For the implementation of the **Land use** FEM parameter, the land use Shape file from the 1st of January 2019 was taken into account. For the purposes of Danube Floodplain project, the original land use categories were aggregated into 14 main categories. Each category was then given a FEM grade (1, 3 or 5) depending on the degree of suitability for such type of land use to be used as a potential flood retentionarea. Generally speaking, built-up areas were graded as being unsuitable (grade 1), intensive agriculturalland as being partly suitable (grade 3), and the rest as being very suitable (grade 5).

LANDUSE_DESCR	GRADE
Built-up Areas	1
Greenhouses	1
Fields	3
Olive Grove	3
Orchards	3
Other permanent crops	3
Tree Plantation	3
Vineyards	3
Dry Open Land	5
Forest	5
Meadows	5
Overgrown Agricultural Land	5
Swamp	5
Water	5

Figure 97: Assigned grades to land use categories

The three areas within a specific floodplain were then divided by the total area of that floodplain, yieldingpercentages of the floodplain marked with certain grade. Every percentage and its respective grade in turn yield subtotal grade.

	Abs. Value	Final Mark
	Weighted Avg.	
SI_KR_AFP_01	4,75	5
SI_KR_AFP_02	4,78	5
SI_KR_AFP_03	4,67	5
SI_KR_AFP_04	4,42	5
SI_KR_AFP_05	4,54	5
SI_KR_FFP_01	4,69	5
SI_KR_FFP_02	4,45	5
SI_KR_FFP_03	4,58	5
SI_KR_FFP_04	4,34	5
SI_KR_FFP_05	4,45	5

Figure 98: Land use – AFP and PFP assessment

For the purpose of flood damage evaluation, Slovenia has already a well established practice for the evaluation of annual expected flood damage which also includes the number of affected buildings population and other vulnerable categories. For the implementation of the **Potentially affected buildings**FEM parameter there are adequate data available.

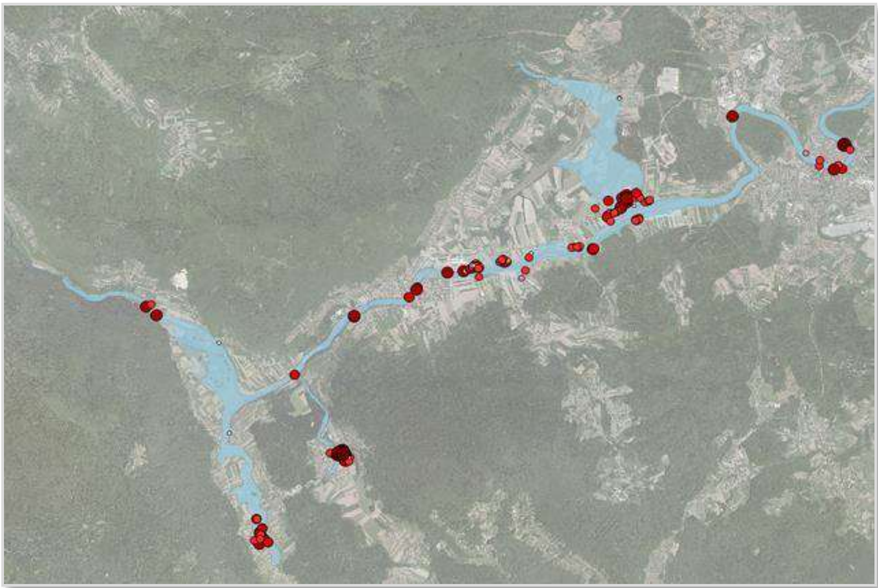


Figure 99: Potentially affected buildings on Floodplain 1- Soteska, and on Floodplain 2 – Prečna

For comparing the results of this parameter, number of the buildings by the area of the floodplain was performed. Because of the fact that the floodplain area around the Krka river is quite urbanized, only oneof the active floodplains gain the highest 5 grade.

For the implementation of the **Presence of documented planning interests** a specific analysis were performed in order to identify potential conflict between the identified floodplains and the spatial planning documents applicable for each specific zone.

This analysis is providing us interesting insight regarding what the local communities are planning for thefloodplains (planned land use) and potential conflict between the planned land use and existing floodplains as well as former floodplains.

For this purpose active spatial plans were collected and harmonized from the local communities and compared with the extent of active floodplains and former floodplains.

An analysis is providing disclosing the defined categories of land used applicable in the Slovenian legislation on spatial planning. They are sorted by the matching land use and potential conflict use with the potential floodplain areas. The figures for the analysed 5 former floodplains result in the span between0,95% (PFP 4) and 6,84% (PFP 2). They should be used as potential indicator for the existing conflict on land use as also PFP 2 has notable number of houses and people recognized to be exposed to flood hazard.

			PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
		AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [m]	d(natural) / d	n	Weighted Avg.	No. houses / km²
KRKA	SI_KR_AFP_02	177,7	1,5	2	0,01	100	34	4,78	7,9
	SI_KR_AFP_03	1524,2	10	13	0,95	100	46	4,67	1,1
	SI_KR_AFP_04	194,5	1	4	0,40	100	29	4,42	0,0
	SI_KR_AFP_05	145,5	0	1	0,25	100	29	4,54	10,3
	SI_KR_PFP_01	121,6	< 1	2	0,50	100	30	4,69	38,5
	SI_KR_PFP_02	248	< 1	4	0,10	100	34	4,45	26,6
	SI_KR_PFP_03	2626,7	4	19	2,10	100	46	4,58	6,3
	SI_KR_PFP_04	241,3	2	14	1,20	100	29	4,34	3,3
	SI_KR_PFP_05	177,7	0	2	0,70	100	29	4,45	42,7

Figure 100: Results of FEM Floodplain Evaluation of AFP and PFP of the Krka river with the parameters values

11.2. Yantra

			FLOOD PEAK REDUCTION	FLOOD WAVE TRANSLATION	WATER LEVEL	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel.Value	Abs. value	Abs. value	Rel.value	Abs. value	Abs. value	Rel.value
		AREA [ha]	ΔQ/Q [%]	Δt [min]	Δh [m]	d(natural)/d	n	Weighted Avg	No build./km^2
YANTRA	BG_YN_AFP_001	569.0	27.67	25	0.05	5	96.79	1.23	0.2
	BG_YN_AFP_002	141.0	0.12	14	0.57	5	29.97	3.85	2.3
	BG_YN_AFP_003	238.0	0.23	42	0.64	5	30.78	3.03	1.7
	BG_YN_AFP_004	2 129.0	7.21	525	0.11	5	263.14	4.25	1.3
	BG_YN_AFP_005	700.0	1.64	208	0.64	5	91.26	3.62	2.6
	BG_YN_AFP_006	64.0	0.21	32	1.38	5	11.97	2.28	9.4
	BG_YN_AFP_007	458.0	7.5	360	2.15	5	43.98	3.44	1.3
	BG_YN_AFP_008	112.0	0.57	70	1.51	5	12.58	2.73	0
	BG_YN_AFP_009	24.0	0.24	15	4.83	5	3.7	1.48	4.1
	BG_YN_PFP_001	3 276.0	3.1	336	0.05	4.5	225.2	4.41	0.7
	BG_YN_PFP_002	1 130.0	4.18	375	0.64	4.5	85.76	4.35	0
	BG_YN_PFP_003	794.0	2.01	247	0.01	4.5	80.1	3.79	0
	BG_YN_PFP_004	1 040.0	0.25	67	0.58	4.5	91.32	3.99	0.3
	BG_YN_PFP_005	595.0	4.01	70	2.11	4.5	68.81	3.11	0.5
	BG_YN_PFP_006	1 606.0	0.41	72	0.31	4.5	145.77	4.03	2.3
	BG_YN_PFP_007	1 375.0	2.44	174	0.95	4.5	140.33	4.16	0.7
	BG_YN_PFP_008	2 403.0	0.49	87	1.16	4.5	249.34	4.03	0.3

Figure 101: Results of FEM Floodplain Evaluation of AFP and PFP of the Yantra river with the parameters values

11.3. Desnăţui

			PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
		AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [m]	d(natural) / d	n	Weighted Avg.	No. houses / km^2
DESNATUI	RO_DE_AFP_01	684,9	1,77%	290	6,9	< Q 50%	57	3,0	9,350
	RO_DE_AFP_02	198,4	0,10%	50	1,4	< Q 50%	16	2,9	7,560
	RO_DE_AFP_03	605,2	0,05%	180	4,4	< Q 50%	18	3,4	0,500
	RO_DE_AFP_04	732,1	0,22%	430	7,0	< Q 50%	10	3,4	5,330
	RO_DE_PFP_01	1148,2	0,45%	180	8,0	< Q 50%	57	3,0	15,100
	RO_DE_PFP_02	676	0,13%	130	5,3	< Q 50%	18	3,4	0,400
	RO_DE_PFP_03	901,7	0,07%	410	8,3	< Q 50%	13	3,4	4,200

Figure 102: Results of FEM Floodplain Evaluation of AFP and PFP of the Desnațui river with the parameters values

11.4. Tisza (HU)

The calculation methodology of the parameters are similar than Krka river, the detailed information canbe found at "Activity 3.3 Floodplain assessment on selected tributaries FLOODPLAIN TISZA (Hungary) REPORT" project document. The summary results are given in the following table:

				PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
				Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
			AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [cm]	d(natural) / d	n	Weighted Avg.	No. houses / km²
Tisza (HU)	Active FP	HU_UA_TI_AFP01	1015.5	8.2	3	-41		76	3.76	0.0
		HU_UA_TI_AFP02	1861.8	9.2	5	-60		76	3.42	0.0
		HU_TI_AFP01	8757.1	30.1	11	-71		76	3.89	1.1
		HU_UA_TI_AFP03	927.5	0.6	1	-34		40	3.46	0.4
		HU_SK_UA_TI_AFP01	4015.9	11.6	7	-41		57	3.90	2.3
		HU_TI_AFP02	578.9	0.1	1	-34		57	4.31	0.3
		HU_TI_AFP03/A	1958.9	1.7	3	-107		57	3.80	5.7
		HU_TI_AFP03/B	4368.0	5.5	11	-108				
		HU_TI_AFP04	1539.5	0.5	4	-103		40	4.56	0.3
		HU_TI_AFP05	4004.2	0.8	11	-129		118	4.32	0.9
		HU_TI_AFP06	10116.6	1.4	14	-139		108	4.98	0.2
		HU_TI_AFP07	2038.8	0.8	4	-85		108	4.98	0.0
		HU_TI_AFP08	5211.1	2.8	19	-77		54	4.56	0.1
		HU_TI_AFP09	3702.6	0.3	9	-65		53	4.36	9.6
		HU_TI_AFP10	7330.9	3.5	20	-75		53	3.87	0.8
		HU_TI_AFP11	5541.5	0.7	8	-67		100	3.88	2.2
		HU_TI_AFP12	718.4	0.4	5	-72		98	4.44	0.1
		HU_TI_AFP13	2882.1	1.2	8	-64		98	4.80	12.7
	Potential FP	HU_TI_PFP01	2089.3	11.9	2	-45		36	3.6	3.7
		HU_TI_PFP02	3944.7	5.4	3	-18		115	4.3	1.3
		HU_TI_PFP03	3107.4	3.5	3	-8		216	3.2	0.3
		HU_TI_PFP04	3618.1	6.5	12	-14		79	3.1	0.9
		HU_TI_PFP05	98.3	1.4	14	-70		53	4.2	9.0
		HU_TI_PFP06	196.2	1.2	3	-68		53	3.8	1.3
		HU_TI_PFP07	86.1	0.9	4	-78		100	3.8	0.0

Figure 103: Results of FEM Floodplain Evaluation of AFP and PFP of the Tisza river (HU) with the parameters values[5]

[5] *In case of Tisza River (Hungarian section) we have used different working method regarding the hydraulic parameters. We assumed a hypothetical loss of all floodplains along the Tisza and we used this scenario to calculate the water level change, which is a different approach as the other partners had. Modeling technically, the HU_TI_AFP03 floodplain had to be divided into two parts to determine the hydraulic / hydrological parameters.*

11.5. Tisa (RS)

Hydrological and hydraulic parameters were provided using HEC RAS model for the Tisa River in Serbia, created and calibrated by JCWI.

The Tisa river unsteady model is developed in HEC–RAS 5.0.7. Model includes the Tisa river from the confluence with the Danube River near Slankamen up to the border between Serbia and Hungary. The Novi Bečej dam was also integrated into the model. The upstream boundary condition of the model is unsteady flow hydrograph, while downstream boundary condition is specified in the form of a rating curve. The model of the Tisa river is incorporated in the model of the Danube river which includes the Serbian part of the Danube river with tributaries.

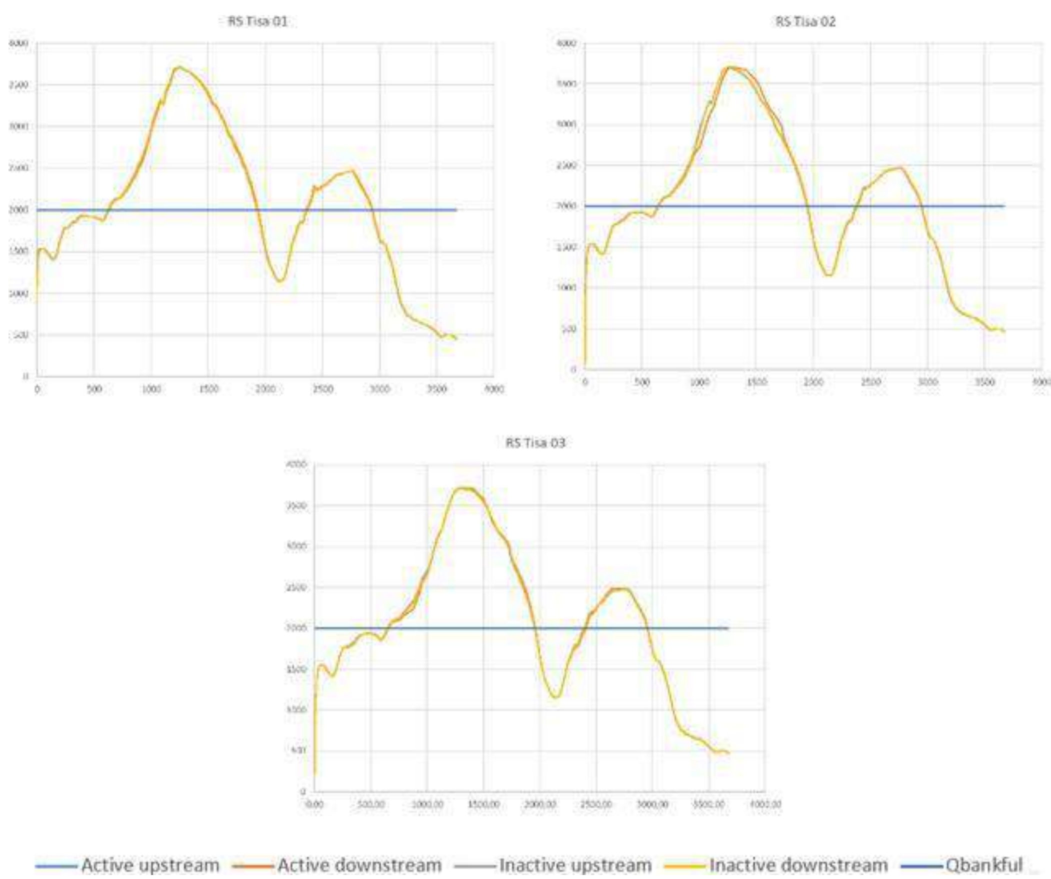


Figure 104: Hydrographs for the Tisa River FPs

A simplified method for the continuity assessment, taking into account only the lateral direction, is appliedfor the Tisa River, based on historical maps (3rd Military Mapping Survey of Austria-Hungary), locations of the flood defence structures (dikes) and expert judgment.

Serbia is not in the NATURA 2000 network and the respective number of protected species is not available.However, ecologically significant areas of the European Union NATURA 2000 will be identified and becomepart of the European ecological network NATURA 2000 on the day of accession of the Republic of Serbia to the European Union. Therefore, the information on the number of protected species is based on the national law and bylaw (Rulebook on the proclamation and protection of strictly protected and protectedwild species of plants, animals and fungi, OG no. 5/2010, 47/2011, 32/2016 and 98/2016).

The number of buildings is derived from the Serbian Geoportal (https://a3.geosrbija.rs/) that provides information on buildings and other structures from the digital cadastral plan as separate parts of plots. Itis important to emphasize that only information on the existence and not the legality of constructed buildings were considered.

The parameter Land use is assessed based on the Corine Land Cover (CLC)

			PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
		AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [m]	d(natural) / d	n	Weighted Avg.	No. houses / km²
TISA (RS)	RS_TI_AFP_01	2017	0,41	3	0,26		178	4,8	1,7
	RS_TI_AFP_02	3444	0,23	24,5	0,19		120	4,0	3,6
	RS_TI_AFP_03	2692	0	22	0,13		205	4,9	1,1

Figure 105: Results of FEM Floodplain Evaluation of AFP and PFP of the Tisa river (RS) with the parameters values

Serbia is not in the NATURA 2000 network and the respective number of protected species is not available.Ecologically significant areas of the European Union NATURA 2000 will be identified and become part of the European ecological network NATURA 2000 on the day of accession of the Republic of Serbia to the European Union (Law on Nature Protection, OG nr. 36/2009, 88/2010, 91/2010, 14/2016, 95/2018). For each FP a source of information is stated. In some cases information is based on an email received from the Institute for Nature Conservation of Serbia on June 24, 2019, while in other cases an assessed (unofficial) number of protected species by relevant experts is stated. Both statements were done in accordance with the Rulebook on the proclamation and protection of strictly protected and protected wild species of plants, animals and fungi, OG no. 5/2010, 47/2011, 32/2016 and 98/2016.

11.6. Morava

Floodplain evaluation was done following the methodology given above. The minimum as well as some ofthe medium set of parameters were evaluated for hydrology, hydraulics, ecology and socio-economics. Current status and the most optimistic scenario RS2 were compared.

To evaluate the effect of potential floodplains for hydrological and hydraulic parameters from the 1D numerical modelling, the retention area Polder Soutok was neglected, meaning that water was not released to the retention area at flood discharges as inflow objects were simulated to be closed. Therefore, water level reduction parameter shows rather high values (Δh up to 2,66 m) as the theoreticalcurrent state water levels are high without water released into the polder (Figure 44). On the other hand,peak reduction of ΔQ is rather low (less than 1% in most of the potential floodplains) (Figure 44).. Flood wave translation also got a final ranking mark 1 in two of the potential floodplains (RANKING TABLE IS MISSING). It has to be noted, that new restoration measures proposed a strongly meandering river channel which influences these parameters. At HQ100 overbank flow pattern across the meandering channel appears, as the water flows through the whole floodplain, the new channel as well as the originalchannel. The water level in the main channel will decrease as the water will spread into the floodplains on both sides of the river which will be 10 times wider than the current floodplains. FEM parameters werecalculated for each floodplain separately, while within 1D and 2D modelling the whole Morava pilot area was evaluated as a whole system, where it was proved by the output hydrographs that the peak dischargewill decrease at the downstream point (Moravský Sv. Ján) (WP4 results – Deliverable D 4.1.1). As a result,flood protection will not be endangered, but the restoration measures will improve ecological status of the pilot area.

In the past, Morava at the area of interest was a strongly meandering river. Historical maps from the 2nd Military Mapping (1806-1869) were used to identify natural (historic) water bodies on the floodplain andto compare former and present connectivity of water bodies. In the most optimistic RS2 scenario, reconnection of former meanders was proposed as part of the main channel – return to the original statewhich was altered by straightening of the river channel. Present channel is planned to be filled up in someparts, and in some parts it will play a role of a cut-off water body filled at Q >100 m^3/s.

Therefore, connectivity parameters were calculated for 2 hydrological scenarios: below and above 100 m^3/s. The whole Morava pilot area was cut-off from the former floodplains by flood protection dykes. Asthere is only one active floodplain at present status, only this one has been evaluated according to the methodology, having 57% of water body length in natural state (Figure 57). The potential floodplains witha proposed meandering channel are expected to have connectivity Ranking mark 5 (more than 80% of thewater body length in natural state).

			PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
		AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [m]	d(natural) / d	n	Weighted Avg.	No. houses / km^2
MORAVA	SK_MR_AFP_01	860,94	-0,42	-6	-1,79	57	187	4,69	0
	SK_MR_PFP_01	1483,8	-0,94	-9	-2,32	100	187	4,24	0
	SK_MR_PFP_02	289,94	> -1	-2	-2,66	81	59	4,25	0
	SK_MR_PFP_03	270,41	> -1	-1	-2,37	84	66	3,71	0
	SK_MR_PFP_04	411,88	> -1	-1	-2,34	83	62	3,82	0
	SK_MR_PFP_05	744,74	-3,52	-17	-1,92	84	62	4,59	0

Figure 106: Results of FEM Floodplain Evaluation of AFP and PFP of the Morava river with the parameters values

For the Socio-economic parameters, land use and potentially affected buildings were evaluated. For evaluation of Landuse FEM parameter, Corine land cover data set was used. In current AFP, broad-leavedforest is the most extensive land cover. Within PFPs, broad-leaved forest and arable land are mostly represented land cover category. PFPs 03 and 04 with higher percentage of arable land were ranked 3, and all other PFPs with higher percentage of forests were ranked 5.

As there are no villages within the pilot area, FEM parameter Potentially affected buildings was set to 5.

11.7. Sava (HR)

			PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
		AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [m]	d(natural) / d	n	Weighted Avg.	No. houses / km^2
SAVA (HR)	CRO_SA_AFP_01	89850	45,26	19,5	2,62		162	4,47	3,57
	CRO_SA_AFP_02	683,7	0,61	4	1,53		85	4,16	0,29
	CRO_SA_AFP_03	1545	0,51	2	0,16		85	4,83	0,45
	CRO_SA_AFP_04	1691,1	1,29	4	0,1		78	3,96	0,71
	CRO_SA_AFP_05	894	8,24	22	1		82	3,96	2,24
	CRO_SA_AFP_06	2193,7	23,35	0	0,51		82	4,81	0,36

Figure 107: Results of FEM Floodplain Evaluation of AFP and PFP of the Sava river (HR) with the parameters values

11.8. Sava (RS)

Hydrological and hydraulic parameters were provided using HEC RAS model for the Sava River obtained from the Sava Commission. The model includes the Sava River from the border between Slovenia and Croatia up to Belgrade, and the major tributaries up to the Sava River backwaters and more. The Sava HEC-RAS is coupled with the Sava HEC-HMS model which output locations match the (lateral) inflow pointsof the HEC-RAS model. Model is incorporated into the Sava Flood Forecasting and Warning System.

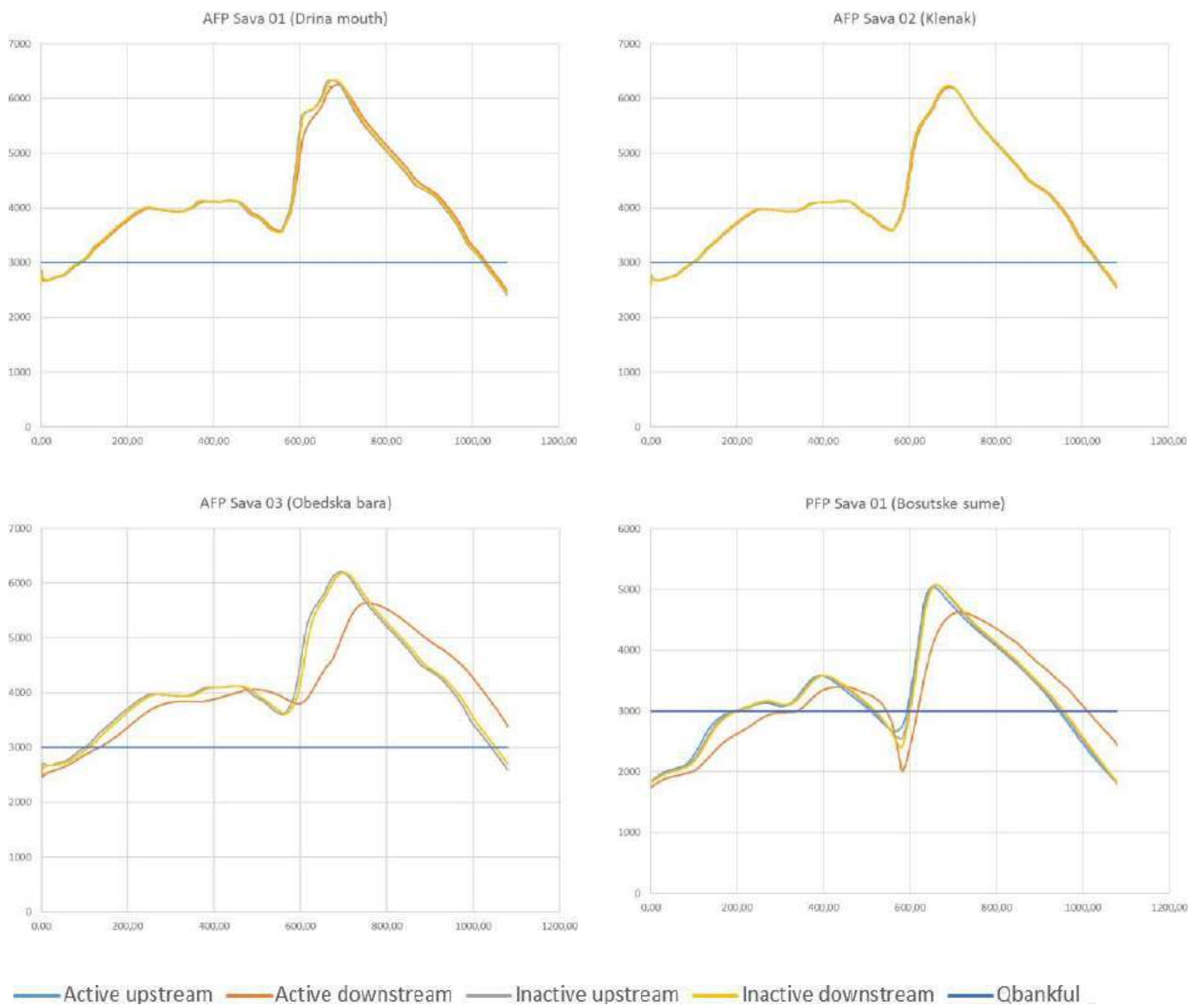


Figure 108: Hydrographs for the Sava River FPs

A simplified method for the continuity assessment, taking into account only the lateral direction, is appliedfor the Sava River, based on historical maps (3rd Military Mapping Survey of Austria-Hungary), locationsof the flood defence structures (dikes) and expert judgment.

Serbia is not in the NATURA 2000 network and the respective number of protected species is not available.However, ecologically significant areas of the European Union NATURA 2000 will be identified and becomepart of the European ecological network NATURA 2000 on the day of accession of the Republic of Serbia to the European Union. Therefore, the information on the number of protected species is based on the national law and bylaw (Rulebook on the proclamation and protection of strictly protected and protectedwild species of plants, animals and fungi, OG no. 5/2010, 47/2011, 32/2016 and 98/2016).

The number of buildings is derived from the Serbian Geoportal (https://a3.geosrbija.rs/) that provides information on buildings and other structures from the digital cadastral plan as separate parts of plots. Itis important to emphasize that only information on the existence and not the legality of constructed buildings were considered.

The parameter Land use is assessed based on the Corine Land Cover (CLC).

			PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	POTENTIALLY AFFECTED BUILDINGS
			Rel. value	Abs. value	Abs. value	Rel. value %	Abs. value	Abs. Value	Rel. value
		AREA [ha]	ΔQ / Q [%]	Δt [h]	Δh [m]	d(natural) / d	n	Weighted Avg.	No. houses / km²
SAVA (RS)	RS_SA_AFP_01	4387	2,3	6	0,57		120	4,4	0,0
	RS_SA_AFP_02	1728	0,7	2	0,16		105	4,9	3,0
	RS_SA_AFP_03	13887	17,1	54	1,58		136	4,8	0,5
	RS_SA_PFP_01	8526	19,7	59	0,95		225	5,0	0,0

Figure 109: Results of FEM Floodplain Evaluation of AFP and PFP of the Sava river (RS) with the parameters values

12. Final Ranking

The final ranking of the floodplains is based on the methodology proposed by the A 3.2 coordinator who presented their similar approach on the Danube river on the last two expert meetings in March in Banská Štiavnica and Bratislava. The methodology was commonly accepted by all PPs.

