Flood Hazard and Flood Risk Maps in the Danube River Basin District

ICPDR IKSD

International Commission for the Protection of the Danube River
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Summary report on implementation of Article 6 of the Directive 2007/60/EC in the Danube River Basin District – Update 2020

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1 Introduction

Directive 2007/60/EC on the assessment and management of flood risks (Floods Directive, FD) requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. This Directive also reinforces the rights of the public to access the information on flood risks and on related measures and to influence the planning process.

Member States shall coordinate their flood risk management practices with all countries sharing an international river basin, including non-Member States, and shall in solidarity not undertake measures that would increase the flood risk in neighbouring countries. In addressing the Directive 2007/60/EC the Member States shall take into consideration long term developments, including climate change and sustainable land use practices.

According to FD, the Member States shall, at the level of the river basin district, or unit of management, prepare flood hazard maps and flood risk maps, at the most appropriate scale for the areas identified under Article 5(1).

The preparation of flood hazard maps and flood risk maps for areas identified under Article 5, which are shared with other Member States, shall be subject to prior exchange of information between the Member States concerned.

Flood hazard maps shall cover the geographical areas, which could be flooded according to the following scenarios:

(a) floods with a low probability, or extreme event scenarios;
(b) floods with a medium probability (likely return period ≥ 100 years);
(c) floods with a high probability, where appropriate.

For each scenario, the following elements shall be shown:

(a) the flood extent;
(b) water depths or water level, as appropriate;
(c) where appropriate, the flow velocity or the relevant water flow.

Flood risk maps shall show the potential adverse consequences associated with flood scenarios referred to above and expressed in terms of the following:

(a) the indicative number of inhabitants potentially affected;
(b) type of economic activity of the area potentially affected;
(c) installations as referred to in Annex I to Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;
(d) other information which the Member State considers useful such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution

For coastal flooding where there is an adequate level of protection in place, and for groundwater flooding, Member States can decide to limit the preparation of flood hazard maps to low probability or extreme events (Articles 6(6) and 6(7)).

To address the issue of flood risk management on a basin-wide the International Commission for the Protection of the Danube River (ICPDR) adopted the Action Programme for Sustainable Flood Prevention in the Danube River Basin at the ICPDR Ministerial Meeting on 13 December 2004.

The key milestone in the implementation of the ICPDR Action Programme was the publication of 17 sub-basin flood action plans in 2009. These plans are based on 45 national planning documents and provide the first ever comprehensive overview of actions to reduce flood risk in the Danube Basin. They review the current situation and set targets and respective measures for reducing adverse impacts and the likelihood of floods, increasing awareness and level of preparedness and improving flood forecasting. The targets and measures are based on the regulation of land use and spatial planning; increase of retention and detention capacities; technical flood defences; preventive actions (e.g. flood forecasting and flood warning systems); capacity building; awareness and preparedness raising and prevention and mitigation of water pollution due to floods.

At the ICPDR Ministerial Meeting in 2016, the Danube Declaration was adopted, in which the Danube Ministers recognized that even though floods are natural phenomena which cannot be prevented in their entirety, there is an urgent need to increase the investments in flood risk management as this will reduce the likelihood and severity of negative flooding consequences and – in the long run – be less expensive than compensating for flood damages. To further promote a harmonised Danube basin-wide flood risk management, the Danube countries have developed in 2015 - building on the ICPDR Action Program for Sustainable Flood Prevention adopted in 2004 and the seventeen sub-basin flood action plans published in 2009 - the first Danube Flood Risk Management Plan (DFRM Plan) in line with the EU Floods Directive.

The Danube Ministers endorsed the DFRM Plan and committed to implement the measures foreseen in the DFRM Plan and in their national flood risk management plans. They underlined their common objectives agreed upon for the basin-wide level, i.e. to avoid new flood risks, to reduce existing flood risks, to strengthen resilience against floods, to raise public awareness and to apply the solidarity principle by avoiding exporting of flood problems to neighboring countries. With the measures agreed in the DFRM Plan priority was given to measures with positive downstream effect such as natural water retention, warning systems, reduction of risk from contaminated sites in floodplain areas or exchange of information.

This report informs the European Commission, the stakeholders and public on the achievements made in the international Danube River Basin District in response to the provisions of the Article 6 and Article 14 of FD. It has been prepared using information collected from the ICPDR Contracting Parties through the activities of the ICPDR Flood Protection Expert Group (FP EG).

This report is based on data delivered until 31 December 2020.