For fulfilling of the requirements of the overall ranking of **Active floodplains**, a method of a 2-step approach is used:

- **Step 1:** Identifying the need for preservation

  → If at least one parameter of the minimum set is evaluated with a 5 (high performance), than the floodplain **has to be preserved**.

  The analyses showed that every single AFP on each of 6 tributaries considered with FEM evaluationand applied thresholds, has at least one parameter evaluated with 5, therefore all of 49 floodplainshave a need for preservation.

- **Step 2:** Identifying the restoration priority of the Active floodplains

  → divided into 3 groups of:

  - **Lower demand → AFPs in this group have the lowest priority for restoration measures**
  - **Medium demand → AFPs in this group have a medium priority for restoration**

measures

- **Higher demand → AFPs in this group have the highest priority for restoration measures**

For each tributary a priority list with potential preservation degree was made. The FEM final values from the FEM Floodplain evaluation of the Active floodplains were categorized according to these criteria:

Lover demand

- 4 parameters (P) evaluated with 5 (blue), 1 P with 3 (green), 2 P with 1 (yellow); or
- 3 P evaluated with 5, 3 P with 3, 1 P with 1

Medium demand:

- 2 P evaluated with 5, 3 P with 3, 2 P with 1; or
- 3 P evaluated with 5, 1 P with 3, 3 P with 1

Higher demand:

- Every FP, where the sum of the values is < 21 (if all 7 parameters are evaluated).

According to the results, in some cases floodplain could be ranked into each of adjacent categories. Thanthe floodplain was ranked into the class with higher demand for restoration to avoid disregarding of the possible adverse circumstances on the specific floodplain. The following find the results of the FEM Floodplain evaluation and ranking.

12.1. Krka

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
KRKA	SI_KR_AFP_03	1524,2	5	5	5	5	5	5	3	LOW
	SI_KR_AFP_04	194,5	3	3	3	5	5	5	5	LOW
	SI_KR_AFP_01	113,8	1	3	1	5	5	5	1	MEDIUM
	SI_KR_AFP_02	177,7	3	3	1	5	5	5	1	MEDIUM
	SI_KR_AFP_05	145,5	1	3	3	5	5	5	1	MEDIUM

Figure 110: Results of FEM Floodplain Evaluation and ranking of AFP on the Krka river with the final FEM values

12.2. Yantra

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
YANTRA	BG_YN_AFP_001	568,0	5	1	1	5	3	5	5	LOW
	BG_YN_AFP_004	2.129,0	5	5	1	5	5	1	3	LOW
	BG_YN_AFP_007	458,0	5	5	5	5	3	3	3	LOW
	BG_YN_AFP_005	700,0	3	5	5	5	3	3	3	LOW
	BG_YN_AFP_008	112,0	1	3	5	5	1	3	5	MEDIUM
	BG_YN_AFP_009	24,0	1	1	5	5	1	5	3	MEDIUM
	BG_YN_AFP_002	141,0	1	1	5	5	1	3	3	HIGH
	BG_YN_AFP_003	238,0	1	1	5	5	1	3	3	HIGH
	BG_YN_AFP_006	64,0	1	1	5	5	1	5	1	HIGH

Figure 111: Results of FEM Floodplain Evaluation and ranking of AFP on the Yantra river with the final FEM values

12.3. Desnăţui

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
DESNATUI (RO)	RO_DE_AFP_01	684,9	3	3	5	3	3	3	1	HIGH
	RO_DE_AFP_02	198,4	1	1	5	3	1	3	1	HIGH
	RO_DE_AFP_03	605,2	1	3	5	3	1	3	5	HIGH
	RO_DE_AFP_04	732,1	1	5	5	3	1	3	1	HIGH

Figure 112: Results of FEM Floodplain Evaluation and ranking of AFP on the Desnațui river with the final FEM values

12.4. Tisza (HU) Tisza (HU)

	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	Restoration priority
Tisza (HU)	HU_UA_TI_AFP01	1015.5	5	3	3	1	5	3	5	Medium
	HU_UA_TI_AFP02	1861.8	5	3	5	1	5	3	5	Low
	HU_TI_AFP01	8757.1	5	5	5	3	5	3	3	Low
	HU_UA_TI_AFP03	927.5	1	1	3	1	3	3	5	High
	HU_SK_UA_TI_AFP01	4015.9	5	5	3	3	5	3	3	Low
	HU_TI_AFP02	578.9	1	1	3	3	5	5	5	Medium
	HU_TI_AFP03/A	1958.9	3	3	5	1	5	3	3	Medium
	HU_TI_AFP03/B	4368.0	5	5	5					
	HU_TI_AFP04	1539.5	1	3	5	1	3	5	5	Medium
	HU_TI_AFP05	4004.2	1	5	5	1	5	5	5	Low
	HU_TI_AFP06	10116.6	3	5	5	5	5	5	5	Low
	HU_TI_AFP07	2038.8	1	3	5	5	5	5	5	Low
	HU_TI_AFP08	5211.1	5	5	5	3	5	5	5	Low
	HU_TI_AFP09	3702.6	1	5	5	1	5	5	1	Medium
	HU_TI_AFP10	7330.9	5	5	5	1	5	3	5	Low
	HU_TI_AFP11	5541.5	1	5	5	5	5	3	3	Low
	HU_TI_AFP12	718.4	1	3	5	3	5	5	5	Low
	HU_TI_AFP13	2882.1	3	5	5	3	5	5	1	Low

Figure 113: Figure 66: Results of FEM Floodplain Evaluation and ranking of AFP on the Tisza river (HU) with the final FEM values

12.5. Tisa (RS)

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
TISA (RS)	RS_TI_AFP_01	2017	1	3	3	1	5	5	3	MEDIUM
	RS_TI_AFP_02	3444	1	5	3	1	5	5	3	MEDIUM
	RS_TI_AFP_03	2692	1	5	3	1	5	5	3	MEDIUM

Figure 114: Results of FEM Floodplain Evaluation and ranking of AFP on the Tisa river (RS) with the final FEM values

12.6. Morava

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
MORAVA	SK_MR_AFP_01	860,941	1	3	5	3	5	5	5	LOW

Figure 115: Figure 68: Results of FEM Floodplain Evaluation and ranking of AFP on the Morava river with the final FEM values

12.7. Sava (HR)

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
SAVA (HR)	CRO_SA_AFP_01	89850	5	5	5	3	5	5	3	LOW
	CRO_SA_AFP_02	683,7	1	3	5	1	5	5	5	LOW
	CRO_SA_AFP_05	894	5	5	5	1	5	3	3	LOW
	CRO_SA_AFP_06	2193,7	5	1	5	1	5	5	5	LOW
	CRO_SA_AFP_03	1545	1	3	3	1	5	5	5	MEDIUM
	CRO_SA_AFP_04	1691,1	3	3	1	1	5	3	5	MEDIUM

Figure 116: Results of FEM Floodplain Evaluation and ranking of AFP on the Sava (HR) river with the final FEM values

12.8. Sava (RS)

TRIBUTARY	FP	AREA [ha]	PEAK REDUCTION ΔQ	FLOOD WAVE TRANSLATION Δt	WATER LEVEL Δh	CONNECTIVITY OF FP WATER BODIES	EXISTENCE OF PROTECTED SPECIES	LAND USE	AFFECTED BUILDINGS	RESTORATION PRIORITY
SAVA (RS)	RS_SA_AFP_01	4387	5	5	5	1	5	5	5	LOW
	RS_SA_AFP_03	13887	5	5	5	5	5	5	5	LOW
	RS_SA_AFP_02	1728	1	3	3	3	5	5	3	MEDIUM

Figure 117: Results of FEM Floodplain Evaluation and ranking of AFP on the Sava river (RS) with the final FEM values

13. Analysis of the results

- 14 Active floodplains are ranked into Medium (Restoration priority), and 8 into High (Restorationpriority) category. These would have to be the first to be restored.
- Among 49 Active floodplains observed 27 are ranked into Low (Restoration priority) category.
- On 3 of 6 tributaries the AFP with High (Restoration priority) category can be found.
  - Tisza river (HU) has most of the identified AFP (18), one of them is in High (Restoration priority)category.
  - On Yantra river there are 3 (of 9) in this less promising category.
  - But, on Desnațui all 4 AFP are categorized with High Restoration priority.

- 8 AFP (16 % of all) on Tisza, Yantra and Desnațui are evaluated and ranked into High (Restoration priority) category, there some measures (in dependence of the national capacities) for the status improvement should be considered, especially on Desnațui river, where all four AFP are in this less favourable category. However, on the tributaries with the AFP ranked into Medium (Restoration priority) category, some effort and caution should be put into further management and monitoring ofthe conditions.

Deliverable 3.3.3 Recommendations for floodplain assessment on tributaries including the description of implemented methods and classification criteria.

Partners on the tributaries assessed the floodplains due to the commonly agreed methodology based onthe previous experiences on the national level, and due to the previous experiences of the partners fromthe Danube river basin. Several meetings and web conferences were needed to achieve a common agreement among the project partners about the data which should be considered, methodology, and overall approach. The differences between the partners stem from the fact that the tributaries, local and national circumstances and water management can quite differ from one participating country to another.

- As it was proven on the partners level, an efficient and sufficient communication between project partners on one side, and stakeholders from the area of the considered floodplains on the other side, proved to be essential for the positive outcome of the project. Through the preparation phase of theproject, that is the way to gain as much as possible opinions, remarks, and suggestions about the circumstances, open issues and obstacles on the local level, which can otherwise postpone or even prevent the implementation of the project and its measures for flood risk reduction, prevention of the habitats, and water protection.

- According to this preparation phase, the project can be properly prepared and implemented. Stakeholders should be constantly informed with the interim outcomes during whole process of the project to avoid misunderstandings and obstruction of the implementation.

- Even though the FEM method is quite new, it can be applicable and useful with relatively small effortto a wide spectre of users. So the initial, or several presentations of the method to the users and decision makers is not a waste of time. Even more – now, when we gain the results of this project, they can be used as an example of a good practice in water management and flood risk reduction.

- The approach of DFP can be applicable under various conditions and can satisfy wide spectrum of interests, needs and requirements, so don't hesitate to introduce it to the possible users, stakeholdersand decision makers. However, catchment, country or region specific conditions are to be taken intoaccount when defining parameter thresholds and criteria for ranking.

14. Recommendations for the pilot area

14.1. Krka (Floodplain Krakovski gozd – Kostanjevica na Krki)

Restoration measures in the Krakovo Forest (Krakovski gozd) must aim at facilitating the water flow fromthe Krka river bed itself into the floodplain, which basically means opening up certain meanders. There are three slight but perceivable depressions within the forest, which means that the measures for floodplain activation should also enable the floodwater to flow freely among them. Moreover, as the restoration measures also aim at improving the water levels during low flow periods within the forest itself, the measures must be designed in a way to prevent the forest from draining.

- Extending the floodplain;
- Reducing the extent of drainage systems;
- Opening up of certain meanders to facilitate water flow into the floodplain.

14.2. Desnatui (Floodplain Bistret on the Danube junction area)

- Construction of a recreational and fishfarming lake (200 ha) in the area of Rast.
- Relocation of the dikes in the confluent area of Desnaţui River with Bistret Lake.
- Creation of a large water drainage channel to supply Lake Bistret and to facilitate the natural flow of
  Desnaţui River back in the Danube.
- Additional dike reloca-tion from the Danube close to the villages along the alluvial terraces.

14.3. Tisza (HU)

Field of action	Measure Category	Type of measure
Prevention	Organizational measures (legislative, institutional ...)	The definition of a legislative, organizational and technical framework for Floods Directive implementation
		Reviewing and updating plans for flood risk management
		Coordination of territorial planning strategies (plans for development of planning at national, county and regional) and urban plans (Regional/Urban/Zonal/Plans) with plans for flood risk management
Protection	Natural water retention measures - associated to watercourses, wetlands, natural lakes, in accordance with Directive 2000/60 /EC	Measures to restore retention areas (creating wetlands, floodplain reconnection, renaturation etc.)

	Change or adapt land use practices (partial recovery of ecosystem functions or structures modified by changing or adapting land use practices) for forest management	Natural water retention measures by changing or adapting land use practices in forest management
	Other water retention measures	Other measures to reduce water levels; Structural and Non-Structural protection measures in connection with EU Flood Directive Risk management plan *
		Measures to improve retention capacity at the level of river basin by construction of polders and small retention reservoirs (made in the upper part of the river basin)
		Structural protection measures (planning and accomplishing)
Protection	Inspection measures and maintenance of watercourses and of the hydraulic flood defense infrastructure	Surveillance, behaviour monitoring, expertise, strengthening interventions, rehabilitation and maintenance of watercourses and hydraulic flood defence infrastructure
	Adapting of the existing defense structures at climate change conditions	Adapting of the construction, infrastructure and existing defence structures in terms of climate change

*(e.g. : Building a new dikes, relocation of the dikes, landuse change on the floodplain; changing vegetation, riverbed stabilizations, *removal of summer dams and small dike, established lateral retention basins etc.)*

14.4. Morava

- Removal of weirs.
- Removal or adjustment of selected barriers (weirs, sills).
- Removal of levees.
- Relocation of flood dykes (to include the cut off side-arms in the floodplain area).
- Relocation of flood dykes.
- Renewal of river pattern.
- Reconnection of oxbows with the main Morava channel.
- Deepening of existing oxbows.

14.5. Yantra

- Preservation of the existing natural floodplain vegetation and forests
- Creation of vegetation buffer strips
- Restoration of the riparian vegetation, afforestation
- Connection/reconnection of side arms, meanders, branches, channels or backwaters
- Removal of sediments / lowering of the floodplain

- Adoption of legislative regulations for floodplain management
- Land use change - replacement arable land with pastures
- Dike relocation
- Connection/reconnection of side arms, meanders, branches, channels or backwaters
- Construction of facilities for controlled flooding of selected areas
- Construction of new dikes – for protection of roads and infrastructure, adjacent to the floodplain

14.6. Sava and Tisa (RS)

Based on country-specific conditions and results of the Sava and Tisa floodplains ranking, a list of measuresis presented below:

The list of measures for either active or potential floodplains in

Serbia is presented below:Regulatory, institutional and other

measures

- By-law on restrictions and conditions for the use of floodplains
- Increasing the efficiency of the inspection service.
  - Landscaping and construction restrictions in floodplains

- Introducing the boundaries of real and potential flood hazard areas in spatial plans when defining therules of construction of facilities and use of flood areas
- Demarcation and introducing water estate boundaries in spatial plans
- Removal of illegally constructed facilities in floodplains
  - Maintenance of hydraulic structures and watercourses

- Monitoring and control of the state of inundation.

15. Conclusions

Although quite new, the methodology for the floodplains identification and evaluation has been proven on several occasions and projects in Danube river basin. Its most powerful characteristic – a wide applicability - is based on the fact that a wide range of scientists and engineers from different fields contributed their knowledge and experiences. The circumstances require a newer, wider approach to water and flood risk management, which would cover not only the fields of flood risk reduction, but also ecology, and socio-economics. Good transnational communication and coordination should besubstantiated to avoid partial approaches to the flood risk management.

Local communities possess a huge knowledge about the environment that they live in, so they should beincluded in the process of water management from the beginning. Beside all of information from the field, the historical data (e.g. historical maps, documents, etc.) should be considered to identify potential floodplains – all that to get a better picture of their position and extent. Namely, nowadays 2/3 of all floodplains in the Danube river basement are urbanized, and it has become harder to see where the floodplains used to be in the past.

For verification of the first findings from the field observation and of the historical sources, the implementation of additional tools and data is needed to prepare adequate working environment for thefollowing studies of former and active floodplains. A whole range of techniques and data sources are available nowadays (GIS, Lidar, DTM, Ortho-photo imagery, hydraulics and hydrology data, modelling tools, etc.) for the river water courses and floodplains analysis. At this point, support from the stakeholders is essential. The organization of meetings for the experts and public is very desirable to assure a wide support to this kind of water management and ecological projects.

Gained information are sorted to the specific groups of parameters of the Floodplain evaluation matrix (FEM), an efficient tool for the evaluation of the Active and Potential floodplains. There are four groups of parameters – Hydrology, Hydraulic, Ecology and Socio-Economics. A wide range of parameters are divided into three sets, Minimum, Medium, and Extended set. For the basic evaluation of the floodplainsat least the implementation of the Minimum set is needed. All other parameters can be a good support for better understanding of situation on the floodplains, and easier decision making.

The procedure of Final ranking of the floodplains follows the primary evaluation. With the final ranking the insight in to the overall conditions of the floodplains on particular water course is given. The information about the need of preservation and urgency of restoration is given. According to this information the decision makers (on the local and governmental level) can get a solid and adequate basisfor their further steps in direction of efficient water management with emphasis on flood risk lowering, and with respect to ecology and socio-economic process.

This document serves as a support for the next steps towards realizing floodplain projects both on Danubebasin wide level, and also on national level in order to implement successful integrative floodplain restoration and management in the Danube basin countries after the Danube Floodplain project.

Recommendations for evaluation of tributary floodplains are based on knowledge exchange among the project partners, and will be incorporated into outputs of WP5.

16. Summary of WP3 deliverables

The main objective of WP3 was review and update active and former floodplain areas including data collection and analyses of these data using GIS. The aim was to provide a spatial reference framework with accompanied database based on comprehensive inventory of floodplain areas and their multicriteria analysis along the Danube River and selected tributaries.

Deliverables of activities results potential and actual floodplain areas inventory and provide the main spatial reference base (geodatabase), where other hydrological, hydraulic and biophysical parameters are analysed. The geodatabase contains a list of associated existing measures identified from national and international FRMPs and RBMPs, which have the integrative positive effect on both – flood protection and ecological improvement. This data were used in order to define the main criteria for floodplains categorization using the Floodplain Evaluation Matrix (FEM). This multicriteria decision support system helps to determine, which floodplains are highly relevant for preservation and/or restoration concerning not only flood protection (hydrology/hydraulics) but also ecological and socio-economic reasons. The FEM approach was supported by a stakeholder ranking, which results in a priority list and proposal of potential preservation and restoration sites considering flood and ecological aspects and stakeholders interests. Floodplain assessment was processed also on selected tributaries.

The geodatabase (in line with DanubeGIS) contain spatial data of active and former floodplains based on flood hazard, environmental and socio-economical information. An important result is the definition of priority areas based on a ranking process that provide information for the development of DRB Strategic Guidance, DRB Floodplain restoration Roadmap and related measures. The output contribute to implementation of WFD, FD through PoM and FRMP win-win measures.

The output helps to improve transnational water management and flood risk prevention.

The results are addressed to Local public Authority, Higher Education and Research, Sectoral Agency, Interest Groups including NGOs and Regional public Authority.

The outputs will be used by national water management authorities and NGO's to better target and guide the preparation of river management plans, programmes of measures and restoration projects. The target groups, which have benefit from the existence of the DanubeGIS platform, either are mainly experts working directly with the ICPDR or in projects related to water management. The results could also be used by water authorities, protection and conservation agencies in order to select the most suitable areas with multiple effects for flood protection, as well as ecological and socio-economic development at the same time.

The DanubeGIS provides a Danube Basin-wide platform to support the ICPDR in its reporting tasks – such as the implementation of the EU Water Framework Directive (WFD) and of the EU Floods Directive (FD). Relevant project data will be publicly accessible through the DanubeGIS database. The spatial data will be compatible with a provided decision support system based on FEM or multi-criteria analysis in a way that potential end-users could use such a system in order to guide their planning activities and to improve the flood risk management and related water bodies ecological status. This approach will also ensure the transferability to practitioners of theoretical knowledge supported by data to its practical implementation.

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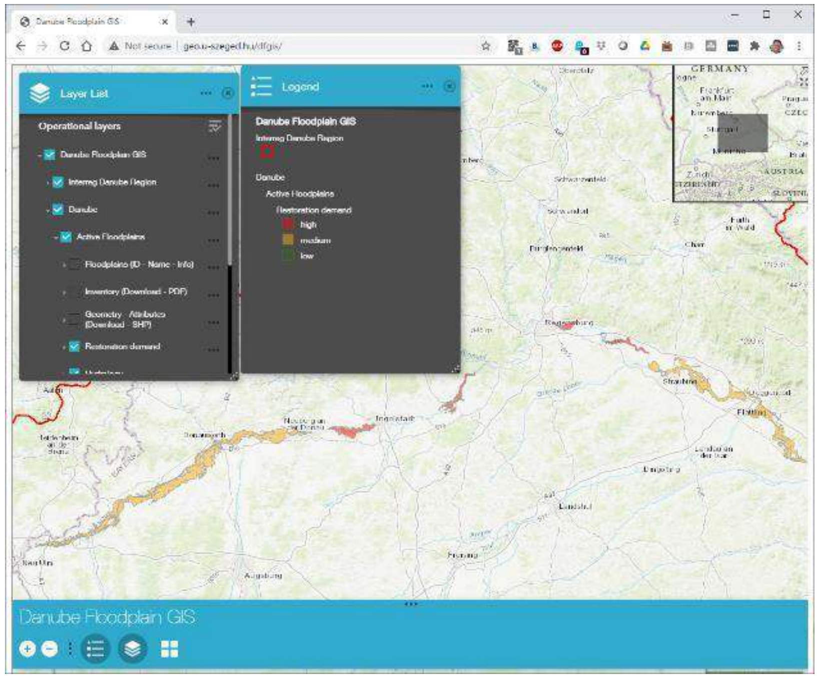
Habersack, Helmut, Bernhard Schober & Christoph Hauer. 2015. Floodplain evaluation matrix (FEM): An interdisciplinary method for evaluating river floodplains in the context of integrated flood risk management. Natural Hazards 75.1. 5–32. doi:10.1007/s11069-013-0842-4.

Annex

Maps published via Danube Floodplain GIS

For each country, a map is presented showing the Restoration demand parameter for the activefloodplains.



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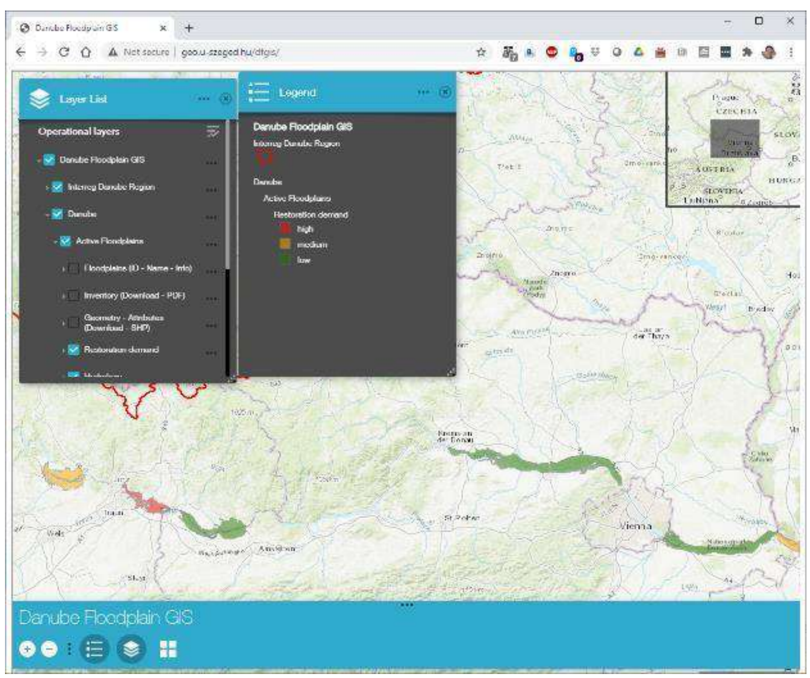

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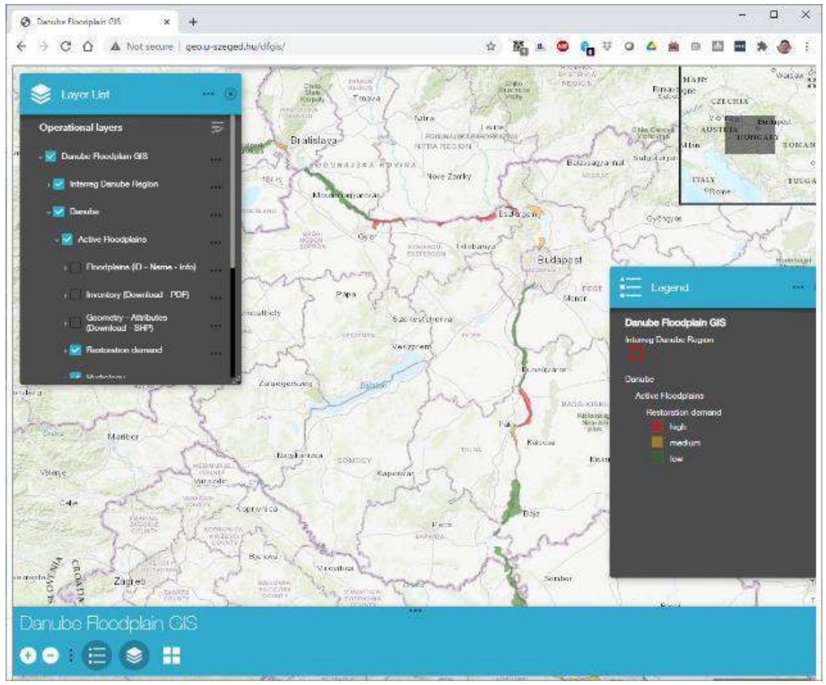
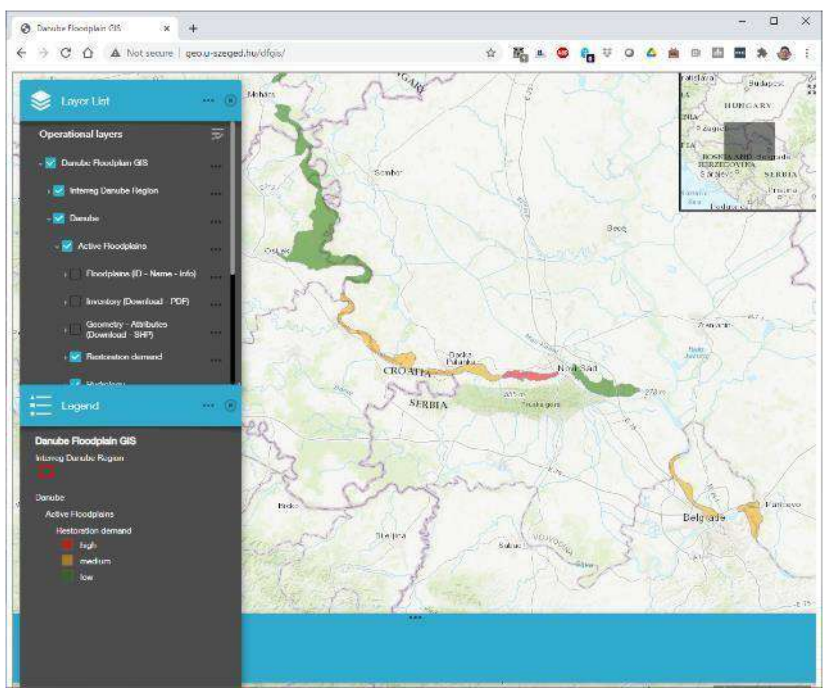
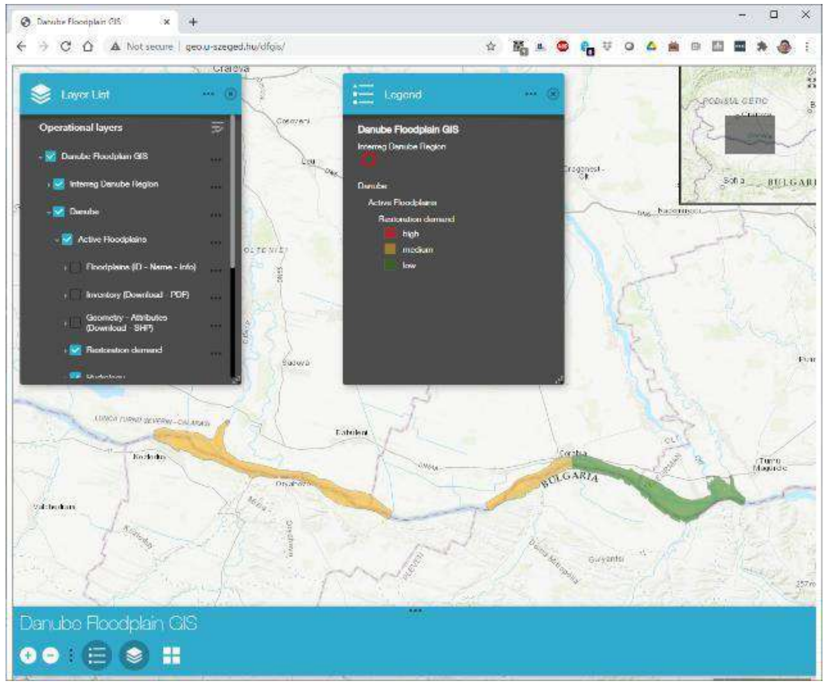


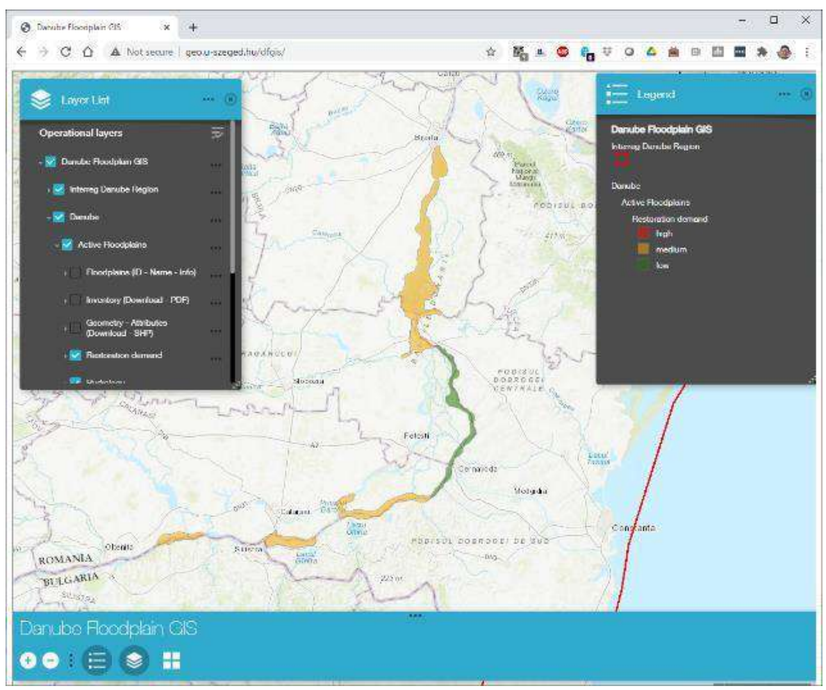
Hungary and Slovakia



Croatia and Serbia

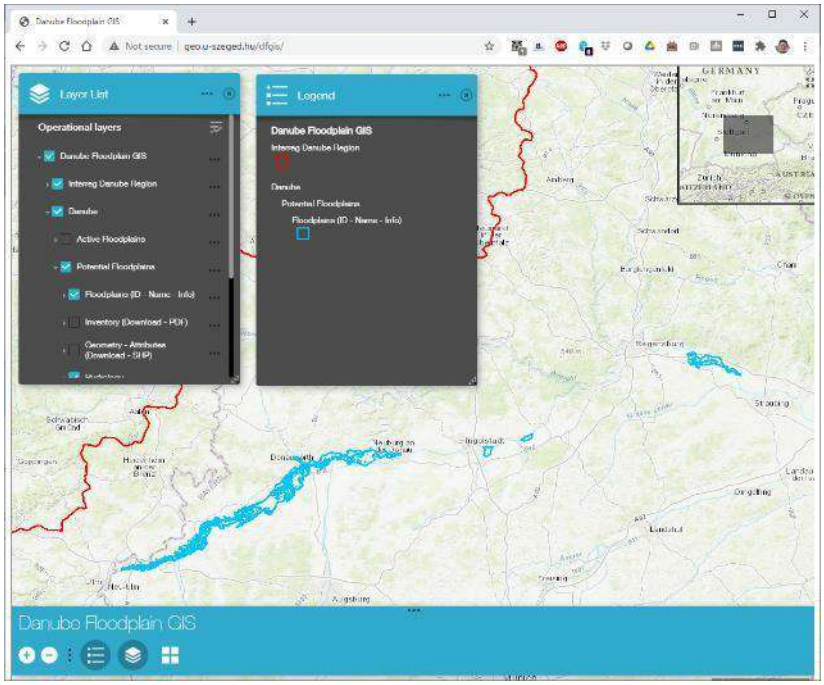


Bulgaria and Romania



Romania and Bulgaria

All Potential floodplains (at different scales):



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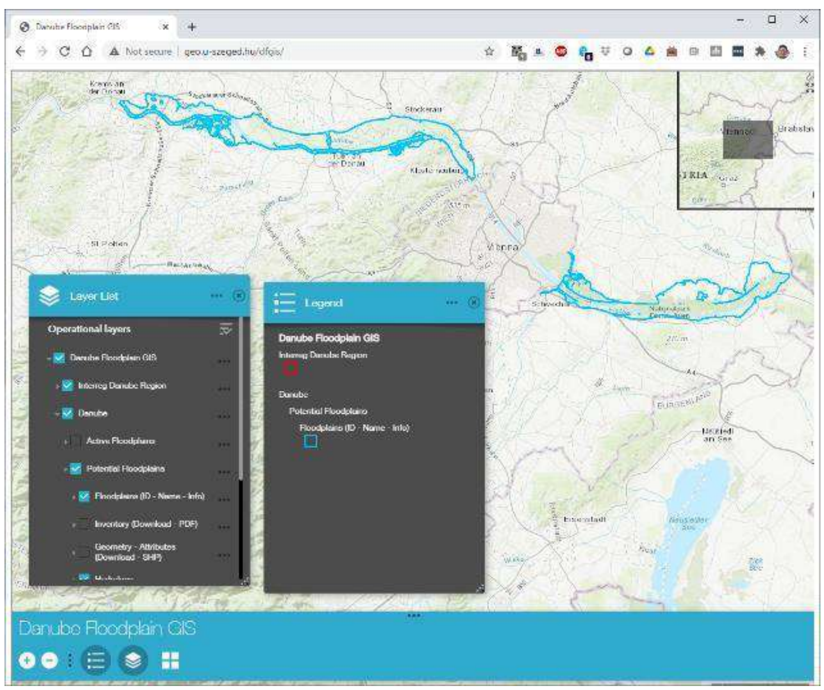

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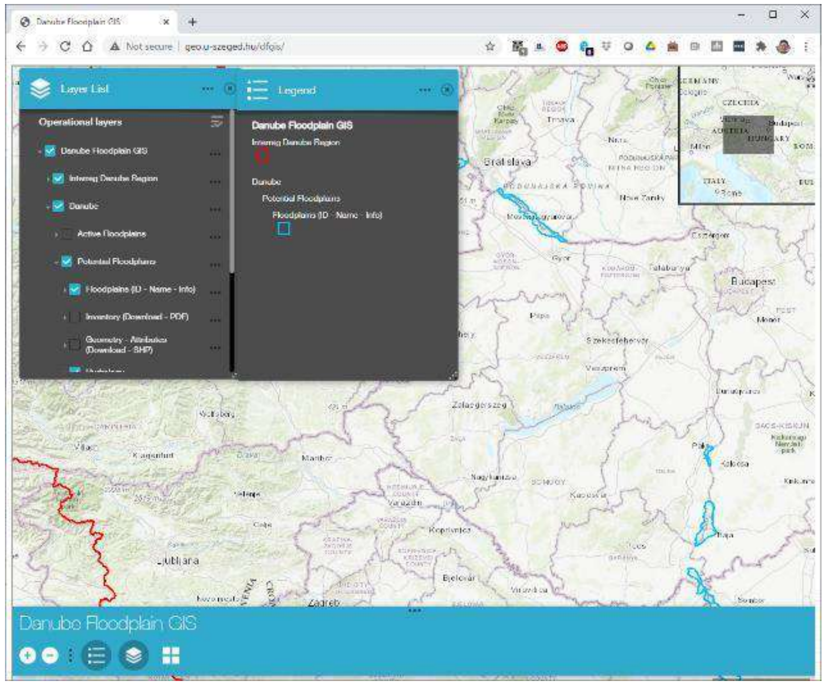

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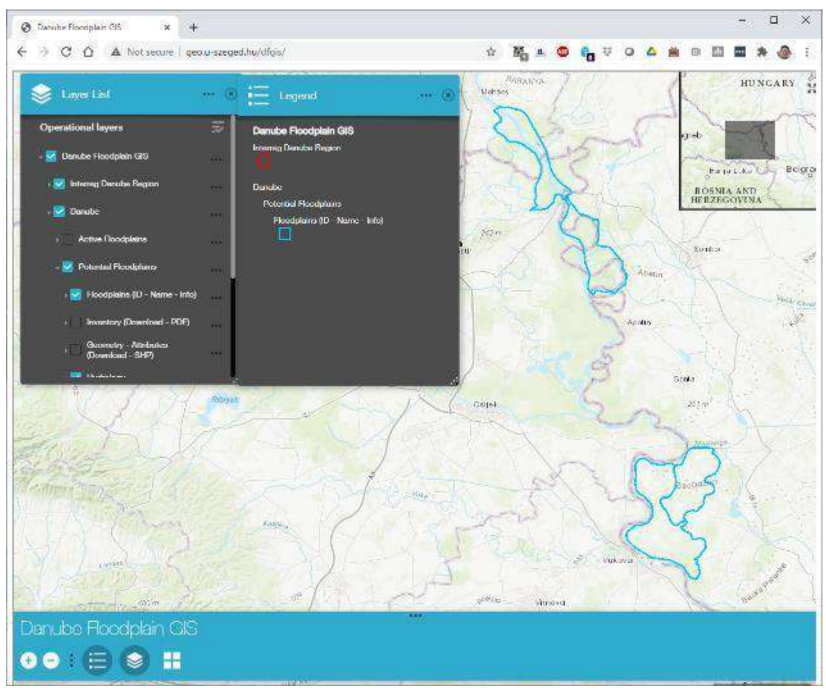
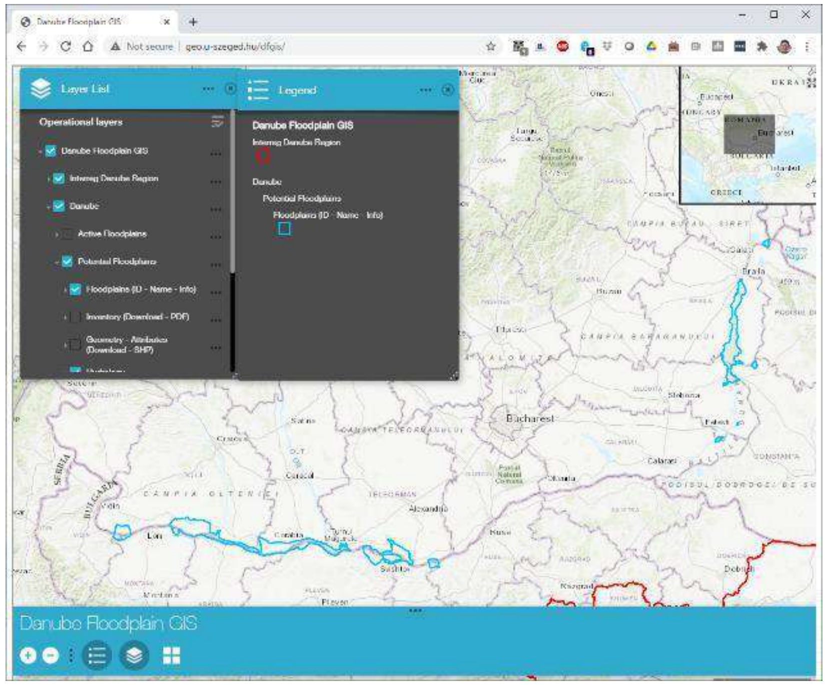
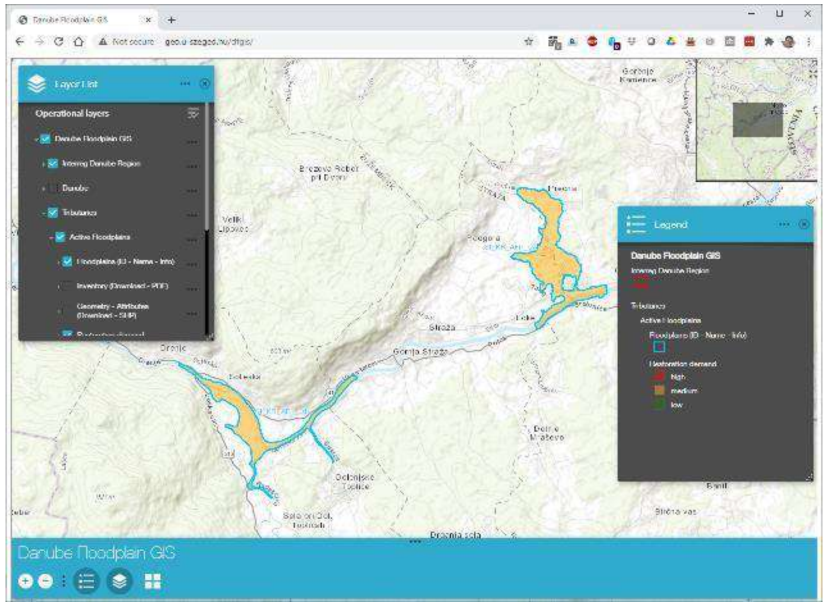


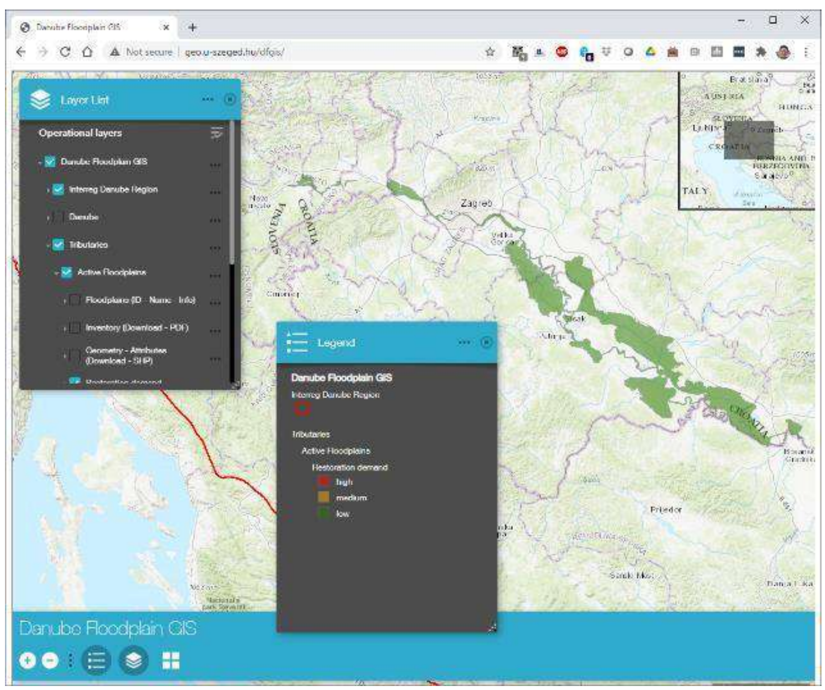
Hungary, Croatia and Serbia

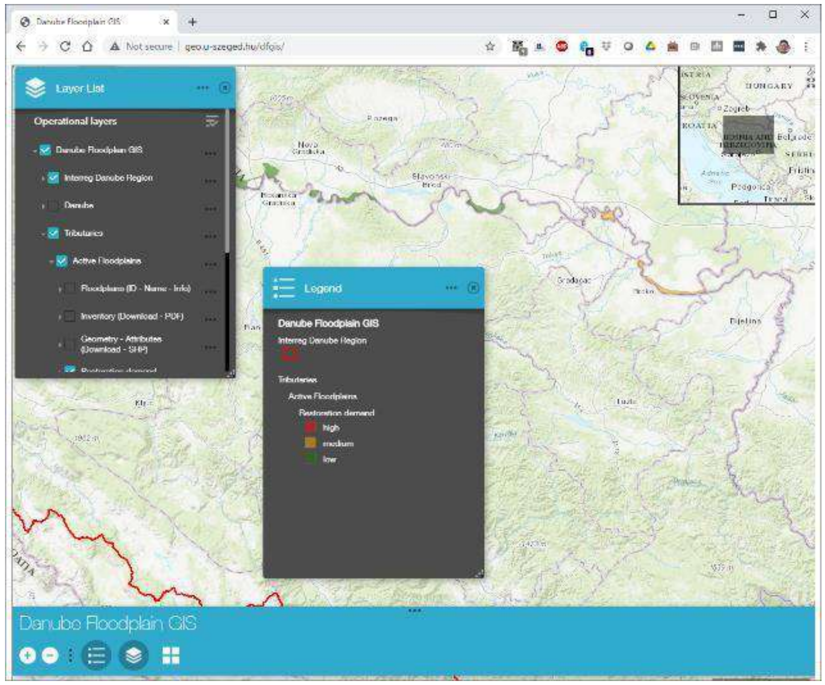
Bulgaria and Romania



Restoration demand parameter for the active floodplains along the tributaries (at different scales)

Krka 

Sava 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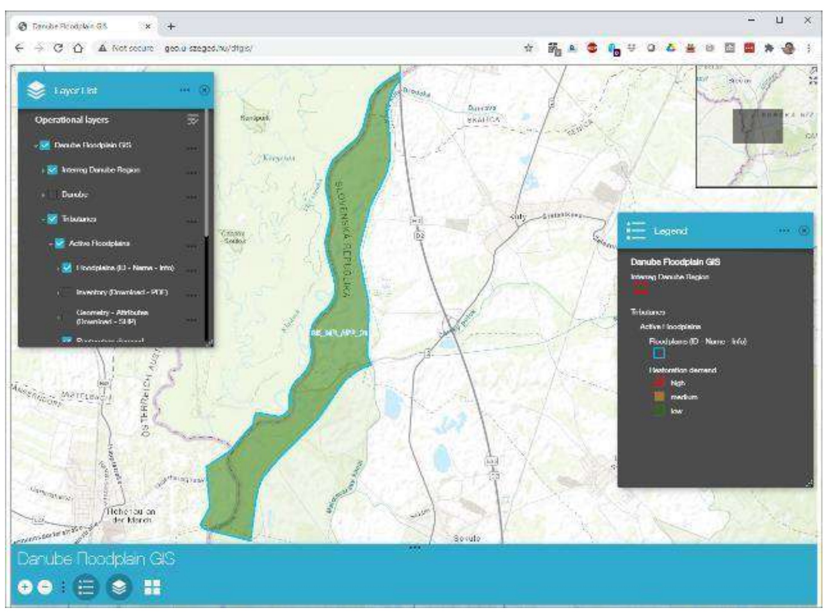
Operational layers
Legend
Danube Floodplain GIS
Interreg Danube Region
Tributaries
Active Floodplains
Restoration demand
high
medium
low
Danube Floodplain GIS

Sava


Layer List
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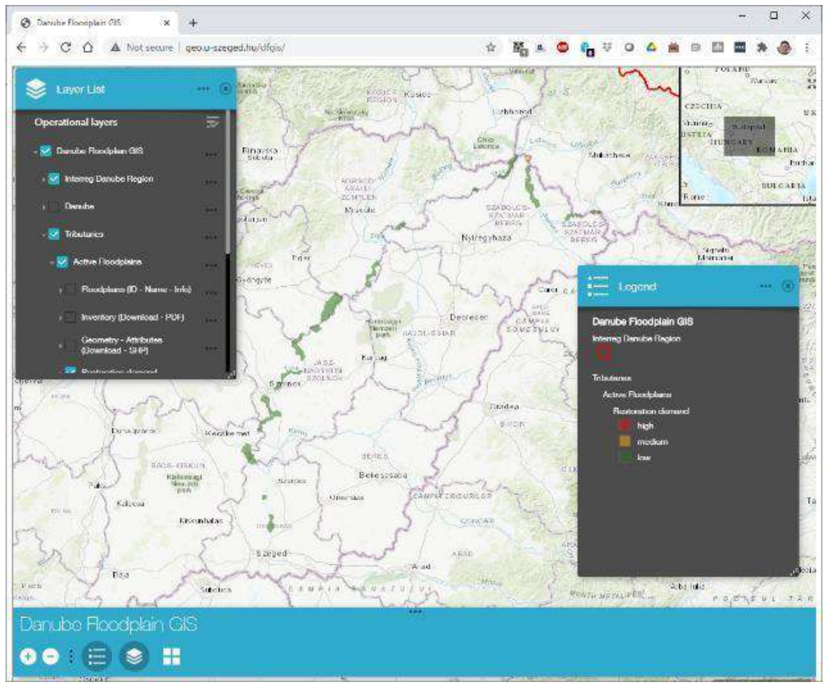
Danube Floodplain GIS
Danube Floodplain GIS

Morava



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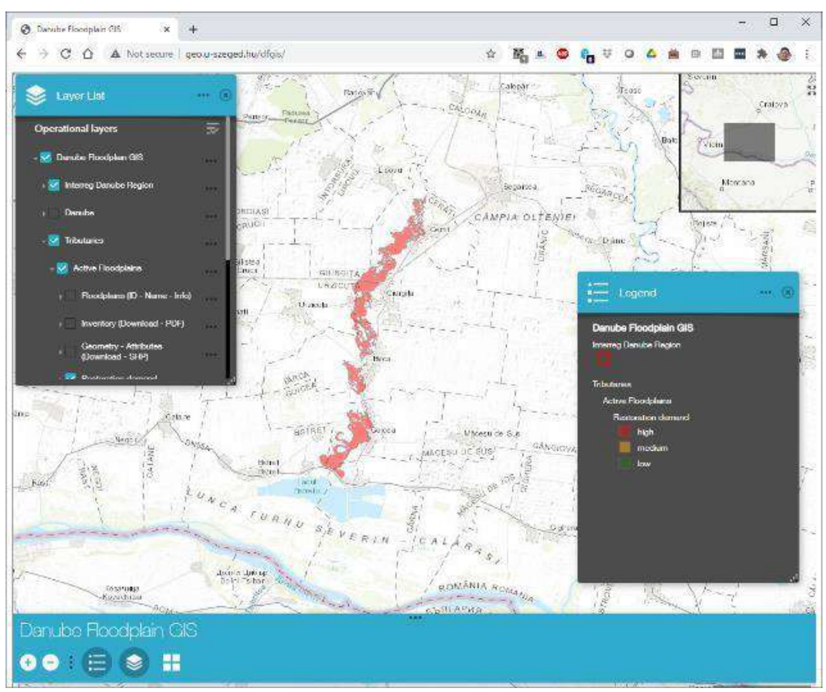
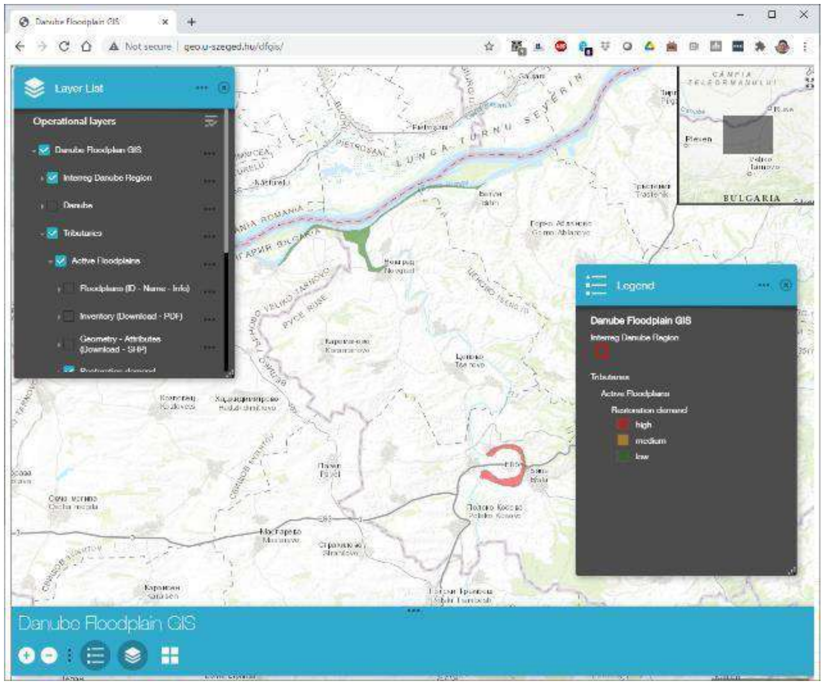
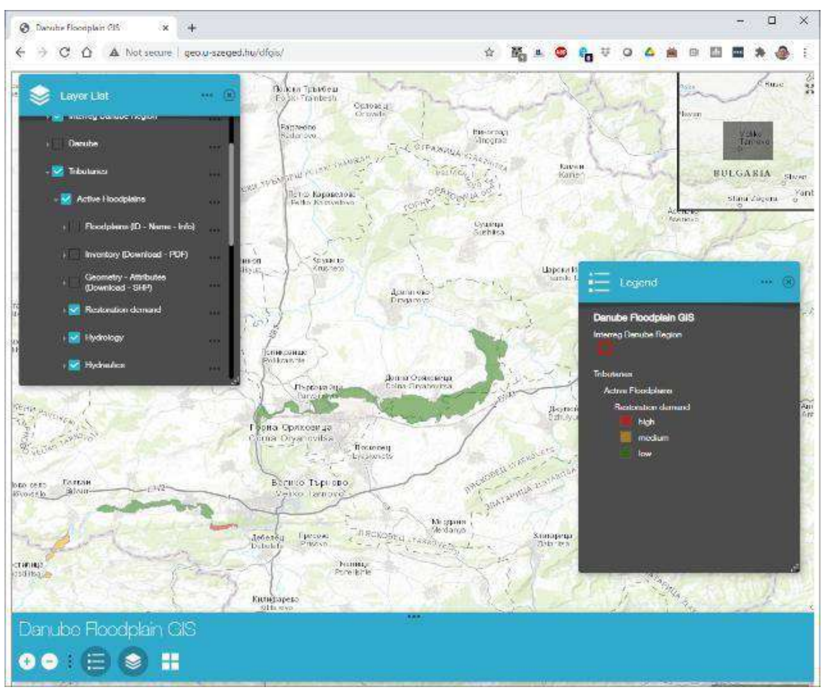


Desnatui



Yantra



Yantra

A FEM-Handbook - minimum set

Introduction

The Danube Floodplain project aims to improve transnational water management and flood risk prevention while maximizing benefits for biodiversity conservation. Preservation and/or restoration of floodplains play a key role in an integrated flood risk management. Therefore, it is important to identify the active and potential floodplains as well as an evaluation of their effects in terms of flood risk reduction, ecological benefits and socio-economic aspects.
This handbook is a guidance for all countries in the Danube River Basin that have to evaluate their floodplains with the Floodplain Evaluation Matrix (FEM). The handbook gives a detailed description of each FEM parameter from the minimum class, a workflow on how to calculate the parameter, some examples and the selected thresholds in the Danube Floodplain project. This minimum class of parameters were accepted by all project partners and have to be applied at selected active and potential floodplain that was identified in WP3.

1. Hydrology

1.1. Flood peak reduction – ΔQ

1.1.1 Description

The flood peak reduction considers the effect of a floodplain on the peak of a flood wave. In order to evaluate the peak reduction for a floodplain, the peak of an input hydrograph (e.g. HQ_{100}) at the beginning of the floodplain and the peak of the output hydrograph at the end of the floodplain will be determined. The difference between the peaks is the peak reduction ΔQ [m³/s] for the investigated floodplain. The retention effect of the river channel has to be considered as well. Therefore, the peak reduction ΔQ_{RC} of the river channel is calculated with a model, where the floodplains is disconnected from the river channel by disabling these areas or by implementing fictive dykes. For demonstrating only the effect of the floodplains on the peak reduction, it is necessary to subtract ΔQ_{RC} from the ΔQ, which was calculated before. For comparison of different river reaches a relative value is used. Therefore, the peak reduction is divided by the HQ_{100} for the whole river in the country and then multiplied by 100 to get the percentage (see formula [2]).

1.1.2 Source

For the determination of the peak reduction, results of unsteady hydrodynamic-numerical 2D-simulations are preferred, which should be calibrated and validated with recorded flood waves at different gauging stations. Using 1D-models is also possible. Other options to calculate the peak reduction would be observed flood waves at different gauging stations within the reach or engineering approaches. If engineering approaches are necessary due to lack of data, a separate handbook will be provided, where these approaches are explained.

1.1.3 Workflow

Step 1: Selecting hydrological input data
You can take the input hydrograph of the closest gauging station upstream of the floodplain from a recorded flood event close to HQ_{100} (e.g. 2006, 2010, 2013) and adjust it (e.g. Scale it to HQ_{100} peak value) or you can use hydrographs from existing hydrodynamic models that are HQ_{100}. If nothing is available, TUM can provide hydrographs from the SWIM model. You should at least use one hydrograph for each floodplain, if possible two (a steep and a flat one). If there are any tributaries within the delineated floodplain, unsteady and/or steady

hydrological input data will be used. In general, unsteady hydrological input data should be preferred for all tributaries. Especially for larger tributaries, unsteady flood waves should be used[3]. Concerning the hydrological input data of the tributaries, you have some options:
Concerning the hydrological input data of the tributaries there are two options. If you have input hydrographs from the real event for the Danube and the tributary and you use it at the Danube by scaling it to a HQ_{100}, then the tributary hydrograph should be scaled in the same rate (and not automatically to a HQ_{100}). If you have don't have hydrographs of this real event at the tributary, you can use a steady or unsteady HQ_{100} hydrograph as input. The documentation of the used flood waves/hydrological input data is very important. You have to provide us your used data.
For generating your final input hydrograph, which you are using for the determination of ΔQ, you have to add the discharge of all tributaries to your input hydrograph of the Danube, to make sure that the new final input hydrograph is larger than the calculated output hydrograph (Figure A 1).

Step 2: Calculating output hydrograph at end of floodplain and computing ΔQ_{tot}
You can use a 2D model or if not available, a 1D model to calculate the output hydrograph at a cross section at the end of the floodplain. If no model is available an engineering approach can be used. This would be for example the Gauckler-Manning-Strickler formula. If a 1D model is used the modeler should make sure that the floodplain flow characteristics are correctly modeled. In order to compute ΔQ_{tot} it is necessary to calculate the difference between the peak of the input and the output flood wave.

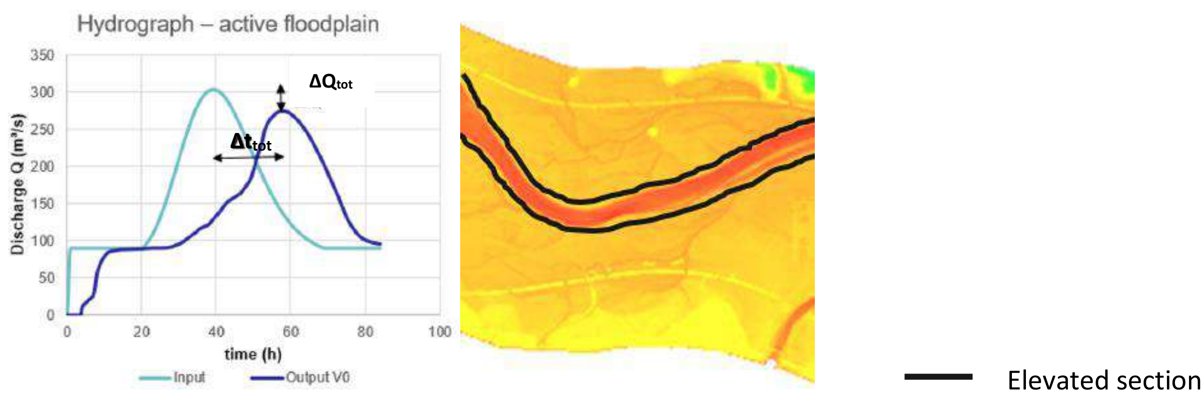
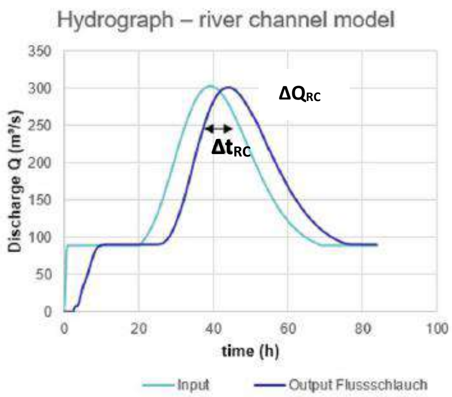


Figure A 1: FEM-parameter flood peak reduction ΔQtot for active floodplains

Step 3: Calculating ΔQ_{RC} of the river channel
To demonstrate only the effect of the floodplains on the peak reduction, it is necessary to run the model a second time with disconnected or disabled floodplains and foreland to calculate the retention effect of the river channel. For disconnecting the floodplains in the model, possible approaches are to deactivate the floodplain or to elevate a section next to the river. After running the simulation, the peak of the new generated output hydrograph has to be subtracted from the input hydrograph to determine ΔQ_{RC} (Figure A 2).

[3] If no data from gauging stations is available for the main tributaries, TUM could provide you flood waves from the SWIM model



$$\Delta Q = \Delta Q_{tot} - \Delta Q_{RC} [m^3 s^{-1}] \qquad [1]$$

Figure A 2: FEM-parameter flood peak reduction ΔQ_{RC} for the river channel

Step 4: Calculating ΔQ and ΔQ_{rel}

$$\Delta Q_{rel} = \frac{\Delta Q}{(Q_{max} - Q_{bankfull})} \times 100\ [\%] \qquad [2]$$

The first calculation of ΔQ_{tot} gives the retention effects of the floodplains as well of the river channel. ΔQ_{RC} shows only the effect of the river channel on the flood peak. Therefore, it is necessary to subtract ΔQ_{RC} from the ΔQ_{tot} for demonstrating only the effect of the floodplains on the peak reduction.

Additionally, the relative peak reduction ΔQ_{rel} [%] has to be calculated by dividing the ΔQ by the difference between Q_{max} and $Q_{bankfull}$ multiplied by 100 to make a comparison of different river reaches possible. The Q_{max} is the flood peak of the inflow wave and $Q_{bankfull}$ the discharge, where the river starts overtopping its bank.

Step 5: Plausibility check of calculated ΔQ

For checking the plausibility of the modelling results, it is necessary to compare the calculated ΔQ with an observed ΔQ_{obs} (Figure A 3), which was measured during a flood event close to the used hydrograph in the model in terms of return period and shape of the flood wave. For determining the observed ΔQ_{obs}, two measured hydrographs are used. The measured hydrograph from the closest gauging station at the beginning/or upstream and at end of the floodplain/or downstream are necessary to determine the observed ΔQ_{obs}.

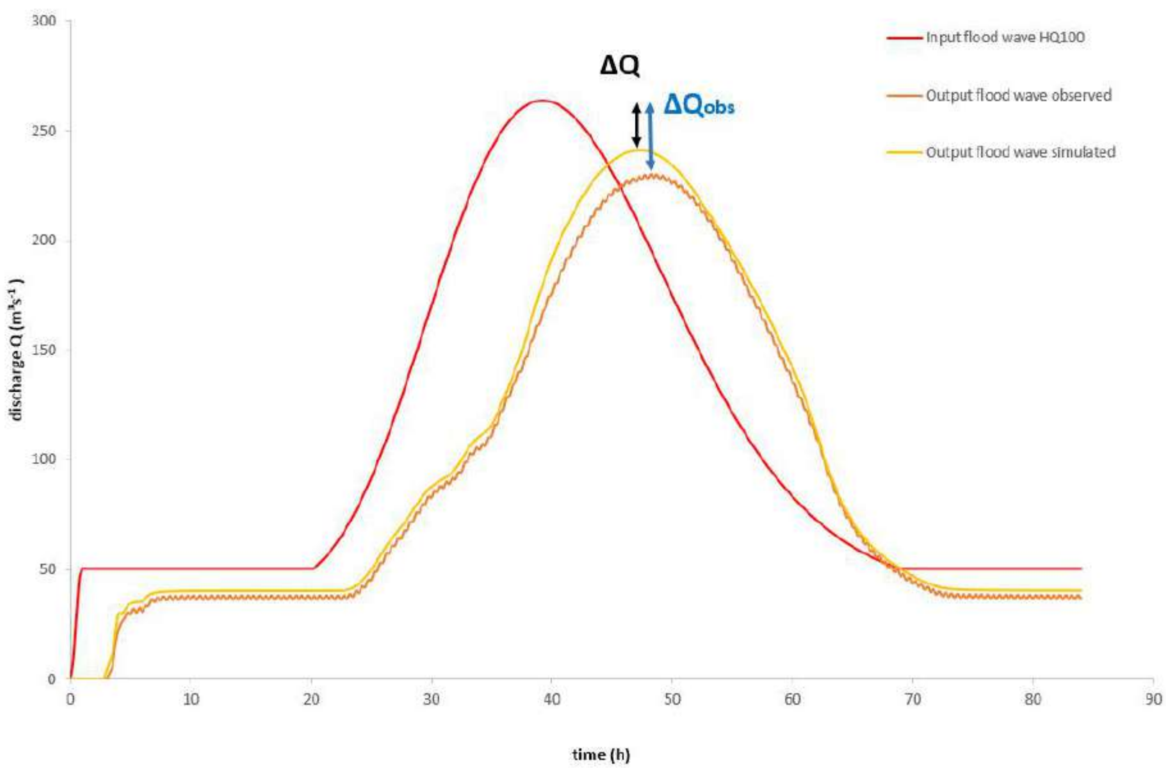


Figure A 3:Comparison of the observed ΔQobs with the calculated ΔQ with the help of the observed and simulated output hydrographs

Hydrological longitudinal section of a flood event, which shows the Q_{max} at all available gauging stations, can deliver also information about the observed ΔQ_{obs} (Figure A 4).

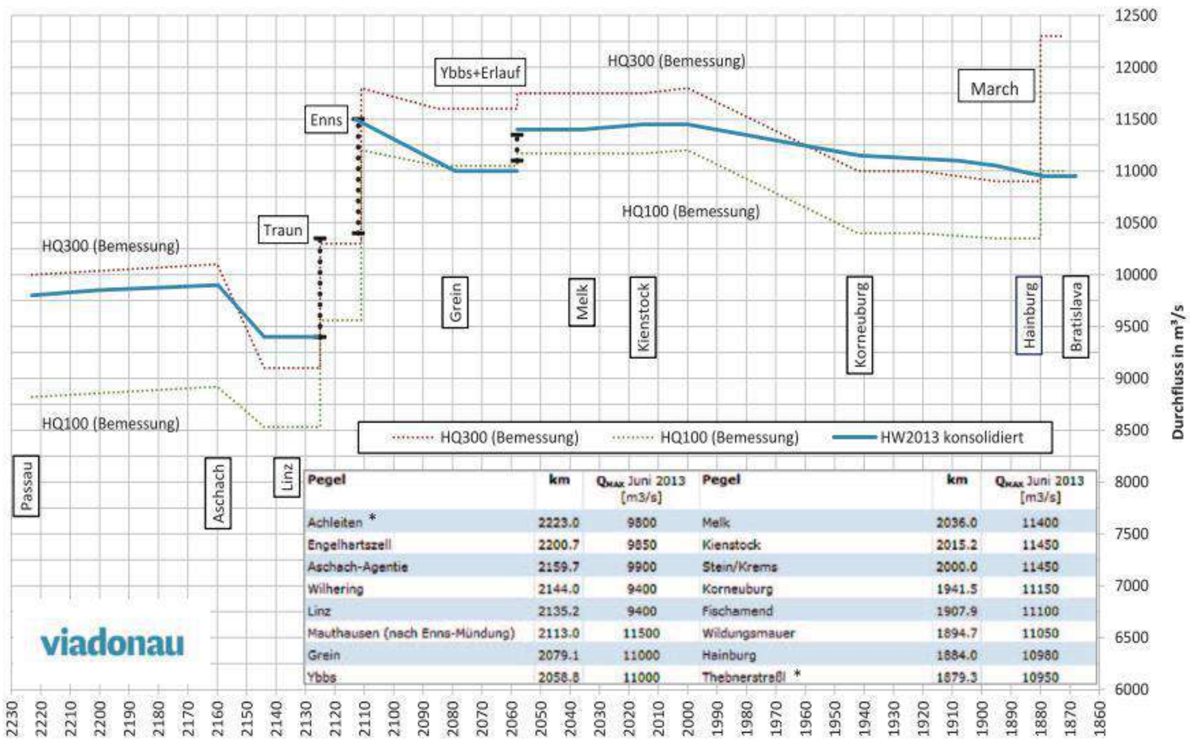


Figure A 4: Hydrological longitudinal section of the flood wave 2013 in Austria (source: Pörky energy GmbH)

Furthermore, if results for the ΔQ are available from 2D and 1D model, they have to be compared.

1.1.4 Example

Austria uses the recorded flood event from 2002 as a steep input hydrograph and the flood event from 1954 as a flat input hydrograph (Figure A 5). The available 2D model is then used to calculate the output hydrographs for both events. The ΔQ_{RC} of the river channel model is then subtracted.

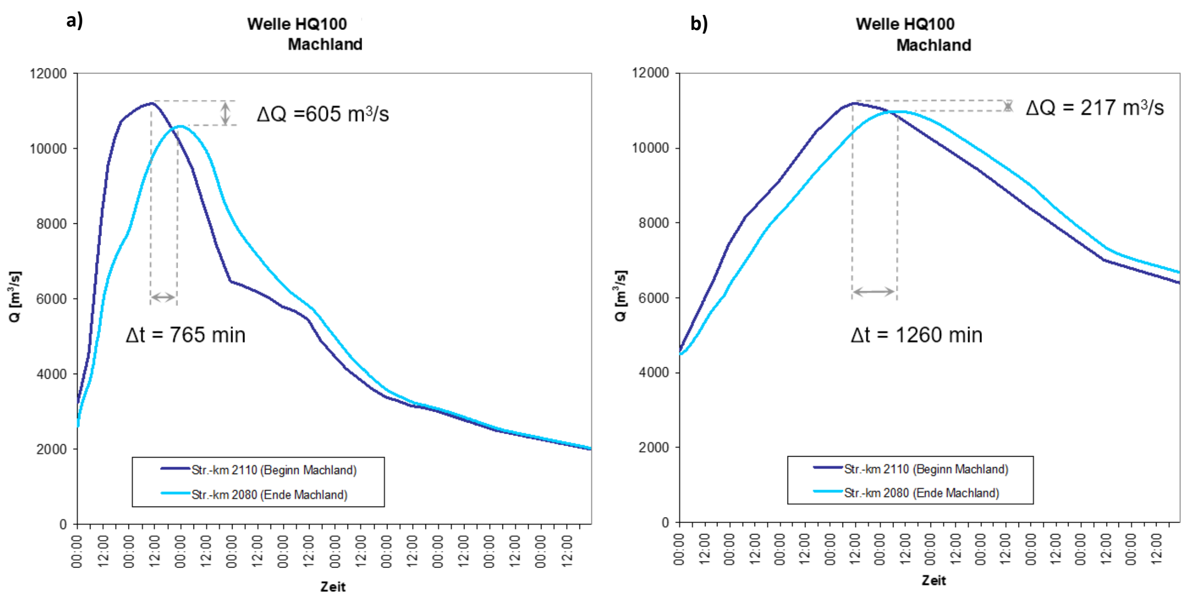
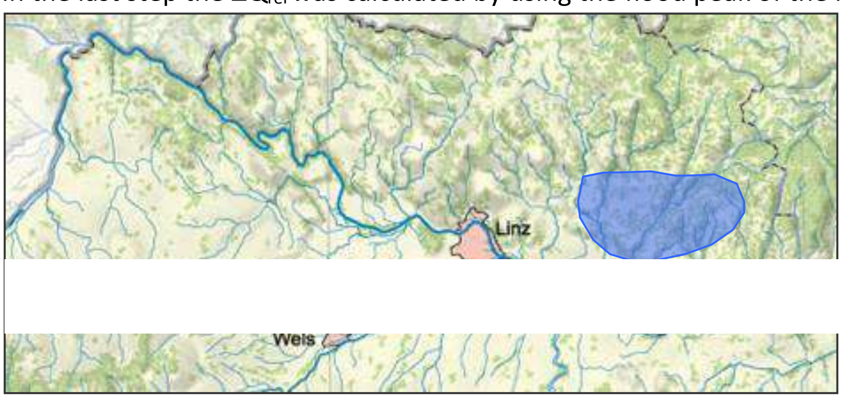


Figure A 5: Flood peak reduction - example Austria (Machland)

In the last step the ΔQ_{rel} was calculated by using the flood peak of the inflow wave (11.203 m³/s).



	Machland
ΔQ	605 m³/s
ΔQrel	5,4 %

Figure A 6: Flood peak reduction relative for a steep flood wave (2002) - example Austria (Machland)

1.1.5 Thresholds

In Table A 1, the thresholds are shown, which are used to determine the performance of the floodplain for the relative flood peak reduction. If the relative flood peak reduction (ΔQ_{rel}) is smaller than 1%, the performance of the floodplain is low. Between 1-2%, the performance is medium. All floodplains with a relative flood peak reduction above 2% perform high.

Table A 1: Thresholds to determine the performance of the relative flood peak reduction ΔQrel in the FEM-Evaluation

Thresholds ΔQrel	
1	< 1 %
3	1 - 2 %
5	> 2 %

1.2. Flood wave translation – Δt

1.2.1 Description

The flood wave translation is the second parameter required for the investigation of the process of wave attenuation due to a floodplain. This parameter is determined in a similar way as the peak reduction, namely by calculating the time difference Δt [h] between the occurrence of the output/input hydrograph peak. Therefore, you can use the same hydrographs, which were calculated for the peak reduction, but this time you determine the time when the peak of the flood waves occur and calculate the difference between them.

1.2.2 Source

For the determination of the flood wave translation, results of unsteady hydrodynamic-numerical 2D-simulations are preferred, which should be calibrated and validated with recorded flood waves at different gauging stations. Using 1D-models is also possible. Other options to calculate the flood wave translation would be observed flood waves at different gauging station within the reach or engineering approaches. If engineering approaches are necessary due to lack of data, a separate handbook will be provided, where these approaches are explained.

1.2.3 Workflow

Step 1: Using output hydrograph at end of floodplain and calculating Δt_{tot}

You can use the same output hydrograph for calculating the flood wave translation Δt_{tot} as for the modelling of the ΔQ (Figure A 7). It is recommended to model and calculate both parameter at the same time. In order to compute Δt_{tot}, it is necessary to determine the time when the peak of the flood waves (input/output) occur and calculate the difference between them.

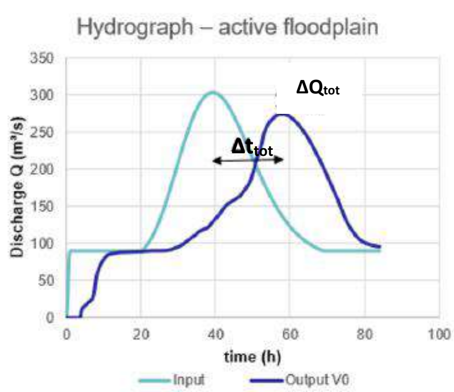


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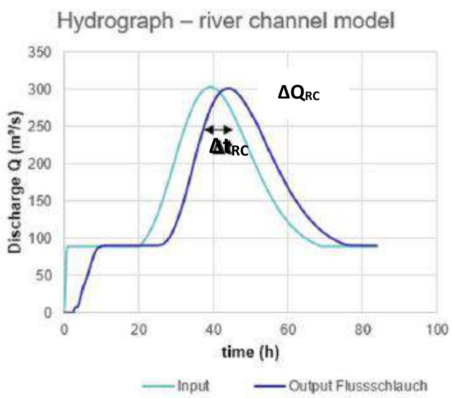
Figure A 7: FEM-parameter flood wave translation Δt_{tot} for active floodplains

Step 2: Calculating the Δt_{RC} for the river channel

You can use the output hydrograph from the modelling of ΔQ_{RC} for calculating the flood wave translation Δt_{RC} for the river channel. In order to compute Δt_{RC}, it is necessary to determine the time when the peak of the flood waves (input/output) occur and calculate the difference between them (Figure A 8).



$$\Delta t = \Delta t_{tot} - \Delta t_{RC}[h] \qquad [3]$$

Figure A 8: FEM-parameter flood wave translation Δt_{RC} for the river channel

Step 3: Calculating Δt

The first calculation of Δt_{tot} shows the effects of the floodplains as well of the river channel on the travel time of the flood wave. Δt_{RC} demonstrates only the effect of the river channel on the travel time. Therefore, it is necessary to subtract Δt_{RC} from the Δt_{tot} for demonstrating only the effect of the floodplains on the travel time.

Step 4: Plausibility check of calculated Δt

For checking the plausibility of the modelling results, it is necessary to compare the calculated Δt with an observed Δt_{obs}, which were measured during a flood event close to the used hydrograph in the model in terms of return period and shape of the flood wave. For determining the observed Δt_{obs}, two measured hydrographs are used. The measured hydrograph from the closest gauging station at the beginning and at end of the floodplain are necessary to determine the observed Δt_{obs} (Figure A 9).

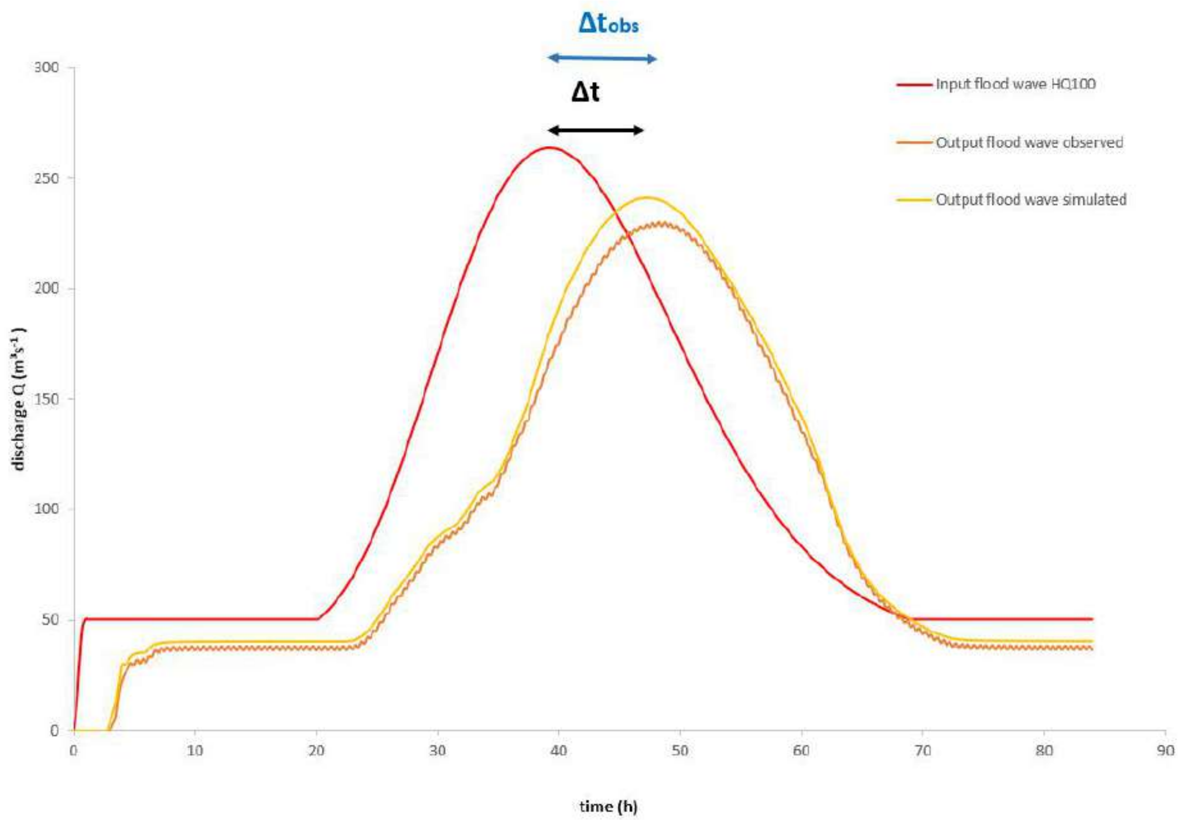


Figure A 9: Comparison of the observed Δt_{obs} with the calculated Δt with the help of the observed and simulated output hydrographs

Furthermore, if results for the Δt are available from 2D and 1D model, they have to be compared.

1.2.4 Example

Austria uses the recorded flood event from 2002 as a steep input hydrograph and the flood event from 1954 as a flat input hydrograph. The available 2D model is used to calculate the output hydrograph for both events. The Δt_{RC} of the river channel model is then subtracted (Figure A 10).

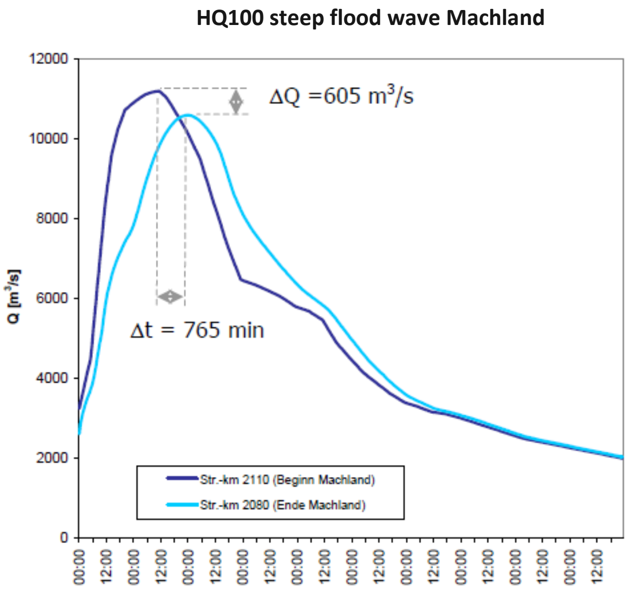


Figure A 10: Flood wave translation - example Austria (Machland)

determine the performance of the floodplain for the parameter flood wave translation. If the flood wave translation (Δt) is smaller than 1h, the performance of the floodplain is low. Between 1-5h, the performance is medium. All floodplains with a flood wave translation above 5h perform high.

Table A 2: Thresholds to determine the performance of the flood wave translation Δt in the FEM-Evaluation

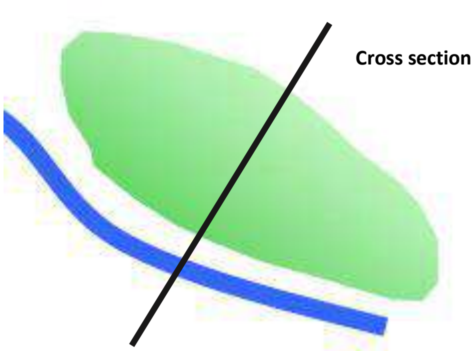
Thresholds Δt	
1	< 1 h
3	1 - 5 h
5	> 5 h

2. Hydraulics

2.1 Water level change – Δh

2.1.1 Description

A hydrodynamic-numerical model is used to determine the influence of changes in floodplain geometry (e.g. by dyke-shifting). Reducing or extending floodplain widths by modelling of fictive dykes exhibits how big changes in the water level surface of the scenarios (Δh) can be. The observed values can be calculated in a cross section at the middle or/and end of the floodplain or in the next settlement. In this project, we want to show the effects of a total loss of a floodplain on the water level. Therefore, we can use the model, which we were using for the calculation of ΔQ_{RC} and Δt_{RC} within this model we have disconnected the floodplains and foreland from the river channel by fictive dykes.



This parameter is also used for showing the effects on potential removal of dykes to reconnect potential floodplains. The removal of the dykes would mean changes of the geometry in the model, which would be necessary to show the effects on the water level.

2.1.2 Source

Comparison of the water surfaces of different scenarios using an unsteady hydrodynamic model (2D, 1D) or engineering approaches.

2.1.3 Workflow

Step 1: Calculating water level for a HQ_{100} with the active floodplain (h_{tot})

You can use the same hydrodynamic-numerical calculation, which is used to determine the hydrological parameters (ΔQ_{tot} and Δt_{tot}). At a defined cross-section (e.g. in the middle of the floodplain) you determine the calculated water level h_{tot} in the middle of the river channel.

Step 2: Calculating water level for a HQ_{100} without floodplain (h_{RC})

In the next step, you use the same hydrodynamic-numerical calculation, which was used to determine the hydrological parameters (ΔQ_{RC} and Δt_{RC}) and you determine the calculated water level (h_{RC}) on the same spot as in step 1.

Step 3: Calculating the Δh

$$\Delta h = h_{tot} - h_{RC} [m] \quad [5]$$

In the last step, you have to compute the Δh by subtracting the calculated water level without floodplains (h_{RC}) from the water level (h_{tot}) with active floodplain. The water level change Δh demonstrates the increase of the water level due to a loss of the floodplain.

2.1.4 Example

In Austria, the water level changes were calculated by shifting an existing dyke 50% closer to the river, 100% closer to the river and also one scenario where the dyke was moved away. The results showed an increase of the water level in the cross section in the middle of the floodplain of 112 cm (Figure A 11). In General, there has to be calculated only one scenario where the floodplain is disconnected completely (eg. by elevation of a section close to the river to simulate a dyke).

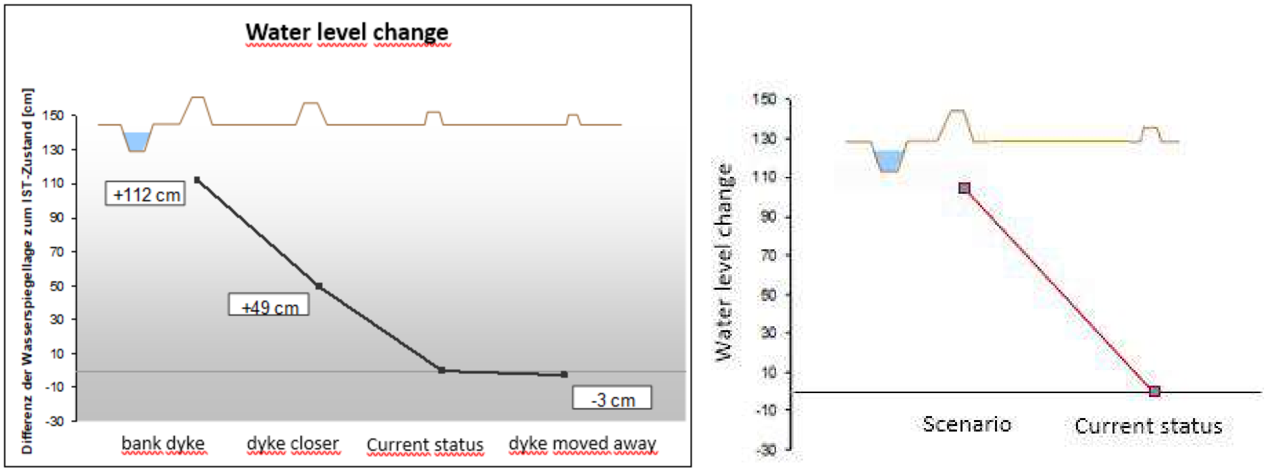


Figure A 11: water level change - example Austria (Machland)

2.1.5 Thresholds

In Table A 3, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter water level change. If the water level change (Δh) is smaller than 10 cm, the performance of the floodplain is low. Between 10-50 cm, the performance is medium. All floodplains with a water level change above 50 cm perform high.

Table A 3: Thresholds to determine the performance of the water level change Δh in the FEM-Evaluation

Thresholds Δh	
1	< 10 cm
3	10 - 50 cm
5	> 50 cm

3. Ecology

3.1 Connectivity of floodplain water bodies

3.1.1 Description

Connectivity is crucial for the functioning of riverine ecosystems. The longitudinal connectivity describes the connectivity in the up- and downstream direction and is especially relevant for the exchange of populations of water organisms and their migration during their life cycle, the lateral connectivity refers to the connection of the river channel and the floodplain and the vertical connectivity is the connection of the river channel and the ground water table in the floodplain (which might be crucial for small temporary water bodies in the floodplain). For simplification, the connectivity of floodplain water bodies will be investigated only in the lateral direction with the help of 3 Scenarios:

4. mean water level (from gauging stations)
5. bankfull flow (1D/2D modeling)
6. above bankfull flow

3.1.2 Source

Unsteady hydrodynamic-numerical 2D-/1D-model can be used.

3.1.3 Workflow

Step 1: Calculate 3 scenarios

The three scenarios (mean water flow, bankfull flow and above bankfull flow) have to be calculated with a 2D or a 1D model. If you use a 1D model, make sure, the flow behavior of the floodplain is correctly simulated.

Step 2: Determine connectivity

The 3 scenarios now help you to determine the connectivity of the water bodies (e.g. branches, oxbows) in the floodplain. You have to find out, at which discharge the water bodies are connected.

Step 3: Checking historic maps

For determination the "natural (historic)" status of water bodies on the floodplain historic maps have to be checked. There are 4 possible outcomes on the comparison between the current status and the historic status:

1. No "natural" (historic) water bodies on the floodplain
2. Existing water bodies on the floodplain (historic and current status)
3. On the historic maps "natural" (historic) water bodies existed, but at the active floodplain no water bodies are left, due to human activity (e.g. dykes etc.)
4. On historic maps "natural" (historic) water bodies existed and are still existing, but were cut off by a dyke

Step 4: FEM-Ranking*

If the river system is meandering, the connectivity is naturally beginning at bankfull discharge so, if this is given, it gets the best rating (5 points) in the FEM and no further steps are needed. For (historically) braided or anastomosing river types the best rating (5 points) is given when the side arms are already connected at discharges below mean water level. The detailed scenarios are listed below:

1. Water bodies connected up to mean water level / No "natural" (historic) water bodies on the floodplain / meandering river systems connected above bankfull discharge (5 points)
2. Water bodies connected at mean water level up to bankfull discharge (3 points)
3. Water bodies not connected above bankfull discharge / On the historic maps "natural" (historic) water bodies existed, but at the active floodplain no water bodies are left (1 point)

* If water bodies are cut off by a dyke but still existing on the floodplain, it will lead to a downgrade into the next FEM-class. E.g. Water bodies are connected up to mean flow –> 5 points, but by checking the historic maps it was discovered that the existing water bodies were cut off. This leads to a downgrade into the next class: 3 points

3.1.4 Thresholds

For the connectivity parameter, the method allows determining the performance without defined thresholds

3.2 Existence of protected species

3.2.1 Description

A floodplain is valuable and should be preserved if red list species or species and habitats (recognized by Natura2000, Emerald network or national legislation) are found on the area.

3.2.2 Source

In case of the European Union countries the Natura 2000 database can be used while countries where such information is not available (e.g., Serbia) can use the equivalent Emerald Network database or other relevant national sources.

3.2.3 Workflow

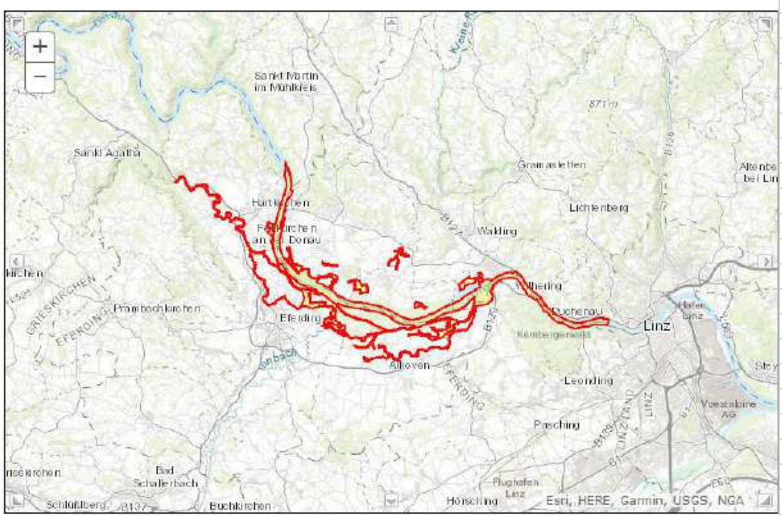
Step 1: Downloading Natura2000 or Emerald Network datasets
First of all you have to open the Natura 2000 viewer at http://natura2000.eea.europa.eu/. There you can go to the floodplain you focus on and select the datasets that are available there. One layer is for the EC Bird Directive and one layer is for the habitats Directive.
Emerald Network (https://emerald.eea.europa.eu/) states Species listed in Resolution 6[4] and site evaluation for them, as well as Other important species of flora and fauna.
Information from the national legislation (e.g., Studies on the Protection) can be also used.

Step 2: Counting number of protected species
The datasets can be downloaded as PDFs. There you can go to the chapter “Habitat types present on the site” and count all habitat types that occur at the floodplain. If available, you can open the second document for the birds and count all species that are listed in the chapter “Species referred to in Article 4 of Directive”

Step 3: Summarizing all protected species
In the final step, you have to add the two amounts of species/groups together, which gives you an overall number for the floodplain. This is the basis for the evaluation of this parameter

3.2.4 Example

Parts of the area of the Eferdinger Becken in Austria are protected by the Habitats Directive, but it is not a protected area according to the birds directive. The total amount of protected species in the Natura 2000 data is 20 (Figure A 12).



Eferdinger Becken			
Group	Code	Scientific Name	Type
F	1130	Aspius aspius	p
M	1308	Barbastella barbastellus	r
M	1337	Castor fiber	p
F	1163	Cottus gobio	p
I	1086	Cucujus cinnaberinus	p
F	2555	Gymnocephalus baloni	p
F	1157	Gymnocephalus schraetzer	p
M	1355	Lutra lutra	p
F	1145	Misgurnus fossilis	p
M	1321	Myotis emarginatus	r
I	1084	Osmoderma eremita	p
F	5339	Rhodeus amarus	p
F	6145	Romanogobio uranoscopus	p
F	5329	Romanogobio vladykovi	p
F	5345	Rutilus virgo	p
F	5197	Sabanejewia balcanica	p
A	1166	Triturus cristatus	p
I	1032	Unio crassus	p
F	1160	Zingel streber	p
F	1159	Zingel zingel	p
	Number:	20	

Figure A 12: Existence of protected species - example Austria (Eferdinger Becken)

[4] Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

3.2.5 Thresholds

In Table A 4, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter existence of protected species for the first step of the ranking process. If no protected species are existing on the floodplain, the performance of the floodplain is low. Between 1-20 species, the performance is medium. All floodplains were more than 20 species are protected, perform high.

Table A 4: Thresholds to determine the performance of the parameter existence of protected species in the FEM-Evaluation for the first step of the ranking process

Thresholds protected species	
1	no protected
3	1 - 20
5	> 20

In Table A 5, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter existence of protected species for the second step of the ranking process. If less than 40 protected species are existing on the floodplain, the performance of the floodplain is low. Between 40-101 species, the performance is medium. All floodplains were more than 101 species are protected, perform high.

Table A 5: Thresholds to determine the performance of the parameter existence of protected species in the FEM-Evaluation for the second step of the ranking process

Thresholds protected species	
1	< 40
3	40 - 101
5	> 101

In both steps different thresholds can be defined based on the national conditions.

4. Socio-Economics

4.1 Potentially affected buildings

4.1.1 Description

This parameter determines the number of buildings on each active floodplain. The more buildings are affected, the higher is the potential damage.

4.1.2 Source

Orthophotos, digital cadastral maps or land charge register can be used.

4.1.3 Workflow

Step 1: Collecting suitable data set(s)

The steps strongly depend on available data. If possible you should collect the information from digital cadastral maps or shape files including the buildings in the floodplain area. If this data is not available, you can also use the latest available orthophotos or even Google Earth.

Step 2: Counting affected buildings

If you upload your data into the GIS, you can easily see which buildings are inside the floodplain. It is also possible to let the GIS automatically count the number of shapes in the area. If you use orthophotos, it may be a bit difficult, but it is possible to count the affected buildings based on the manually created point shapefile. If a building is only partially in the floodplain area, it is counted as well.

Step 3: Dividing the number of buildings by the area of the floodplain
For comparing the results of this parameter, it is necessary to divide the number of the buildings by the area of the floodplain.

4.1.4 Example

For Austria, we counted the number of buildings by using a GIS layer that included all buildings as polygon shapes (Figure A 13). The Eferdinger Becken is 53.16 km² large and there are 1044 buildings on the floodplain. After dividing the amount by the area, it gives 19.63 buildings/km².

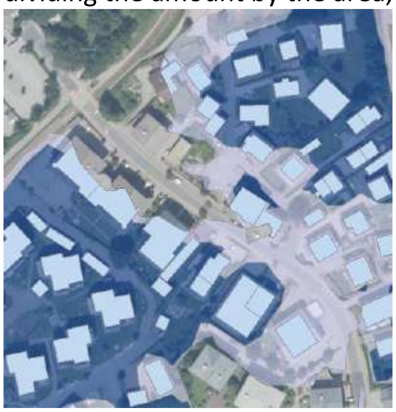


Figure A 13: potentially affected buildings - example Austria (Feldbach)

4.1.5 Thresholds

In Table A 6, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter potentially affected buildings. If more than 5 buildings per km² are on the floodplain, the performance of the floodplain is low. Between 1 and 5 buildings per km² the performance is medium. All floodplains with less than 1 building per km², perform high in the FEM-evaluation.

Table A 6: Thresholds to determine the performance of the parameter potentially affected buildings in the FEM-Evaluation

Thresholds affected buildings	
1	> 5 [n/km²]
3	1 - 5 [n/km²]
5	< 1 [n/km²]

4.2 Land use

4.2.1 Description

Land use that is adapted to future inundation will minimize the socio-economical vulnerability of the floodplain. Therefore, flood-adapted land use (=low vulnerability) gets the highest rating, non-adapted the lowest (settlements=high vulnerability). The different types of land uses are aggregated proportional to their areas to one evaluation value for the whole floodplain.

4.2.2 Source

CORINE land cover dataset should be used and checked with aerial photos.

4.2.3 Workflow

Step 1: Downloading and prepare CORINE land cover dataset
The dataset can be downloaded from the Copernicus database https://land.copernicus.eu/pan-european/corine-land-cover/clc2018 and loaded into a GIS. Then it has to be edited with the help of the floodplain polygon shape to cut the boundaries according to the floodplain. Additionally, it should be checked if the land cover classes are matching with the latest aerial photos of the area.

Step 2: GIS-analysis of the floodplain CLC data set (CLC)
With the GIS analysis tool (e.g. ArcGIS zonal statistics) it is possible to get an output table with all land cover classes of the data set and the corresponding area of the floodplain. This table will later be expanded with the evaluation value for each class.

Step 3: Determining the vulnerability of the floodplain based on the land use
Each land use class was assigned to one of three groups based on the vulnerability against flooding (Table A 7). E.g. land uses like urban fabric or industrial units have a high vulnerability (=low performance (1) – in the FEM-evaluation).

Table A 7: Land use types of the Corine Land Cover data set with corresponding FEM-evaluation (1=low, 3=medium, 5=high performance) based on the vulnerability against flooding

CLC_CO	LABEL2	LABEL3	FEM-evaluation	RGB
111	Urban fabric	Continuous urban fabric	1	230-000-077
112	Urban fabric	Discontinuous urban fabric	1	255-000-000
121	Industrial, commercial and transport units	Industrial or commercial units	1	204-077-242
122	Industrial, commercial and transport units	Road and rail networks and associated land	1	204-000-000
123	Industrial, commercial and transport units	Port areas	1	230-204-204
124	Industrial, commercial and transport units	Airports	1	230-204-230
131	Mine, dump and construction sites	Mineral extraction sites	1	166-000-204
132	Mine, dump and construction sites	Dump sites	1	166-077-000
133	Mine, dump and construction sites	Construction sites	1	255-077-255
141	Artificial, non-agricultural vegetated areas	Green urban areas	1	255-166-255
142	Artificial, non-agricultural vegetated areas	Sport and leisure facilities	1	255-230-255
211	Arable land	Non-irrigated arable land	3	255-255-168
212	Arable land	Permanently irrigated land	3	255-255-000
213	Arable land	Rice fields	3	230-230-000
221	Permanent crops	Vineyards	3	230-128-000
222	Permanent crops	Fruit trees and berry plantations	3	242-166-077
223	Permanent crops	Olive groves	3	230-166-000
231	Pastures	Pastures	3	230-230-077
241	Heterogeneous agricultural areas	Annual crops associated with permanent crops	3	255-230-166
242	Heterogeneous agricultural areas	Complex cultivation patterns	3	255-230-077
243	Heterogeneous agricultural areas	Land principally occupied by agriculture, with significant areas of natu	3	230-204-077
244	Heterogeneous agricultural areas	Agro-forestry areas	3	242-204-166
311	Forests	Broad-leaved forest	5	128-255-000
312	Forests	Coniferous forest	5	000-166-000
313	Forests	Mixed forest	5	077-255-000
321	Scrub and/or herbaceous vegetation asso	Natural grasslands	5	204-242-077
322	Scrub and/or herbaceous vegetation asso	Moors and heathland	5	166-255-128
323	Scrub and/or herbaceous vegetation asso	Sclerophyllous vegetation	5	166-230-077
324	Scrub and/or herbaceous vegetation asso	Transitional woodland-shrub	5	166-242-000
331	Open spaces with little or no vegetation	Beaches, dunes, sands	3	230-230-230
332	Open spaces with little or no vegetation	Bare rocks	5	204-204-204
333	Open spaces with little or no vegetation	Sparsely vegetated areas	5	204-255-204
334	Open spaces with little or no vegetation	Burnt areas	3	000-000-000
335	Open spaces with little or no vegetation	Glaciers and perpetual snow	not relevant	166-230-204
411	Inland wetlands	Inland marshes	5	166-166-255
412	Inland wetlands	Peat bogs	5	077-077-255
421	Maritime wetlands	Salt marshes	not relevant	204-204-255
422	Maritime wetlands	Salines	not relevant	230-230-255
423	Maritime wetlands	Intertidal flats	5	166-166-230
511	Inland waters	Water courses	5	000-204-242
512	Inland waters	Water bodies	5	128-242-230
521	Marine waters	Coastal lagoons	5	000-255-166
522	Marine waters	Estuaries	5	166-255-230
523	Marine waters	Sea and ocean	5	230-242-255

Step 4: Calculating the total FEM-value

The areas with different vulnerabilities are summed up in the respective group (1 – low, 3 – medium, 5 – high performance). E.g. the total area of areas with a high vulnerable land use are recorded. A weighted FEM value is then calculated by multiplying the number of points, which depends on the vulnerability, by the area by the total area (Table A 9). The resulting values of the three groups are then summed to obtain one's FEM value for the floodplain.

4.2.4 Example

For Austria, we downloaded the CORINE land cover data set from the Copernicus webpage and cut the data with the help of the floodplain polygon shape (Figure A 14).

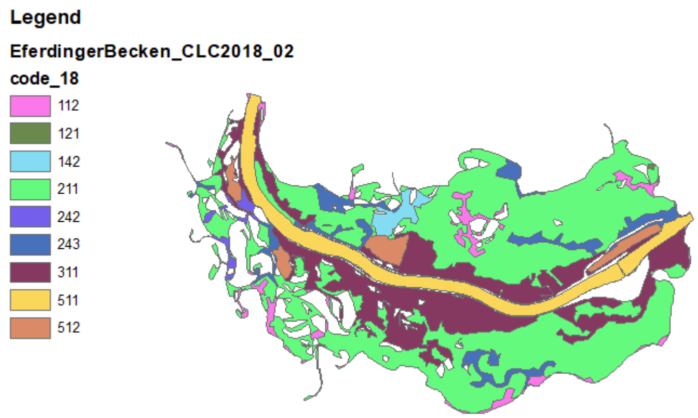


Figure A 14: land use - example Austria (Eferdinger Becken)

Afterwards we used the ArcGIS zonal statistics tool to produce a table with the land cover classes and the corresponding areas in the floodplain (Table A 8).

Table A 8: land use table - example Austria (Eferdinger Becken)

Area ha	Label	FEM-evaluation
209	Discontinuous urban fabric	1
2	Industrial or commercial units	1
78	Sport and leisure facilities	1
3072	Non-irrigated arable land	3
60	Complex cultivation patterns	3
331	Land principally occupied by agriculture, with significant a	3
1221	Broad-leaved forest	5
163	Water bodies	5

We summed up all areas with low, medium and high performance and calculated the weighted FEM-value for this floodplain.

Table A 9: Calculation of the weighted FEM-value for the Eferdinger Becken

FEM-evaluation	Area (ha)		Total
1	290	1*290/5136 = 0.06	3.43
3	3462	3*3462/5136 = 2.02	
5	1384	5*1384/5136 = 1.35	
Sum	5136		

4.2.5 Thresholds

In Table A 10, the thresholds are shown, which are used to determine the performance of the floodplain for the land use parameter. If the land use parameter is smaller than 2, the performance of the floodplain is low. Between 2-4, the performance is medium. All floodplains with a land use parameter above 4 perform high.

Table A 10: Thresholds to determine the performance of the land use parameter in the FEM-Evaluation

Thresholds land use	
1	< 2
3	2 - 4
5	> 4

B FEM-Handbook - additional parameters

Introduction

The Danube Floodplain project aims to improve transnational water management and flood risk prevention while maximizing benefits for biodiversity conservation. Preservation and/or restoration of floodplains play a key role in an integrated flood risk management. Therefore, it is important to identify the active and potential floodplains as well as to evaluate their effects in terms of flood risk reduction, ecological benefits and socio-economic aspects.
This handbook is a guidance for all countries in the Danube River Basin that have to evaluate their floodplains with the Floodplain Evaluation Matrix (FEM). The handbook gives a detailed description of each FEM parameter from the medium and extended class, a workflow on how to calculate the parameter, some examples and the selected thresholds. These additional parameters were accepted by all project partners and can be applied at selected active and potential floodplain if the partners decide to do so.

1. Hydrology

1.1. Effects in case of extreme discharge

1.1.1 Description

Effects of floodplain areas on hydrological parameters (ΔQ, Δt) for scenarios with discharges larger (HQ_{1000}) than the design discharge (HQ_{100}) of flood protection measures (remaining risk, higher risk, e.g. climate change) are also incorporated in the FEM. Hydrodynamic-numerical modelling of the higher discharge (HQ_{1000}) can highlight additional capacities of floodplains or increased risks for settlements behind the dykes, e.g. by overtopping of existing dykes. The evaluation considers the effects on peak reduction and flood wave translation in each floodplain for this higher discharge compared to HQ_{100}.

1.1.2 Source

For the determination of the peak reduction, results of unsteady hydrodynamic-numerical 2D-simulations are preferred, which should be calibrated and validated with recorded flood waves at different gauging stations. Using 1D-models is also possible. Other options to calculate the peak reduction would be observed flood waves at different gauging stations within the reach or engineering approaches. If engineering approaches are necessary due to lack of data, a separate handbook will be provided, where these approaches are explained.

1.1.3 Workflow

Step 1: Selecting hydrological input data
You can take the input hydrograph of the closest gauging station upstream of the floodplain from a recorded flood event and adjust it (e.g. scale it to HQ_{1000} peak value) or you can use hydrographs from existing hydrodynamic models that are HQ_{1000}[5]. You should at least use one hydrograph for each floodplain, if possible two (a steep and a flat one). If there are any tributaries within the delineated floodplain, unsteady and/or steady hydrological input data will be used. In general, unsteady hydrological input data should be preferred for all tributaries. Especially for larger tributaries unsteady flood waves should be used. If no data is available for the main tributaries, TUM could provide you flood waves from the SWIM model. For smaller tributaries, it is possible to use steady hydrological input data. The documentation of the used flood waves/hydrological input data is very important. You have to provide us your used data.

[5] If nothing is available, TUM can provide hydrographs from the SWIM model for the whole Danube basin

Step 2: Calculating output hydrograph at end of floodplain and computing $\Delta Q_{extreme,tot}$

You can use a 2D model or if not available, a 1D model to calculate the output hydrograph at a cross section at the end of the floodplain. If no model is available an engineering approach can be used. This would be for example the Gauckler-Manning-Strickler formula. If a 1D model is used the modeler should make sure that the floodplain flow characteristics are correctly modeled. In order to compute $\Delta Q_{extreme,tot}$ it is necessary to calculate the difference between the peak of the input and the output flood wave (Figure B 1).

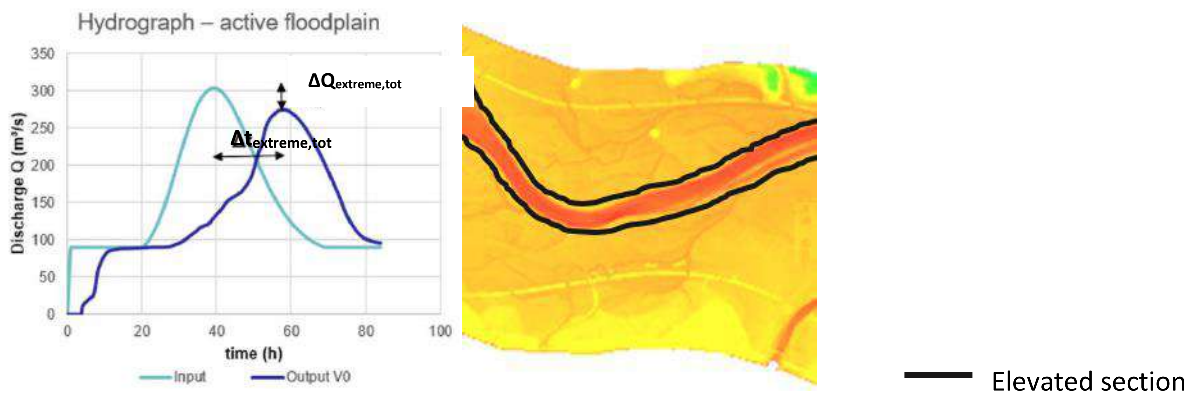


Figure B 1: FEM-parameter flood peak reduction ΔQextreme,tot for active floodplains

Step 3: Calculating $\Delta Q_{extreme,RC}$ of the river channel

To demonstrate only the effect of the floodplains on the peak reduction, it is necessary to run the model a second time with disconnected or disabled floodplains and foreland to calculate the retention effect of the river channel. For disconnecting the floodplains in the model, possible approaches are to deactivate the floodplain or to elevate a section next to the river. After running the simulation, the peak of the new generated output hydrograph has to be subtracted from the input hydrograph to determine $\Delta Q_{extreme,RC}$ (Figure B 2).

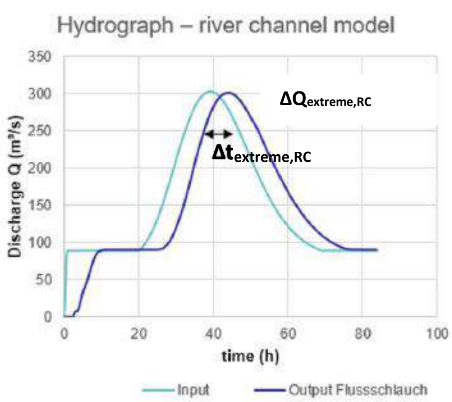


Figure B 2: FEM-parameter flood peak reduction $\Delta Q_{extreme,RC}$ for the river channel

Step 4: Calculating $\Delta Q_{extreme}$ and $\Delta Q_{extreme,rel}$

The first calculation of $\Delta Q_{extreme,tot}$ gives the retention effects of the floodplains as well of the river channel.

$\Delta Q_{extreme,RC}$ shows only the effect of the river channel on the flood peak. Therefore, it is necessary to subtract $\Delta Q_{extreme,RC}$ from the $\Delta Q_{extreme,tot}$ for demonstrating only the effect of the floodplains on the peak reduction.

$$\Delta Q_{extreme} = \Delta Q_{extreme,tot} - \Delta Q_{extreme,RC}[m^3s^{-1}] \quad [1]$$

Additionally, the $\Delta Q_{extreme,rel}$ [%] has to be calculated by dividing the ΔQ by the $Q_{extreme,max}$ multiplied by 100 to make a comparison of different river reaches possible. The $Q_{extreme,max}$ is the flood peak of the inflow wave.

$$\Delta Q_{extreme,rel} = \frac{\Delta Q_{extreme}}{Q_{extreme,max}} \times 100\ [\%] \quad [2]$$

Step 5: Using output hydrograph at end of floodplain and calculating $\Delta t_{extreme,tot}$

You can use the same output hydrograph for calculating the flood wave translation $\Delta t_{extreme,tot}$ as for the modelling of the $\Delta Q_{extreme}$. It is recommended to model and calculate both parameter at the same time. In order to compute $\Delta t_{extreme,tot}$ it is necessary to determine the time when the peak of the flood waves (input/output) occur and calculate the difference between them (Figure B 3).

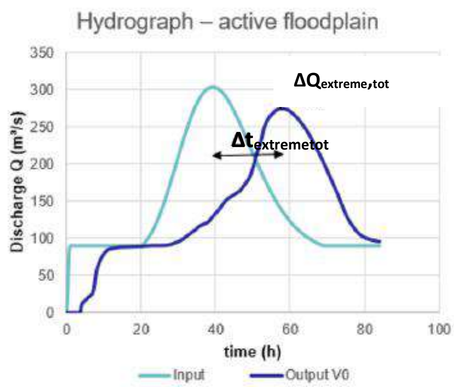


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Figure B 3: FEM-parameter flood wave translation $\Delta t_{extreme,tot}$ for active floodplains

Step 6: Calculating the $\Delta t_{extreme,RC}$ for the river channel

You can use the output hydrograph from the modelling of $\Delta Q_{extreme,RC}$ for calculating the flood wave translation $\Delta t_{extreme,RC}$ for the river channel. In order to compute $\Delta t_{extreme,RC}$, it is necessary to determine the time when the peak of the flood waves (input/output) occur and calculate the difference between them (Figure B 4).

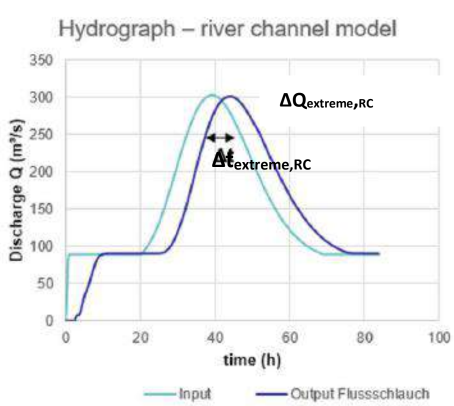


Figure B 4: FEM-parameter flood wave translation $\Delta t_{extreme,RC}$ for the river channel

Step 7: Calculating $\Delta t_{extreme}$ and $\Delta t_{extreme,rel}$

The first calculation of $\Delta t_{extreme,tot}$ shows the effects of the floodplains as well of the river channel on the travel time of the flood wave. $\Delta t_{extreme,RC}$ demonstrates only the effect of the river channel on the travel time. Therefore, it is necessary to subtract $\Delta t_{extreme,RC}$ from the $\Delta t_{extreme,tot}$ for demonstrating only the effect of the floodplains on the travel time.

$$\Delta t_{extreme} = \Delta t_{extreme,tot} - \Delta t_{extreme,RC} [h] \quad [3]$$

Step 8: Compare ΔQ_{rel} with $\Delta Q_{extreme,rel}$ and Δt with $\Delta t_{extreme}$

Now you calculate the relation between the ΔQ_{rel} and the $\Delta Q_{extreme,rel}$

$$\Delta Q_{compared} = \frac{\Delta Q_{rel}}{\Delta Q_{extreme,rel}} \times 100 \, [\%] \quad [5]$$

And the relation between the Δt and the $\Delta t_{extreme}$,

$$\Delta t_{compared} = \frac{\Delta t}{\Delta t_{extreme}} \times 100 \, [h] \quad [6]$$

1.1.4 Thresholds

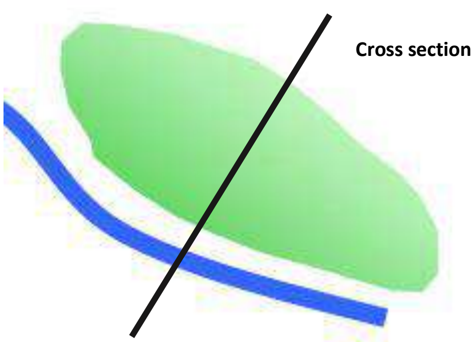
No thresholds were defined for this parameter, since no partner applied it.

2. Hydraulics

2.1 Flow velocity – Δv

2.1.1 Description

A hydrodynamic-numerical model is used to determine the influence of changes in floodplain geometry (e.g. by dyke-shifting). Reducing or extending floodplain widths by modelling of fictive dykes exhibits how big changes in the flow velocity of the scenarios (Δv) can be. The observed values can be calculated in a cross section at the middle or/and end of the floodplain or in the next settlement. With this parameter, we want to show the effects of a total loss of a floodplain on the flow velocity in the river channel. Therefore, we can use the model, which we were using for the calculation of ΔQ_{RC} and Δt_{RC}. Within this model we have disconnected the floodplains and foreland from the river channel by fictive dykes.



This parameter is also used for showing the effects on potential removal of dykes to reconnect potential floodplains. The removal of the dykes would mean changes of the geometry in the model, which would be necessary to show the effects on the flow velocity.

2.1.2 Source

Comparison of the flow velocity of different scenarios using an unsteady hydrodynamic model (2D, 1D) or engineering approaches.

2.1.3 Workflow

Step 1: Calculating flow velocity for a HQ_{100} with the active floodplain (v_{tot})
You can use the same hydrodynamic-numerical calculation, which is used to determine the hydrological parameters (ΔQ_{tot} and Δt_{tot}). At a defined cross-section (e.g. in the middle of the floodplain) you determine the calculated flow velocity v_{tot} in the middle of the river channel.

Step 2: Calculating flow velocity for a HQ_{100} without floodplain (v_{RC})

In the next step, you use the same hydrodynamic-numerical calculation, which was used to determine the hydrological parameters (ΔQ_{RC} and Δt_{RC}) and you determine the calculated flow velocity (v_{RC}) on the same spot as in step 1.

Step 3: Calculating the Δv
In the last step, you have to compute the Δv by subtracting the calculated flow velocity without floodplains (v_{RC}) from the flow velocity (v_{tot}) with active floodplain. The flow velocity change Δv demonstrates the increase of the flow velocity due to a loss of the floodplain.

$$\Delta v = v_{tot} - v_{RC} [cms^{-1}] \quad [7]$$

2.1.4 Example

In Austria the flow velocity changes were calculated by shifting an existing dyke 50% closer to the river, 100% closer to the river and also one scenario where the dyke was moved away. The results showed an increase of the flow velocity in the cross section in the middle of the floodplain of 25 cms^{-1}. In general, only one scenario has to be calculated where the floodplain is disconnected completely (e.g. by elevation of a section close to the river to simulate a dyke) (Figure B 5).

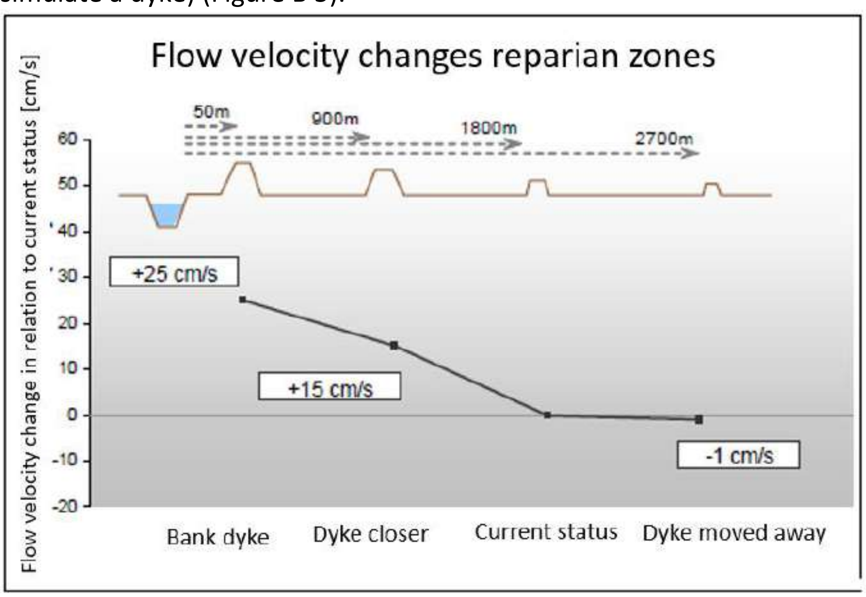


Figure B 5: flow velocity change – example Austria (Machland)

2.1.5 Thresholds

In Table 11:, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter flow velocity change. If the flow velocity change (Δv) is smaller than 0.1 m/s, the performance of the floodplain is low. Between 0.1-0.2 m/s, the performance is medium. All floodplains with a flow velocity change above 0.2 m/s perform high (Table B 1).

Table B 1: Thresholds to determine the performance of the flow velocity change Δv in the FEM-Evaluation

Thresholds Δv	
1	< 0.1 m/s
3	0.1 - 0.2 m/s
5	> 0.2 m/s

2.2 Bottom shear stress – Δτ

2.2.1 Description

A hydrodynamic-numerical model is used to determine the influence of changes in floodplain geometry (e.g. by dyke-shifting). Reducing or extending floodplain widths by modelling of fictive dykes exhibits how big changes in the bottom shear stress of the scenarios (Δτ) can be. The observed values can be calculated in a cross section at the middle or/and end of the floodplain or in the next settlement. With this parameter, we want to show the effects of a total loss of a floodplain on the bottom shear stress. Therefore, we can use the model, which we were using for the calculation of ΔQ_{RC} and Δt_{RC} within this model we have disconnected the floodplains and foreland from the river channel by fictive dykes.
This parameter is also used for showing the effects on potential removal of dykes to reconnect potential floodplains. The removal of the dykes would mean changes of the geometry in the model, which would be necessary to show the effects on the bottom shear stress.

2.2.2 Source

Comparison of the bottom shear stress of different scenarios using an unsteady hydrodynamic model (2D, 1D) or engineering approaches.

2.2.3 Workflow

Step 1: Calculating bottom shear stress for a HQ_{100} with the active floodplain (τ_{tot})
You can use the same hydrodynamic-numerical calculation, which is used to determine the hydrological parameters (ΔQ_{tot} and Δt_{tot}). At a defined cross-section (e.g. in the middle of the floodplain) you determine the calculated bottom shear stress τ_{tot} in the middle of the river channel.

Step 2: Calculating bottom shear stress for a HQ_{100} without floodplain (τ_{RC})

In the next step, you use the same hydrodynamic-numerical calculation, which was used to determine the hydrological parameters (ΔQ_{RC} and Δt_{RC}) and you determine the calculated bottom shear stress (τ_{RC}) on the same spot as in step 1.

Step 3: Calculating the Δτ
In the last step, you have to compute the Δτ by subtracting the calculated bottom shear stress without floodplains (τ_{RC}) from the bottom shear stress (τ_{tot}) with active floodplain. The bottom shear stress change Δτ demonstrates the increase of the bottom shear stress due to a loss of the floodplain.

$$\Delta\tau = \tau_{tot} - \tau_{RC} [Nm^{-2}] \quad [8]$$

2.2.4 Example

In Austria the bottom shear stress changes were calculated by shifting an existing dyke 50% closer to the river, 100% closer to the river and also one scenario where the dyke was moved away. The results showed an increase of the bottom shear stress in the cross section in the middle of the floodplain of 26,61 N/m² (Figure B 6). In general, only one scenario has to be calculated where the floodplain is disconnected.

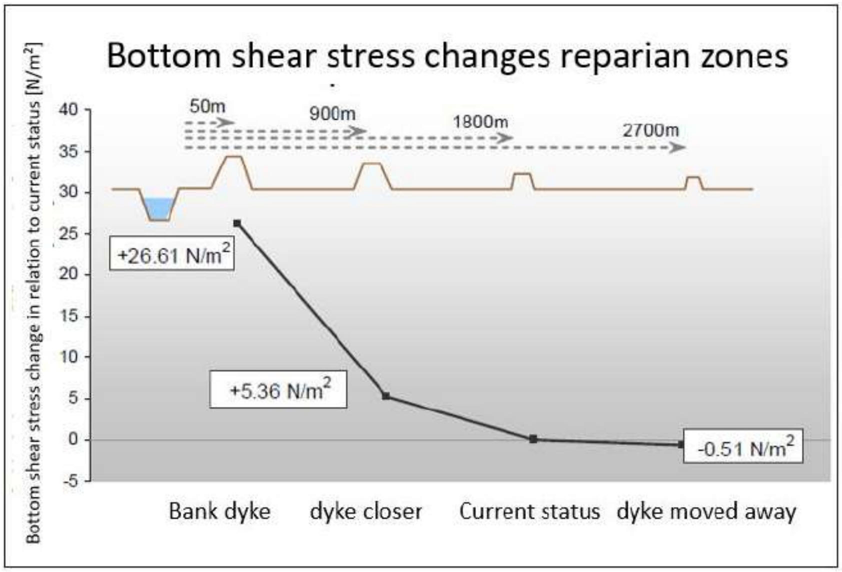


Figure B 6: bottom shear stress change – example Austria (Machland)

2.2.5 Thresholds

In Table B 2, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter bottom shear stress change. If the bottom shear stress change (Δτ) is smaller than 1.5 N/m², the performance of the floodplain is low. Between 1.5-3 N/m², the performance is medium. All floodplains with a bottom shear stress change above 3 N/m² perform high.

Table B 2: Thresholds to determine the performance of the bottom shear stress change Δτ in the FEM-Evaluation

Thresholds τ	
1	< 1.5 N/m²
3	1.5 - 3 N/m²
5	> 3 N/m²

3. Ecology

3.1 Existence of protected habitats

3.1.1 Description

This parameter shows what part of the floodplain area is designated as protected area according to the Natura 2000 or other documents about protected species or habitats like the Emerald Network. The higher the share of protected areas, the more valuable is the floodplain.

3.1.2 Source

In case of the European Union countries the Natura 2000 database can be used and non-EU member states can use the equivalent Emerald Network database.

3.1.3 Workflow

Step 1: Downloading Natura 2000 or Emerald Network datasets
First of all, you have to go to the Natura 2000 webpage https://www.eea.europa.eu/data-and-maps/data/natura-10#tab-gis-data and download the latest version of the Natura 2000 areas as shape file. Countries not being in the Natura 2000 network should obtain shape files from other sources (e.g. national databases on nature protection areas) since they are not downloadable from the Emerald viewer (http://emerald.eea.europa.eu/).

Step 2: GIS analysis of protected area on the floodplain
Use ArcGIS or a similar software to show both the shapes of your active floodplain and the downloaded Natura 2000 (or equivalent) shapes. One possible way is to create a new feature class in the same folder where the Natura 2000 dataset was saved. Then open the Editor mode and select from the Natura 2000 polygons all that are located on your floodplains. Copy them to the newly created feature class. Now you can remove the original layer from your map. Go to the edit mode of the new feature class and use the “Clip” tool to cut the Natura 2000 polygons to the shape of your floodplains. Make sure, that the tool does not cut away polygon parts that are not part of one floodplain, but part of another floodplain. Now you can open the attribute table and look up the area of the Natura 2000 habitats that are located in your floodplains. Other ways which lead to a similar result are also possible.

Step 3: Calculating the parameter
Look at each floodplain and select the protected areas in GIS. Add all areas on the floodplain together, but don’t calculate areas twice if two polygons lay above each other (this can happen if you have protected areas according to the Habitats and the Birds Directive). Then divide this area by the total floodplain area and multiply it by 100 to get the percentage of protected habitats on your floodplain.

$$\text{protected habitat} = \left(\frac{A_{\text{protected}}}{A_{\text{floodplain}}}\right) * 100 \quad [9]$$

3.1.4 Example

The Eferdinger Becken in Austria has only a part of it protected by the Habitats Directive. In the graphic you can see the whole floodplain in green and the protected area in purple (Figure B 7). The area was then cut to the floodplain shape to calculate the part which lies in the floodplain (green).

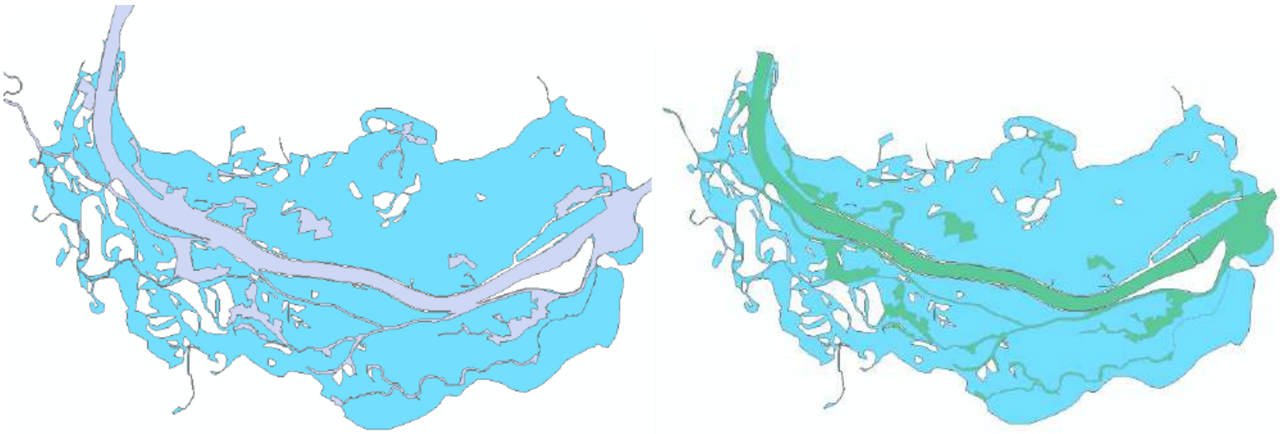


Figure B 7: Natura 2000 area at Eferdinger Becken

The parameter was calculated in the following way:

$$\text{protected habitat} = \left(\frac{A_{\text{protected}}}{A_{\text{floodplain}}}\right) * 100 = \left(\frac{10{,}31\ \text{km}^2}{53{,}16\ \text{km}^2}\right) * 100 = 19{,}40\ \% \qquad [10]$$

3.1.5 Thresholds

In Table B 3, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter existence of protected habitats. If less than 33% of the floodplain area is protected, the performance of the floodplain is low. Between 33-67%, the performance is medium. If more than 67% of the floodplain area is protected, the performance is high.

Table B 3: Thresholds to determine the performance of the parameter existence of protected habitats in the FEM-Evaluation

Thresholds protected habitats	
1	< 33 %
3	33 - 67 %
5	> 67 %

3.2 Vegetation naturalness

3.2.1 Description

The landscape patterns of a floodplain can be a good indicator for the naturalness of vegetation. Therefore it is possible to calculate patch-level landscape indices (like the class level landscape metric Area Weighted Mean Shape Index (AWMSI) for all land cover polygons of natural and semi natural areas (NSN). Mean Shape Index can be calculated by the V-LATE extension of ArcGIS. NSN patches with a complex shape with irregular edges indicate a higher level of naturalness.

Because this method is very scale sensitive, and the detailed land cover data (Copernicus vegetation zones) are available only for the active floodplains, we offer to use this method only for estimation the vegetation naturalness of the active floodplain units. See details in: Szilassi P. et.al (2017) The link between landscape pattern and vegetation naturalness on a regional scale. In: Ecological Indicators (81) 252-259.pp

3.2.2 Source

The riparian vegetation land cover dataset is available from the whole Danube floodplain and most of the tributaries too. This dataset can be downloaded from the Copernicus Land Monitoring Service website: https://land.copernicus.eu/local/riparian-zones/land-cover-land-use-lclu-image

3.2.3 Workflow

Step 1: Downloading and preparing Riparian vegetation land cover database.
The riparian vegetation land cover dataset is available for all Danube floodplains and for most of the tributaries. This dataset can be downloaded from the Copernicus Land Monitoring Service website:
https://land.copernicus.eu/local/riparian-zones/land-cover-land-use-lclu-image

Step 2: Downloading and setting up the V-LATE - Vector-based Landscape Analysis Tools Extension, for ArcGIS10.x
Downloading and setting up the V-LATE - Vector-based Landscape Analysis Tools Extension, for ArcGIS 10.x from this website:
https://sites.google.com/site/largvlate/gis-tools/v-late

Step 3: Making a new land cover map which contains only the “natural or semi natural” land cover patches
Open the Copernicus Riparian Zone land cover maps with ArcGIS 10.x. For making a new shape file which will contains only the “natural or semi natural” land cover patches, select the following main land cover categories from the riparian zones land cover dataset: Woodland (code 3), Grassland (code 4), and Heathland (Code 5)

Step 4: Calculation of the perimeter area values, and other landscape indexes representing the area and shape characteristics of each “natural or semi natural” land cover polygons
Open the new “natural and semi natural” land cover map with ArcGIS 10.x. and click on the V-Late extension. Following the V-late flowchart, you should calculate first the Perimeter and Area of each land cover polygons, clicking Area/Perimeter box. The V-late extension will automatically put these new attribute columns into the attribute table of your digital land cover map.
Follow the flowchart steps, click on Area Analysis, Edge Analysis, and Form Analysis boxes. You should select the unique id column of the polygon patches to calculate the values for the all patches. The V-late extension will automatically calculate and put the landscape indices (e.g. Shape Index = shape_idx) into the attribute table of the digital land cover map (Copernicus Riparian Zone). These landscape indexes are representing the area, and form characteristics of each land cover polygons in the new attribute columns. You will use only the Shape Index (MSI) data (shape_idx columns) of each land cover polygons for the further analyses.

Step 5: Downloading and setting up the Geospatial Modelling Environment (GME), for ArcGIS 10.x
Downloading and setting up the Geospatial Modelling Environment (GME), and R software for ArcGIS 10.x from this website, following the instructions:
http://www.spatialecology.com/gme/gmedownload.htm
You can download the user’s manual from this website:
http://www.spatialecology.com/gme/images/SpatialEcologyGME.pdf

Step 6: Calculation of Area Weighted Mean values of Shape Index (MSI) of the natural and semi natural land cover patches for every active floodplain units (AFU) by Geospatial Modelling Environment (GME).
Open the GME icon in your computer. Choose and click on the “isectpolypoly” options on the left menus of the GME. This tool calculates the Area Weighted Average of MSI values of each natural and semi natural land cover polygons inside of the floodplain units (zonal polygon dataset). This tool writes automatically the results into the attribute table of the digital map of the active floodplain units (zonal polygon) dataset.
You should also select the zonal polygon shape file. This shape file will be the digital polygon map of the active floodplain units. You can put it into the “in” field (active floodplain unit data source). You should select into this second polygon layer to process your “natural or semi natural” land cover polygon shape file, which attribute

table includes yet the MSI data of each land cover polygons. You should select this shape file from your computer and select the MSI column from its attribute table. This MSI column will be the quantitative data to summarize field.
You should write into “prefixa” a short prefix to use in the summary statistic fields with AWM, the prefix should be no longer than 6 characters.
Set up the “thematic”, “proportion” and “where” menus into the FALSE options, the “area weighted mean” menu (AWM) into the TRUE options, the “minimum” (MIN), “maximum” (MAX), and “area weighted sum” (AWS) menus to the FALSE options (Figure B 8).

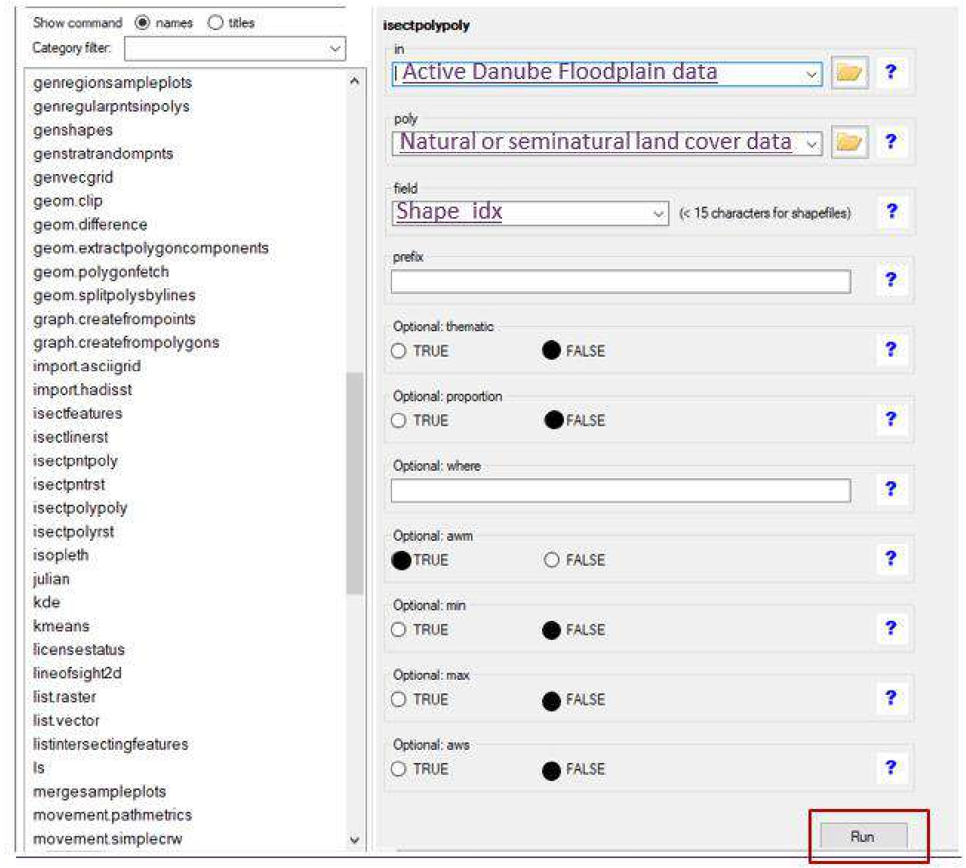


Figure B 8: Input mask of the GIS tool to calculate the landscape metrics

Step 7: Estimating the vegetation naturalness of active floodplain units (AFU) based on the shape characteristics of natural and semi natural land cover polygons of the riparian zones

Open the digital maps of active floodplain units (AFU) with ArcGIS 10.x. This file is containing yet the Area Weighted Mean Shape Index (AWMSI) values of each floodplain units (AFU). You should add a new field (column) into the attribute table of this shape file, and define it as the string column, which will represent the vegetation naturalness of each AFU. You should select the 0 – 3.7 AWMSI values and to write “low naturalness” into the new attribute table (in the Field calculator).
You should select the 3.71 – 6.00 AWMSI values and to write “medium naturalness” into the new attribute table.
You should select the over 6.01 AWMSI values and to write “high naturalness” into the new attribute table.

3.2.4 Example

USZ calculated the AWMSI values of each Hungarian Vegetation Monitoring quadrants along the Danube River, based on its Natural and semi natural land cover patches. Based on this AWMSI values they could estimate the vegetation naturalness of each Hungarian Vegetation Mapping Units along the Danube River (Figure B 9).

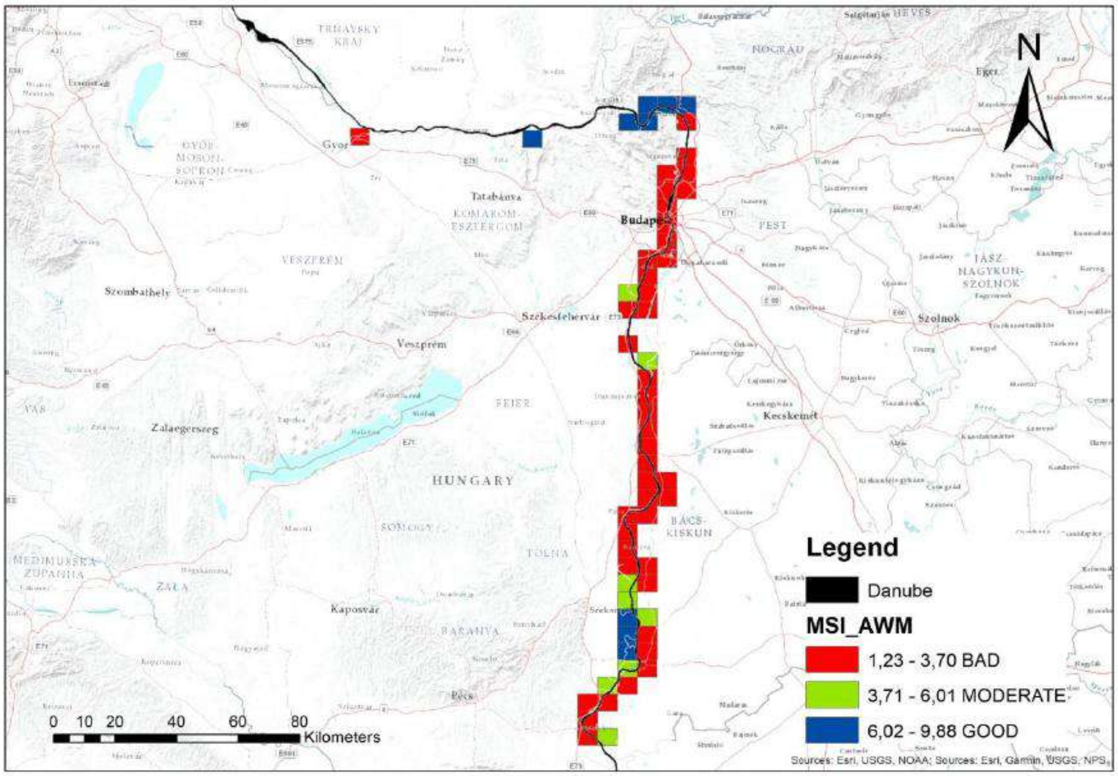


Figure B 9: Vegetation naturalness - example Hungary

3.2.5 Thresholds

In Table B 4, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter vegetation naturalness. If the vegetation naturalness is smaller than 3.7, the performance of the floodplain is low. Between 3.71-6.01, the performance is medium. All floodplains with a vegetation naturalness above 6.02 perform high.

Table B 4: Thresholds to determine the performance of the vegetation naturalness in the FEM-Evaluation

Thresholds vegetation naturalness	
1	< 3.7
3	3.71 - 6.01
5	> 6.02

3.3 Water level dynamics

3.3.1 Description

In order to restore floodplain habitats, rivers and floodplains must have a water level dynamic, almost like the one that exists in the natural floodplains. For this reason the water level dynamics are used as a FEM parameter. If important changes have been made on the river, floodplain areas may have completely different water level dynamics. This can result in permanently (excessive) high water levels in dammed up parts of the river or in dry floodplain areas in deepened river segments. An uncontrolled retention is impossible where barrages have been built, which means that this is also a criterion for exclusion with a view to the implementation of non-technical floodplain enlargements.
In the floodplain areas are other barriers, mostly of anthropogenic origin, which can, even after removal of the front river dyke, prevent the water level dynamics from affecting the whole area. However, there are also natural landscapes which create obstacles for incoming water, such as river banks which have developed naturally.
The parameters water level duration, frequency of the flood and amplitude of the water levels are summarized to describe the possible water level dynamics. Every spatial point has its own typical water level dynamics in relation to its altitude above the river. The historical state before the development of the river serves as a point of reference. A detailed surface assessment for this parameter would be very time-consuming, so that the assessment is made with the help of experts for the whole area at once. For the evaluation, a classification on the basis of expert knowledge has to be set up: low disturbance of natural water level dynamics leads to a high rating within FEM.

3.3.2 Source

Expert knowledge is needed to evaluate this parameter.

3.3.3 Workflow

Step 1: Collection of information about current state
An expert should collect information about the duration, frequency and amplitude of the water level dynamics including the following factors: headwater, riverbed, dykes (natural or man-made), street dams, swells, channel-bed erosions, barrages

Step 2: Collection information about historical state
The expert has to collect the same information (duration, frequency, amplitude, other factors) also for the historical state.

Step 3: Comparison of current with historical state
Now the current state has to be compared with the historical state. The duration, frequency and amplitude of the water level dynamics have to be compared. The following scenarios are then part of the evaluation:
5 – Duration, frequency and amplitude are **marginally** affected. Further aspects: headwaters are not obstructed, the river bed is not deepened and there are no major obstacles for inundation
3 - Duration, frequency and amplitude are **moderately** affected. Further aspects: there are natural banks but the headwaters are dammed or dams and streets are in the floodplain
1 - Duration, frequency and amplitude are **strongly** affected. Further aspects: there are summer dykes existing, the riverbed is deepened and swells can be found

3.3.4 Example

The water level dynamics parameter was evaluated at the Morava floodplain south of Zwentendorf (Figure B 10). The March River still has a near natural discharge regime in its lower part only influenced by some reservoirs at the tributaries. The still meandering channel with low incision rates and some cut-off meanders close to the proposed area is also under good hydro-morphological conditions. Therefore the following evaluation was given:

- Duration: marginally affected → 5
- Frequency: marginally affected → 5
- Amplitude: marginally affected → 5

As there are no further aspects relevant, the total evaluation is 5 "marginally affected".

Figure B 10: March floodplain south of Zwentendorf

3.3.5 Thresholds

For the water level dynamics parameter, the method allows determining the performance without defined thresholds.

3.4 Potential for typical habitats

3.4.1 Description

The typical river and floodplain habitats should have the possibility to re-establish habitats if they are not already existing. 14 habitat types typical for floodplains are included in the Habitats Directive. Not every area must include all, but the more habitat types exist or can be redeveloped, the more valuable is this area.

3.4.2 Source

In case of the European Union countries the Natura 2000 database can be used and Serbia can use the equivalent Emerald Network database. Additionally, the pilot sites can use the data from the habitat modelling of Act. 4.2

3.4.3 Workflow

Step 1: Downloading Natura2000 or Emerald Network datasets

First of all you have to open the Natura 2000 viewer at http://natura2000.eea.europa.eu/. There you can go to the floodplain of interest and then you have to select the datasets that are available there. One layer is for the Habitats Directive.

Step 2: Analysing available habitat types typical for floodplains

The datasets from the Habitats Directive can be downloaded as a PDF at each floodplain (Table B 5). There you can go to the chapter "3.1 Habitat types present on the site and assessment for them" and compare which of the habitats typical for floodplains are available at this specific floodplain.

Table B 5: typical floodplain habitat types

Number	Name
3130	Oligotrophic to mesotrophic standing waters
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp.*
3150	Natural eutrophic lakes
3160	Natural dystrophic lakes and ponds
3260	Water courses of plain to montane levels with *Ranunculion fluitantis* vegetation
3270	Rivers with muddy banks with *Chenopodion rubri p.p.* and *Bidention p.p.* vegetation
6410	Molinia meadows
6430	*Hydrophilous tall herb* fringe communities
6440	Alluvial meadows of river valleys of the *Cnidion dubii*
7210*	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
7230	Alkaline fens
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests (*Stellario-Carpinetum*)
91E0*	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*
91F0	Riparian mixed forests along the great rivers

The sign '*' indicates priority habitat types

Now you can create a list of the available floodplain specific habitats for each floodplain. It is also relevant to list listing the habitats that are currently not present but could additionally occur or being re-established. An expert judgment is needed for this.

3.4.4 Example

At the floodplain NP Donauauen the Habitats Directive lists 14 protected Habitats and from that list 8 habitats are typically for floodplains (Figure B 11). Until now, no expert evaluation for the habitats that could additionally occur was made.

NP Donauauen		8
Code	Name	
3130	Oligotrophic to mesotrophic standing water	1
3150	Natural eutrophic lakes with Magnopotamic	1
3260	Water courses of plain to montane levels w	1
3270	Rivers with muddy banks with Chenopodior	1
6110	Rupicolous calcareous or basophilic grasslar	0
6190	Rupicolous pannonic grasslands (Stipo-Festu	0
6210	Semi-natural dry grasslands and scrubland f	0
6240	Sub-Pannonic steppic grasslands	0
6430	Hydrophilous tall herb fringe communities c	1
6440	Alluvial meadows of river valleys of the Cni	1
6510	Lowland hay meadows (Alopecurus pratens	0
8310	Caves not open to the public	0
9180	Tilio-Acerion forests of slopes, screes and ra	0
91E0	Alluvial forests with Alnus glutinosa and Fra	1
91F0	Riparian mixed forests of Quercus robur, Ul	1
91H0	Pannonian woods with Quercus pubescens	0

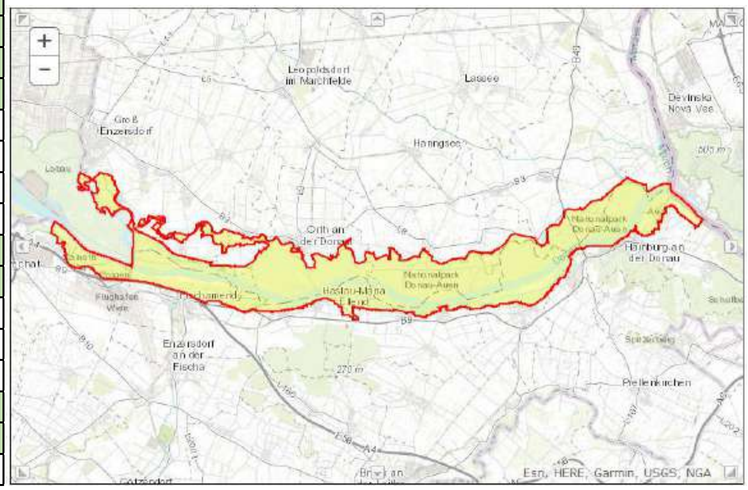


Figure B 11: protected Habitat types - NP Donauauen

3.4.5 Thresholds

In Table B 6, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter potential for typical habitats. If less than 5 typical habitats exist or can be redeveloped, the performance of the floodplain is low. Between 5-10 habitats, the performance is medium. All floodplains were more than 10 typical habitats exist or can be redeveloped, perform high.

Table B 6: Thresholds to determine the performance of the parameter potential for typical habitats in the FEM-Evaluation

Thresholds typical habitats	
1	< 5
3	5 - 10
5	> 10

3.5 Ecological water body status

3.5.1 Description

As part of the water framework directive, the countries should evaluate the ecological and chemical status of the water bodies as well as the chemical and quantitative status of groundwater bodies in the floodplain. If the river section of this floodplain is rated for the ecological water body status with a good or very good status, it should get a high ranking.

3.5.2 Source

To identify the ecological water body status you can use the national implementation documents of the Water Framework Directive.

3.5.3 Workflow

Step 1: Downloading implementation documents of the water framework directive
Each European country has developed some national implementation documents for the Water Framework Directive. They should be available for you for all river water bodies and the groundwater bodies. You can look up which waterbody is part of your floodplain (e.g. Danube section) and in which groundwater body it lies.

Step 2: Collecting information of the ecological water body status
The downloaded documents should include an evaluation section where the ecological water body status is described. Extract this information for each floodplain in a table.

3.5.4 Example

In Austria the floodplain NP Donauauen is part of the Danube waterbody between KW Freudenau and Devin (Figure B 12).

NP Donauauen	
Waterbody:	Danube
Ecological	2 (good)
Chemical	1 (very good)

Figure B 12: Waterbody Danube between power plant Freudenau and Devin

3.5.5 Example

In Table B 7, the thresholds are shown, which are used to determine the performance of the floodplain for the parameter ecological water body status. If the ecological water body status is bad or poor, the performance of the floodplain is low. If the water body status is moderate, the performance is medium. All floodplains with a good or high ecological water body status receive a high performance in the FEM-evaluation.

Table B 7: Thresholds to determine the performance of the parameter ecological water body status in the FEM-Evaluation

Thresholds water body status	
1	bad, poor
3	moderate
5	high, good

4. Socio-Economics

4.1 Presence of documented planning interests

4.1.1 Description

This parameter evaluates the presence of infrastructure or spatial development plans/projects in the floodplain area or close to it. A presence would lead to a lower ranking of the floodplain. This can also include plans from other interest groups (agriculture, tourism, hunting, fishing, etc.)

4.1.2 Source

Basis of the evaluation can be municipal spatial plans, urban plans, plans on space and land use or other development plans.

4.1.3 Workflow

Step 1: Searching for relevant documents
On each floodplain you have to search for available spatial plans, urban plans or other development plans and ask your national or local authorities.

Step 2: Analysing the planning interests
If you find some plans you can analyse their content in terms of development projects for building, industry and infrastructure. If such interests are shown in the documents this should be documented at a map or at least a table including the project, the planned area in the floodplain and the planned year.

4.1.4 Thresholds

No thresholds were selected, since no partner applied this additional parameter

C Overview of the FEM-results for the additional parameters

Table C 1: Overview of the results for the additional FEM-parameters for all active floodplains along the Danube River (Partners could choose, which parameter they want to calculate)

	Floodplain	Hydraulics		Ecology			
		flow velocity change (m/s)	bottom shear stress (N/m²)	Existence of protected habitats (%)	Vegetation naturalness (-)	Potential for typical habitas (-)	ecological water body status (-)
Germany	DE_DU_AFP_01						
	DE_DU_AFP_02						
	DE_DU_AFP_03	0.03		12	4.58	11	moderate
	DE_DU_AFP_04	0.43		52	5.69	5	3
	DE_DU_AFP_05	0.08		77	6.23	6	3
	DE_DU_AFP_06	0.00		60	3.42	7	3
	DE_DU_AFP_07	0.07		10	5.27	6	3
	DE_DU_AFP_08	-0.05		94	3.09	6	3
	DE_DU_AFP_09	-0.02		45	4.05	9	3
	DE_DU_AFP_10	0.02		51	6.89	9	3
Austria, Slovakia	AT_DU_AFP_01	0.15		19		3	3
	AT_DU_AFP_02	1.06		6		5	3
	AT_DU_AFP_03	1.27		50		7	3
	AT_DU_AFP_04	0.14		92		8	3
	AT_DU_AFP_05	0.24		98		8	2
	AT_SK_DU_AFP_01	0.17		36		8	2
Slovakia, Hungary	HU_SK_DU_AFP_01			99	4.06	13	3
	HU_SK_DU_AFP_02			68	3.96	13	3
	HU_SK_DU_AFP_03			41	5.11	11	3
	HU_SK_DU_AFP_04			60	6.08	11	3
	HU_SK_DU_AFP_05			53	3.29	11	3
Hungary	HU_DU_AFP_01			60	5.88	11	3
	HU_DU_AFP_02			66	2.59	11	3
	HU_DU_AFP_03			57	5.30	11	3
	HU_DU_AFP_04			59	3.91	11	3
	HU_DU_AFP_05			53	4.98	6	3
	HU_DU_AFP_06			75	4.26	6	3
	HU_DU_AFP_07			96	5.83	6	3
	HU_DU_AFP_08			99	4.45	6	3
	HU_HR_DU_AFP_01			97	4.82	6	3
Croatia, Serbia	RS_HR_DU_AFP_01						
	RS_HR_DU_AFP_02						
	RS_HR_DU_AFP_03						
	RS_HR_DU_AFP_04						
	RS_HR_DU_AFP_05						
Serbia	RS_DU_AFP_01						
	RS_DU_AFP_02						
	RS_DU_AFP_03						
	RS_DU_AFP_04						
	RS_DU_AFP_05						
Bulgaria, Romania	RO_BG_DU_AFP_01	0.18	1.91	79	9.33		3
	RO_BG_DU_AFP_02	0.18	2.09	95	6.10		3
	RO_BG_DU_AFP_03	0.45	3.85	64	6.20		3
	RO_BG_DU_AFP_04	0.28	1.24	94	11.84		3
	RO_BG_DU_AFP_05	0.49	3.77	22	6.01		3
	RO_BG_DU_AFP_06	0.40	3.89	97	6.83		3
Romania	RO_DU_AFP_01	0.04	0.54	96	8.30		3
	RO_DU_AFP_02	0.06	0.91	100	10.30		3
	RO_DU_AFP_03	0.02	1.09	97	14.75		3
	RO_DU_AFP_04	0.03	0.21	99	18.71		3
FEM-rating	performance	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds	Thresholds
	low	<0.1 m/s	< 1.5 N/m²	< 33 %	< 3.7	< 5	4 - 5
	medium	0.1 - 0.2 m/s	1.5 - 3 N/m²	33 - 67 %	3.7 - 6.01	5 - 10	3
	high	> 0.2 m/s	> 3 N/m²	>67 %	> 6.01	> 11	1 - 2

Annex D. Danube Floodplain inventories active and potential floodplains

AT_DU_AFP01 Danube

Aschach - Ottensheim

Boundary of active floodplain with Restoration demand

5 km

Country: **Austria**
Type: **active floodplain**
Floodplain length: **15.2 km**
Floodplain area: **56.4 km²**
Centroid: **48.32°N 14.092°E**
River kilometre: **2160 - 2144.5**
HQ_{100}: **8320 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

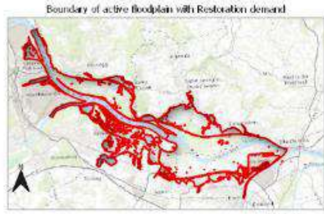
Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

AT_DU_AFP02 Danube

Linz - Mauthausen

Boundary of active floodplain with Restoration demand



5 km

Country: **Austria**
Type: **active floodplain**
Floodplain length: **18.1 km**
Floodplain area: **34.8 km²**
Centroid: **48.253°N 14.426°E**
River kilometre: **2130 - 2112**
HQ_{100}: **8530 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

AT_DU_AFP03 Mauthausen - Ardagger Markt

Danube

Country: **Austria**
Centroid: **48.185°N 14.707°E**
Type: **active floodplain**
River kilometre: **2109 - 2084**
Floodplain length: **23.5 km**
Floodplain area: **72.2 km²**
HQ_{100}: **9560 m³/s**

Boundary of active floodplain with Restoration demand

8 km

FEM PARAMETER:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (medium)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity (high)	Existence of protected habitats (medium)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

AT_DU_AFP04 Krems - Wien

Danube

Country: **Austria**
Centroid: **48.36°N 16.035°E**
Type: **active floodplain**
River kilometre: **1999.5 - 1938**
Floodplain length: **60 km**
Floodplain area: **151.9 km²**
HQ_{100}: **11200 m³/s**

Boundary of active floodplain with Restoration demand

19 km

FEM PARAMETER:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity (medium)	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

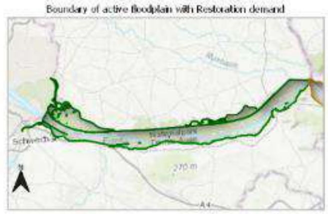
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

AT_DU_AFP05 Wien - Devin
Danube

Country: **Austria**
Type: **active floodplain**
Floodplain length: **37.8 km**
Floodplain area: **85.3 km²**
Centroid: **48.138°N 16.733°E**
River kilometre: **1918 - 1880**
HQ_{100}: **10400 m³/s**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (medium)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity (high)	Existence of protected habitats (high)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION: yes
RESTORATION DEMAND: low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

AT_DU_PFP01 Krems - Wien
Danube

Country: **Austria**
Type: **potential floodplain**
Floodplain length: **60 km**
Floodplain area: **160.7 km²**
Centroid: **48.362°N 16.019°E**
River kilometre: **1999.5 - 1938**
HQ_{100}: **11200 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity (medium)	Existence of protected habitats (high)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

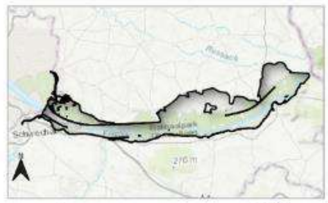
FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

AT_DU_PFP02 Wien - Devin
Danube

Country: **Austria**
Centroid: **48.143°N 16.757°E**
Type: **potential floodplain**
River kilometre: **1918 - 1880**
Floodplain length: **37.8 km**
Floodplain area: **121.4 km²**
HQ_{100}: **10400 m³/s**



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

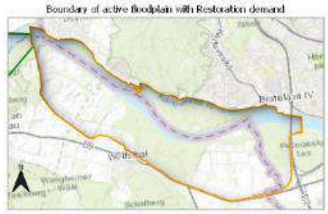
NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

AT_SK_DU_AFP01 Devin - Wolfsthal
Danube

Country: **Austria / Slovakia**
Centroid: **48.144°N 17.025°E**
Type: **active floodplain**
River kilometre: **1880 - 1871.5**
Floodplain length: **9.8 km**
Floodplain area: **19.8 km²**
HQ_{100}: **11000 m³/s**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION: yes
RESTORATION DEMAND: medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

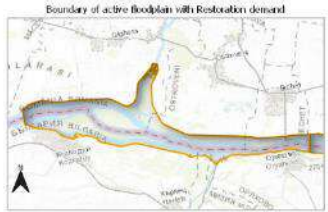
BG_RO_DU_AFP01 RO: Ostroveni - Bistret aria; BG: Kozlodui - Oreahovo area
Danube

Country: **Bulgaria / Romania** Centroid: **43.779°N 23.811°E**

Type: **active floodplain** River kilometre: **703 - 677**

Floodplain length: **25.2 km** Floodplain area: **60.1 km²** HQ_{100}: **nodata**

Boundary of active floodplain with Restoration demand



8 km

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

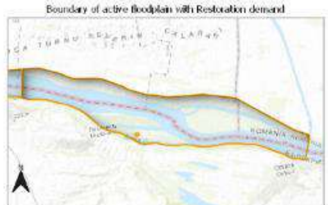
BG_RO_DU_AFP02 RO:Dabuleni area; BG:Leskovet - Ostrov area
Danube

Country: **Bulgaria / Romania** Centroid: **43.716°N 24.069°E**

Type: **active floodplain** River kilometre: **677 - 661**

Floodplain length: **15.6 km** Floodplain area: **32.3 km²** HQ_{100}: **nodata**

Boundary of active floodplain with Restoration demand



5 km

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

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BG_RO_DU_AFP03 Danube

RO: upstream from Corabia; BG: Baikal - Ghighen area

Boundary of active floodplain with Restoration demand

Country: **Bulgaria / Romania**		Centroid: **43.736°N 24.433°E**	
Type: **active floodplain**		River kilometre: **646 - 630**	
Floodplain length: **15.4 km**	Floodplain area: **29.3 km²**	HQ_{100}: **nodata**	

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

BG_RO_DU_AFP04 Danube

RO: downstream from Corabia-Islaz area; BG: Zagrajden-Somovit area

Boundary of active floodplain with Restoration demand

Country: **Bulgaria / Romania**		Centroid: **43.725°N 24.697°E**	
Type: **active floodplain**		River kilometre: **630 - 600.3**	
Floodplain length: **30.9 km**	Floodplain area: **81.6 km²**	HQ_{100}: **nodata**	

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

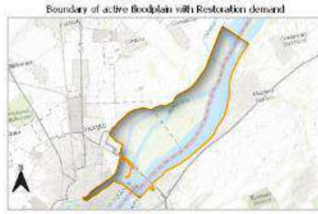
Interreg Danube Transnational Programme Danube Floodplain

BG_RO_DU_AFP05 RO: Giurgiu area; BG: Marten area

Danube

Country: **Bulgaria / Romania**		Centroid: **43.911°N 26.033°E**	
Type: **active floodplain**		River kilometre: **490 - 479.5**	
Floodplain length: **10.3 km**	Floodplain area: **25.3 km²**	HQ_{100}: **nodata**	

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

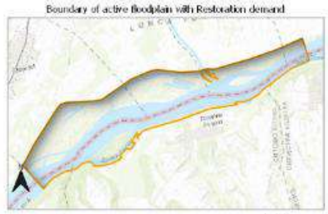
Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

BG_RO_DU_AFP06 RO: Chiselet-Dorobantu area; BG: Popina area

Danube

Country: **Bulgaria / Romania**		Centroid: **44.136°N 26.93°E**	
Type: **active floodplain**		River kilometre: **412 - 395.5**	
Floodplain length: **14.9 km**	Floodplain area: **33.6 km²**	HQ_{100}: **nodata**	

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

BG_RO_DU_PFP01 RO: Desa area; BG: Slivata - Orsoia area
Danube

Country: **Bulgaria / Romania** Centroid: **43.81°N 23.054°E**

Type: **potential floodplain** River kilometre: **763 - 753**

Floodplain length: **10.6 km** Floodplain area: **82.8 km²** HQ_{100}: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters
NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

BG_RO_DU_PFP02 RO: Bistret - Bechet area; BG: Dolni Tibar - Oreahovo area
Danube

Country: **Bulgaria / Romania** Centroid: **43.829°N 23.641°E**

Type: **potential floodplain** River kilometre: **725 - 677**

Floodplain length: **47.7 km** Floodplain area: **279.7 km²** HQ_{100}: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

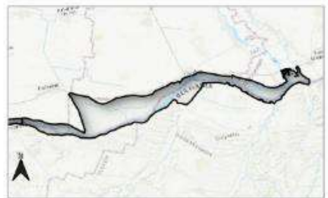
FEM-EVALUATION:
based on minimum parameters
NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

BG_RO_DU_PFP03 RO: Bechet - Turnu Magurele area; BG: Oreahovo - Cerkovita area

Danube



Country: **Bulgaria / Romania** Centroid: **43.727°N 24.388°E**

Type: **potential floodplain** River kilometre: **677 - 600**

Floodplain length: **77.8 km** Floodplain area: **309.7 km²** HQ_{100}: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

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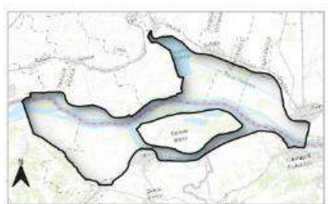
BG_RO_DU_PFP04 RO: Traian - Zimnicea area; BG: Deagas Voivoda - Svistov area

Danube



Country: **Bulgaria / Romania** Centroid: **43.685°N 25.162°E**

Type: **potential floodplain** River kilometre: **590 - 554**

Floodplain length: **35.7 km** Floodplain area: **204.5 km²** HQ_{100}: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

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BG_RO_DU_PFP05 RO: Nasturelu area; BG: Novgrad area
Danube

Country: **Bulgaria / Romania** Centroid: **43.633°N 25.527°E**
Type: **potential floodplain** River kilometre: **543 - 537**
Floodplain length: **6.2 km** Floodplain area: **31.7 km²** HQ_{100}: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) http://www.geo.univie.ac.at/projekte/danube-floodplain/BG_RO_DU_PFP05.pdf
Download floodplain object (ESRI Shape) http://www.geo.univie.ac.at/projekte/danube-floodplain/BG_RO_DU_PFP05.zip

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

3.7 km

FEM-EVALUATION:
based on minimum parameters

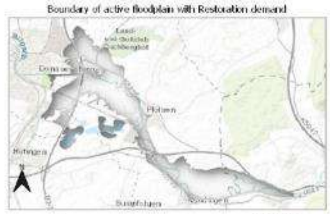
NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

DE_DU_AFP01 Donaueschingen
Danube

Boundary of active floodplain with Restoration demand



Country: **Germany** Centroid: **47.935°N 8.549°E**
Type: **active floodplain** River kilometre: **nodata**
Floodplain length: **13.3 km** Floodplain area: **9.7 km²** HQ_{100}: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) http://www.geo.univie.ac.at/projekte/danube-floodplain/DE_DU_AFP01.pdf
Download floodplain object (ESRI Shape) http://www.geo.univie.ac.at/projekte/danube-floodplain/DE_DU_AFP01.zip

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

3.7 km

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION: no
RESTORATION DEMAND: no info.

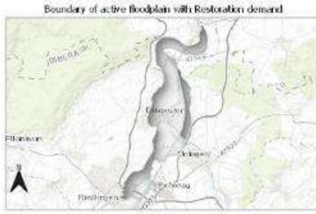
Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

DE_DU_AFP02 Riedlingen
Danube

Country: **Germany**
Centroid: **48.183°N 9.501°E**
Type: **active floodplain**
River kilometre: **nodata**
Floodplain length: **10.6 km**
Floodplain area: **6.3 km²**
HQ_{100}: **nodata**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
no	no info.

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

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DE_DU_AFP03 Oberelchingen - Lech
Danube

Country: **Germany**
Centroid: **48.599°N 10.581°E**
Type: **active floodplain**
River kilometre: **2576 - 2490**
Floodplain length: **82.7 km**
Floodplain area: **155.5 km²**
HQ_{100}: **1350 m³/s**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity (low)	Existence of protected habitats (low)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

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DE_DU_AFP04 Lech - Neuburg

Danube

Floodplain length: 20.4 km	Country: **Germany**	Centroid: **48.73°N 11.033°E**
	Type: **active floodplain**	River kilometre: **2490 - 2477.5**
	Floodplain area: **32.3 km²**	HQ_{100}: **1450 m³/s**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high | medium | low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_AFP05 Bergheim – Ingolstadt

Danube

Floodplain length: 15.3 km	Country: **Germany**	Centroid: **48.743°N 11.332°E**
	Type: **active floodplain**	River kilometre: **2484.5 - 2458**
	Floodplain area: **21.9 km²**	HQ_{100}: **2100 m³/s**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high | medium | low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_AFP06 Neustadt – Weltenburg

Danube

Boundary of active floodplain with Restoration demand


7 km

Country: **Germany**		Centroid: **48.831°N 11.75°E**	
Type: **active floodplain**		River kilometre: **2432 - 2408**	
Floodplain length: **15.5 km**	Floodplain area: **16.4 km²**	HQ100: **2200 m³/s**	

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_AFP07 Regensburg

Danube

Boundary of active floodplain with Restoration demand


2.5 km

Country: **Germany**		Centroid: **49.018°N 12.192°E**	
Type: **active floodplain**		River kilometre: **2376.5 - 2367.5**	
Floodplain length: **8.9 km**	Floodplain area: **7.5 km²**	HQ100: **3400 m³/s**	

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

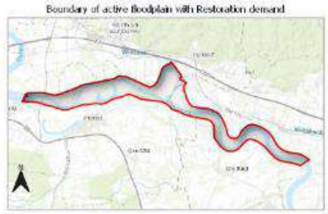
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_AFP08 Geisling/Gmünd

Danube

Boundary of active floodplain with Restoration demand



Country: **Germany**

Centroid: **48.97°N 12.432°E**

Type: **active floodplain**

River kilometre: **2354 - 2347**

Floodplain length: **18.6 km**

Floodplain area: **10.6 km²**

HQ_{100}: **3400 m³/s**

FEM PARAMETER:

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (high)
Flood wave translation (low)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity (low)	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (low)	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

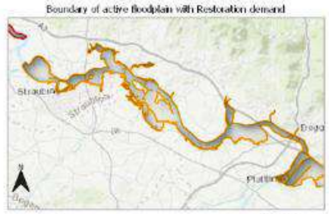
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_AFP09 Straubing - Isar

Danube

Boundary of active floodplain with Restoration demand



Country: **Germany**

Centroid: **48.867°N 12.742°E**

Type: **active floodplain**

River kilometre: **2327 - 2284.5**

Floodplain length: **46.8 km**

Floodplain area: **67.2 km²**

HQ_{100}: **3400 m³/s**

FEM PARAMETER:

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity (low)	Existence of protected habitats (medium)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

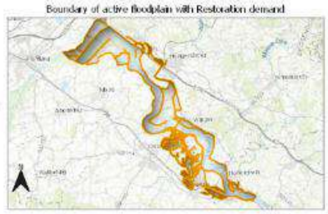
FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_AFP10 Isar - Vilshofen
Danube



Country: **Germany**
Type: **active floodplain**
Floodplain length: **30.7 km**
Floodplain area: **45.3 km²**
Centroid: **48.731°N 13.043°E**
River kilometre: **2284.5 - 2249.5**
HQ_{100}: **4100 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (medium)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges (n/a)	Flow velocity (low)	Existence of protected habitats (medium)	Presence of documented planning interests (n/a)
	Bottom shear stress (n/a)	Vegetation naturalness (high)	
		Water level dynamics (n/a)	
		Potential for typical habitats (medium)	
		Ecological water body status (n/a)	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_PFP01 Oberelchingen - Lech
Danube

Country: **Germany**
Type: **potential floodplain**
Floodplain length: **nodata**
Floodplain area: **167 km²**
Centroid: **48.601°N 10.587°E**
River kilometre: **nodata**
HQ_{100}: **1250 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges (n/a)	Flow velocity (n/a)	Existence of protected habitats (n/a)	Presence of documented planning interests (n/a)
	Bottom shear stress (n/a)	Vegetation naturalness (n/a)	
		Water level dynamics (low)	
		Potential for typical habitats (n/a)	
		Ecological water body status (n/a)	

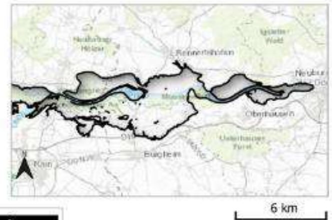
FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_PFP02 Lech - Neuburg
Danube



Country: **Germany**		Centroid: **48.731°N 11.027°E**	
Type:	**potential floodplain**	River kilometre:	**nodata**
Floodplain length: **nodata**	Floodplain area: **37.4 km²**	HQ_{100}:	**2100 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (medium)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics (low)	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_PFP03 Großmehring
Danube

Country: **Germany**		Centroid: **48.746°N 11.516°E**	
Type:	**potential floodplain**	River kilometre:	**nodata**
Floodplain length: **nodata**	Floodplain area: **4.9 km²**	HQ_{100}:	**2100 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (high)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (medium)
Flood wave translation (low)		Existence of protected species (medium)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics (low)	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

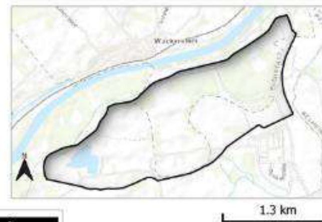
FEM-EVALUATION: based on minimum parameters

NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

DE_DU_PFP04 Katzau

Danube



Country: **Germany** Centroid: **48.781°N 11.675°E**

Type: **potential floodplain** River kilometre: **nodata**

Floodplain length: **nodata** Floodplain area: **3.1 km²** HQ_{100}: **2100 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance
- high
- medium
- low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

no

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg
Danube Transnational Programme
Danube Floodplain

DE_DU_PFP05 Geisling/Gmünd

Danube

Country: **Germany** Centroid: **48.979°N 12.391°E**

Type: **potential floodplain** River kilometre: **nodata**

Floodplain length: **nodata** Floodplain area: **25 km²** HQ_{100}: **3400 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance
- high
- medium
- low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

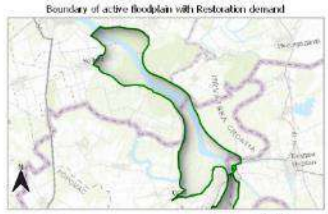
Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg
Danube Transnational Programme
Danube Floodplain

HR_HU_DU_AFP01 Béda-Karapnacsa
Danube

Country: Hungary / Croatia / Serbia
Type: active floodplain
Floodplain length: 18.6 km
Floodplain area: 48.2 km²
Centroid: 45.908°N 18.793°E
River kilometre: 1444 - 1425
HQ_{100}: 8312 m³/s

Boundary of active floodplain with Restoration demand



9 km

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

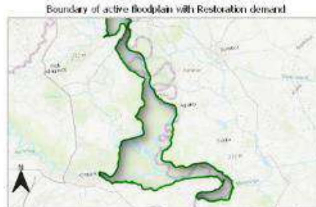
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HR_RS_DU_AFP01 Kopački rit/Gornje Podunavlje
Danube

Country: Serbia / Croatia
Type: active floodplain
Floodplain length: 70.1 km
Floodplain area: 279.9 km²
Centroid: 45.614°N 18.905°E
River kilometre: 1425 - 1354.2
HQ_{100}: 8614 m³/s

Boundary of active floodplain with Restoration demand



20 km

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

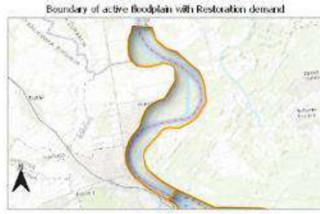
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HR_RS_DU_AFP02 Borovo/Vajska

Danube

Country: **Serbia / Croatia**
Centroid: **45.41°N 18.999°E**
Type: **active floodplain**
River kilometre: **1349.8 - 1334**
Floodplain length: **16.2 km**
Floodplain area: **19.6 km²**
HQ_{100}: **8443 m³/s**



FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high (blue), medium (green), low (orange)

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

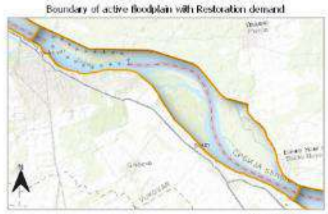
Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

HR_RS_DU_AFP03 Vukovar/Bačko Novo Selo

Danube

Country: **Serbia / Croatia**
Centroid: **45.323°N 19.084°E**
Type: **active floodplain**
River kilometre: **1334 - 1318**
Floodplain length: **16.8 km**
Floodplain area: **24.6 km²**
HQ_{100}: **8433 m³/s**



FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high (blue), medium (green), low (orange)

FEM-EVALUATION:
based on minimum parameters

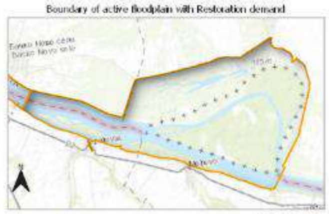
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

HR_RS_DU_AFP04 Mohovo/Karađorđevo
Danube

Boundary of active floodplain with Restoration demand



3.9 km

Floodplain length: 9.3 km	Country: **Serbia / Croatia**	Centroid: **45.268°N 19.226°E**	
	Type: **active floodplain**	River kilometre: **1318 - 1308.4**	
	Floodplain area: **30 km²**	HQ_{100}: **8420 m³/s**	

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (medium)
Flood wave translation (medium)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (low)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness (low)	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HR_RS_DU_AFP05 Ilok/Bačka Palanka
Danube

Boundary of active floodplain with Restoration demand

8 km

Floodplain length: 27.2 km	Country: **Serbia / Croatia**	Centroid: **45.235°N 19.485°E**	
	Type: **active floodplain**	River kilometre: **1303.8 - 1275.8**	
	Floodplain area: **49.2 km²**	HQ_{100}: **8406 m³/s**	

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (medium)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (low)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness (low)	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

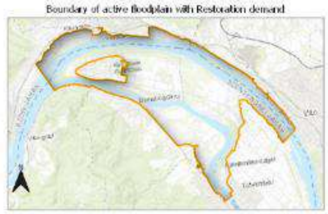
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP01 Szentendrei-sz. North
Danube

Country: **Hungary** | Centroid: **47.798°N 19.056°E**
Type: **active floodplain** | River kilometre: **1691.9 - 1679.1**
Floodplain length: **13.4 km** | Floodplain area: **32.3 km²** | HQ_{100}: **9412 m³/s**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP02 Szentendrei-sz. South
Danube

Country: **Hungary** | Centroid: **47.627°N 19.096°E**
Type: **active floodplain** | River kilometre: **1665.1 - 1657.5**
Floodplain length: **7.9 km** | Floodplain area: **18.2 km²** | HQ_{100}: **9352 m³/s**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP03 Csepel-sziget
Danube

Country: **Hungary** Centroid: **47.231°N 18.919°E**
Type: **active floodplain** River kilometre: **1636.6 - 1590.8**
Floodplain length: **45.9 km** Floodplain area: **70.8 km²** HQ_{100}: **9272 m³/s**

Boundary of active floodplain with Restoration demand

24 km

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high, medium, low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP04 Dunaújváros
Danube

Country: **Hungary** Centroid: **46.97°N 18.957°E**
Type: **active floodplain** River kilometre: **1590.8 - 1564.8**
Floodplain length: **26.4 km** Floodplain area: **44.7 km²** HQ_{100}: **9084 m³/s**

Boundary of active floodplain with Restoration demand

14 km

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high, medium, low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP05 Dunaföldvár
Danube

Boundary of active floodplain with Restoration demand

Country: **Hungary**	Type: **active floodplain**	Centroid: **46.74°N 18.977°E**
Floodplain length: **29.6 km**	Floodplain area: **63.8 km²**	River kilometre: **1564.8 - 1535.8**
		HQ_{100}: **9022 m³/s**

Download detailed report (PDF) · Download floodplain object (ESRI Shape)

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (low)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (high)
Flood wave translation (low)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (medium)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high · medium · low

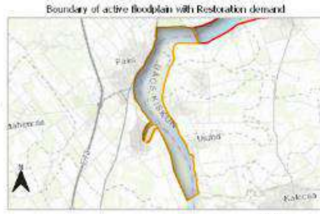
FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP06 Paks
Danube

Boundary of active floodplain with Restoration demand



Country: **Hungary**	Type: **active floodplain**	Centroid: **46.598°N 18.881°E**
Floodplain length: **14.4 km**	Floodplain area: **20.3 km²**	River kilometre: **1535.8 - 1520.7**
		HQ_{100}: **8871 m³/s**

Download detailed report (PDF) · Download floodplain object (ESRI Shape)

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (high)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (medium)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high · medium · low

FEM-EVALUATION:
based on minimum parameters

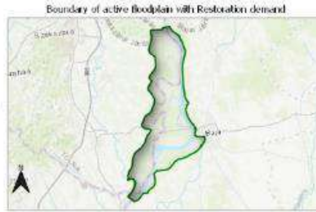
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP07 Veránka-sziget
Danube

Country: **Hungary**	Centroid: **46.217°N 18.871°E**	
Type: **active floodplain**	River kilometre: **1498.1 - 1462.7**	
Floodplain length: **36.3 km**	Floodplain area: **159 km²**	HQ_{100}: **8741 m³/s**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (medium)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters
- NEED FOR PRESERVATION: yes
- RESTORATION DEMAND: low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_AFP08 Bezerédy-sziget
Danube

Country: **Hungary**	Centroid: **46.054°N 18.74°E**	
Type: **active floodplain**	River kilometre: **1458.9 - 1452.9**	
Floodplain length: **6.2 km**	Floodplain area: **9 km²**	HQ_{100}: **8382 m³/s**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (high)	Connectivity of floodplain water bodies (high)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (medium)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters
- NEED FOR PRESERVATION: yes
- RESTORATION DEMAND: low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_PFP01 Szigetköz
Danube

Country: **Hungary**		Centroid:	**47.88°N 17.487°E**
Type:	**potential floodplain**	River kilometre:	**1851.8 - 1797**
Floodplain length: **54.8 km**	Floodplain area: **157.1 km²**	HQ_{100}:	**10425 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance
high
medium
low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_PFP02 Paks
Danube

Country: **Hungary**		Centroid:	**46.601°N 18.883°E**
Type:	**potential floodplain**	River kilometre:	**1535.8 - 1520.7**
Floodplain length: **15.1 km**	Floodplain area: **22.1 km²**	HQ_{100}:	**8865 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance
high
medium
low

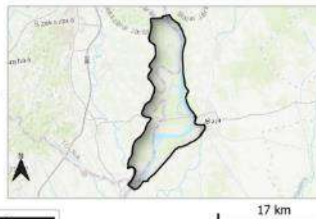
FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_PFP03 Veránka-sziget
Danube



Country: **Hungary**
Type: **potential floodplain**
Floodplain length: **35.4 km**
Floodplain area: **161.7 km²**
Centroid: **46.216°N 18.871°E**
River kilometre: **1498.1 - 1462.7**
HQ_{100}: **8732 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (medium)	Water level change (high)	Connectivity of floodplain water bodies (high)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_DU_PFP04 Béda-Karapnacsa
Danube

Country: **Hungary**
Type: **potential floodplain**
Floodplain length: **nodata**
Floodplain area: **54.7 km²**
Centroid: **45.912°N 18.793°E**
River kilometre: **1444 - 1425**
HQ_{100}: **8300 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (high)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION: yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_SK_DU_AFP01 Szigetköz

Danube

Boundary of active floodplain with Restoration demand

Country: **Slovakia / Hungary**	Centroid: **47.889°N 17.476°E**	
Type: **active floodplain**	River kilometre: **1851.8 - 1797**	
Floodplain length: **51.4 km**	Floodplain area: **140.2 km²**	HQ_{100}: **10425 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (high)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_SK_DU_AFP02 Gönyű

Danube

Boundary of active floodplain with Restoration demand

Country: **Slovakia / Hungary**	Centroid: **47.737°N 17.853°E**	
Type: **active floodplain**	River kilometre: **1797 - 1777**	
Floodplain length: **19.9 km**	Floodplain area: **40.6 km²**	HQ_{100}: **9420 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (medium)
Flood wave translation (low)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (medium)	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

HU_SK_DU_AFP03 Almásfüzitő
Danube

Boundary of active floodplain with Restoration demand

Country: **Slovakia / Hungary**	Type: **active floodplain**	Floodplain area: **8.3 km²**
Centroid: **47.727°N 18.296°E**	River kilometre: **1756 - 1751.3**	HQ_{100}: **9293 m³/s**
Floodplain length: **4 km**		

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) · Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (high)
Flood wave translation (low)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (low)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness (medium)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

HU_SK_DU_AFP04 Esztergom
Danube

Boundary of active floodplain with Restoration demand

Country: **Slovakia / Hungary**	Type: **active floodplain**	Floodplain area: **31.2 km²**
Centroid: **47.76°N 18.665°E**	River kilometre: **1732.1 - 1719.4**	HQ_{100}: **9176 m³/s**
Floodplain length: **12.3 km**		

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF) · Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (medium)	Potentially affected buildings (medium)
Flood wave translation (low)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats (medium)	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness (high)	
		Water level dynamics	
		Potential for typical habitats (high)	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

HU_SK_DU_AFP05 Pilismarót

Danube

Boundary of active floodplain with Restoration demand

Country: **Slovakia / Hungary**		Centroid: **47.802°N 18.875°E**	
Type: **active floodplain**		River kilometre: **1710.1 - 1699.8**	
Floodplain length: **10.5 km**	Floodplain area: **14.9 km²**	HQ_{100}: **9473 m³/s**	

FEM PARAMETER: Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain

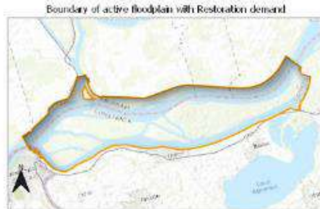
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

RO_DU_AFP01 Calarasi area

Danube

Boundary of active floodplain with Restoration demand



Country: **Romania**		Centroid: **44.125°N 27.37°E**	
Type: **active floodplain**		River kilometre: **375 - 356**	
Floodplain length: **17.7 km**	Floodplain area: **50.3 km²**	HQ_{100}: **nodata**	

FEM PARAMETER: Download detailed report (PDF) | Download floodplain object (ESRI Shape)

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain

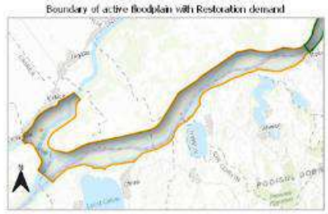
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

RO_DU_AFP02 Oltina - Rasova area
Danube

Country: **Romania**
Type: **active floodplain**
Floodplain length: **31.2 km**
Floodplain area: **79.4 km²**
Centroid: **44.226°N 27.714°E**
River kilometre: **345 - 313.5**
HQ_{100}: **nodata**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (high)	Potentially affected buildings (high)
Flood wave translation (medium)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity (low)	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress (low)	Vegetation naturalness (high)	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RO_DU_AFP03 Rasova - Cernavoda - Harsova area
Danube

Country: **Romania**
Type: **active floodplain**
Floodplain length: **58.6 km**
Floodplain area: **93.6 km²**
Centroid: **44.475°N 28.031°E**
River kilometre: **313.5 - 252.5**
HQ_{100}: **nodata**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (high)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity (low)	Existence of protected habitats (high)	Presence of documented planning interests
	Bottom shear stress (low)	Vegetation naturalness (high)	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RO_DU_AFP04 Harsova - Braila area

Danube

Boundary of active floodplain with Restoration demand

Country: **Romania** | Centroid: **44.901°N 27.903°E**

Type: **active floodplain** | River kilometre: **252.5 - 172**

Floodplain length: **77.9 km** | Floodplain area: **298.8 km²** | HQ_{100}: **nodata**

FEM PARAMETER:

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RO_DU_PFP01 Borcea Buliga

Danube

Country: **Romania** | Centroid: **44.342°N 27.79°E**

Type: **potential floodplain** | River kilometre: **nodata**

Floodplain length: **6.3 km** | Floodplain area: **8.6 km²** | HQ_{100}: **nodata**

FEM PARAMETER:

Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RO_DU_PFP02 Bentu
Danube

	Country: **Romania**	Centroid: **44.429°N 27.938°E**
	Type: **potential floodplain**	River kilometre: **nodata**
Floodplain length: **2.5 km**	Floodplain area: **0.7 km²**	HQ100: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg
Danube Transnational Programme
Danube Floodplain

RO_DU_PFP03 Garliciu
Danube

	Country: **Romania**	Centroid: **44.762°N 28.073°E**
	Type: **potential floodplain**	River kilometre: **nodata**
Floodplain length: **4.1 km**	Floodplain area: **10.8 km²**	HQ100: **nodata**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg
Danube Transnational Programme
Danube Floodplain

RO_DU_PFP04 Tichilesti

Danube

Country: **Romania**

Centroid: **44.915°N 27.904°E**

Type: **potential floodplain**

River kilometre: **nodata**

Floodplain length: **77.9 km**

Floodplain area: **318.1 km²**

HQ_{100}: **nodata**

40 km

FEM PARAMETER:

Minimum Parameter Set:

Download detailed report (PDF)

Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

Danube Floodplain

Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

RO_DU_PFP05 Cotu Pisicii

Danube

Country: **Romania**

Centroid: **45.444°N 28.168°E**

Type: **potential floodplain**

River kilometre: **nodata**

Floodplain length: **5.5 km**

Floodplain area: **11.6 km²**

HQ_{100}: **nodata**

3 km

FEM PARAMETER:

Minimum Parameter Set:

Download detailed report (PDF)

Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION

yes

Danube Floodplain

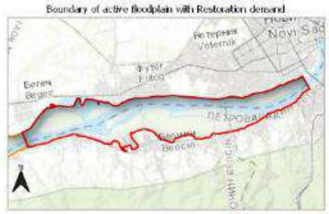
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

Interreg Danube Transnational Programme Danube Floodplain

RS_DU_AFP01 — Futog-Beočin
Danube

Country: **Serbia**	Type: **active floodplain**	
Floodplain length: **16.8 km**	Floodplain area: **34.8 km²**	
Centroid: **45.224°N 19.729°E**	River kilometre: **1275.8 - 1258.2**	HQ_{100}: **8367 m³/s**

Boundary of active floodplain with Restoration demand



6 km

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (medium)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (low)
Flood wave translation (medium)		Existence of protected species (high)	Land use (high)

Additional Parameter Set: Effects in case of extreme discharges; Flow velocity; Existence of protected habitats; Precence of documented planning interests; Bottom shear stress; Vegetation naturalness; Water level dynamics; Potential for typical habitats; Ecological water body status

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

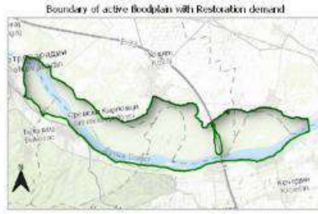
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	high

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_AFP02 — Koviljsko-petrovaradinski rit
Danube

Country: **Serbia**	Type: **active floodplain**	
Floodplain length: **25.2 km**	Floodplain area: **74.8 km²**	
Centroid: **45.195°N 20.028°E**	River kilometre: **1250.7 - 1224.8**	HQ_{100}: **8338 m³/s**

Boundary of active floodplain with Restoration demand



8 km

FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (high)	Water level change (low)	Connectivity of floodplain water bodies (low)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (high)

Additional Parameter Set: Effects in case of extreme discharges; Flow velocity; Existence of protected habitats; Precence of documented planning interests; Bottom shear stress; Vegetation naturalness; Water level dynamics; Potential for typical habitats; Ecological water body status

FEM performance: high / medium / low

FEM-EVALUATION: based on minimum parameters

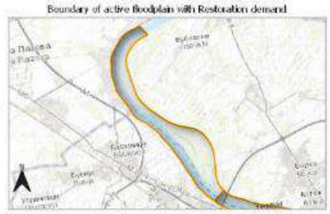
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	low

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_AFP03 — Novi Banovci
Danube

Country: **Serbia**		Centroid: **44.928°N 20.333°E**
Type: **active floodplain**		River kilometre: **1195.5 - 1176.8**
Floodplain length: **17.3 km**	Floodplain area: **27.7 km²**	HQ_{100}: **11265 m³/s**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

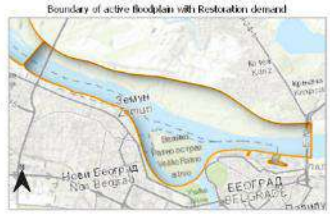
NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_AFP04 — Beograd
Danube

Country: **Serbia**		Centroid: **44.844°N 20.436°E**
Type: **active floodplain**		River kilometre: **1176.8 - 1166.5**
Floodplain length: **10.4 km**	Floodplain area: **18.4 km²**	HQ_{100}: **15261 m³/s**

Boundary of active floodplain with Restoration demand



FEM PARAMETER:
Minimum Parameter Set:

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_AFP05 Pančevo
Danube

Country: **Serbia**
Type: **active floodplain**
Floodplain length: **16.1 km**
Floodplain area: **43.2 km²**
Centroid: **44.829°N 20.616°E**
River kilometre: **1160.9 - 1145.3**
HQ_{100}: **15223 m³/s**

Boundary of active floodplain with Restoration demand

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION	RESTORATION DEMAND
yes	medium

Interreg Danube Transnational Programme Danube Floodplain

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_PFP01 Šiga - Kazuk
Danube

Country: **Serbia**
Type: **potential floodplain**
Floodplain length: **16 km**
Floodplain area: **60.6 km²**
Centroid: **45.775°N 18.919°E**
River kilometre: **1425 - 1409**
HQ_{100}: **7906 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction	Water level change	Connectivity of floodplain water bodies	Potentially affected buildings
Flood wave translation		Existence of protected species	Land use

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Precence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

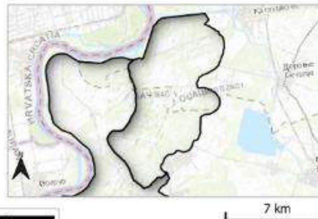
FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Interreg Danube Transnational Programme Danube Floodplain

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_PFP02 Vajska
Danube



Country: **Serbia**	Centroid: **45.455°N 19.11°E**	
Type: **potential floodplain**	River kilometre: **1364 - 1361**	
Floodplain length: **3 km**	Floodplain area: **59.9 km²**	HQ_{100}: **8454 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (low)	Connectivity of floodplain water bodies (high)	Potentially affected buildings (high)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

RS_DU_PFP03 Kamari[illegible]te
Danube

Country: **Serbia**	Centroid: **45.403°N 19.054°E**	
Type: **potential floodplain**	River kilometre: **1361 - 1324**	
Floodplain length: **37 km**	Floodplain area: **100.7 km²**	HQ_{100}: **8415 m³/s**

FEM PARAMETER:
Minimum Parameter Set:

Download detailed report (PDF)
Download floodplain object (ESRI Shape)

Hydrology	Hydraulics	Ecology	Socio-Economics
Peak reduction (low)	Water level change (high)	Connectivity of floodplain water bodies (high)	Potentially affected buildings (medium)
Flood wave translation (high)		Existence of protected species (high)	Land use (medium)

Additional Parameter Set:

Effects in case of extreme discharges	Flow velocity	Existence of protected habitats	Presence of documented planning interests
	Bottom shear stress	Vegetation naturalness	
		Water level dynamics	
		Potential for typical habitats	
		Ecological water body status	

FEM performance: high / medium / low

FEM-EVALUATION:
based on minimum parameters

NEED FOR PRESERVATION
yes

Danube Floodplain
Reducing the flood risk through floodplain restoration along the Danube River and tributaries

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Danube Transnational Programme
Danube Floodplain

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