In Ukraine, according to the Ukraine-EU Accession Agreement the timetable for the preparation of flood hazard and flood risks maps is 6 years from the entry into force of this Agreement, which is the end of 2020. Ukraine is at present in the first cycle, a new project on flood mapping started in 2020. The data for flood hazard maps will be available by mid-

2022, flood risk maps will be available later. In Moldova, the preparation of flood hazard and flood risk maps has not started yet. The major reasons are the lack of legal instruments requiring development of such maps and also financial constraints. No information about flood mapping was obtained from Montenegro.

2 Flood hazard maps of the 1st cycle of implementation in the DRBD Countries

2.1 Germany

The FD was transposed into German national law in 2009 by means of the amended Federal Water Act (*Gesetz zur Ordnung des Wasserhaushalts* (*Wasserhaushaltsgesetz*) – WHG), with the relevant provisions being identical to those of the Directive. References below to provisions of the FD therefore relate also to the binding provisions of the Federal Water Act as amended.

The German Working Group on Water Issues of the Federal States and the Federal Government (LAWA) adopted at the 139th LAWA General Meeting in Dresden on 25/26 March 2010 the "Recommendations for the Establishment of Flood Hazard Maps and Flood Risk Maps". The Recommendations contain standards so that the process of establishing flood hazard maps and flood risk maps meets the requirements set out in the FD. The aim was to ensure that the content and design of the maps are standardized as far as possible, thus ensuring that the set of maps produced has nationwide coherence. The Recommendations were updated in 2017 in order to improve further the harmonization of the maps.

Flood hazard maps cover all areas of potential significant flood risk (APSFR) which could be flooded according to the following scenarios:

- extreme event scenarios, likely return period = 1000 year or 1.5x HQ_{100} (this very rare event can be defined because different scenarios are included such as a failure of flood protection infrastructure. The comparable localized conditions may also occur even with smaller flood events due to, e.g. relocation of bridges)
- floods with a medium probability (likely return period $\geq$ 100 years),
- floods with a high probability, likely return period = 10 years, according to the LAWA Recommendations for all areas where adverse consequences of flooding are expected.

To calculate the flooding extent digital terrain models based on laser scan data (high resolution on 1m*1m grids or higher) are used in connection with a terrestrial measurement. The flooding models used for hydraulic simulations are mostly 2-dimensional, with steady or unsteady calculation. As up-to-date hydrological statistics are used for the flood hazard maps, climate change impacts that have taken effect to date are included in the data. A specific "climate change" scenario is not included in the flood hazard maps. The maps refer to the flood extent and water depths. Water depth is represented in at least five-tone colour intensity scales with variable colour tone and brightness.

2.2 Austria

According to Austria's Water Act, flood hazard and risk maps were established until the 22nd December 2013. The main goal was to have an effective tool to communicate flood hazards and risk to the public. To provide easy access to the data available all maps were published on the publicly available Water Information System Austria (https://maps.wisa.bmlrt.gv.at/hochwasser, please be aware that the link to the 1st cycle FHRM differs from the link to the 2nd cycle updated FHRM) as a web-GIS-service.
Flood hazard maps outline inundation of low, medium and high probability of flooding. The maps refer to the flood extent, water depths and flow velocities. The flood extent of all scenarios is displayed in one map and referred to by different shades of blue colour. Water depth and flow velocity are categorised in clusters.
On the national level, methods have been agreed upon to obtain uniform maps for the Federal territory. For Austria's APSFRs (and beyond, as Austria decided to prepare maps for all areas where data is available) best available data has been consulted to calculate the flooding extend. Referring to the state-of-the-art digital terrain models based on laser scan data (high resolution on 1m*1m Grids; elevation errors of a few cm) are used in connection with terrestrial measurement in the river stem and two-dimensional hydrodynamic models. In rare cases where these data were not available, information based on 1D models or HORA (natural hazard overview and risk assessment Austria, www.hora.gv.at) had been used. Based on Austrian standards scenarios of a 30-years flood, 100-years flood and 300-years flood had been considered. Information on climate change had been taken into account based on state –of – knowledge studies published during recent years and will be considered in more detail in the frame of the following cycles.

2.3 Czech Republic

Assessing flood danger and flood risk of flood plains is carried out by a risk matrix method. This method does not require a quantitative estimation of the damage caused by flood but expresses flood risk through colour scaling. Whole process is closely connected to the standard database established, operated and administrated within the Czech Republic. These maps will be a base for main goal of FD: to prepare flood risk management plans for areas with significant flood risk.
The input Data are results of hydraulic modelling (1D, 2D): water depths, flow velocity for required flood scenarios with return period 5, 20, 100 and 500 years. Flood Intensity IP is understood as a criterion of flood destructiveness and is defined as a function of the water depth h [m] and water flow velocity v [m/s]. The flood intensity IP calculation has to be performed for all monitored scenarios of flood hazard (according to return periods – usually for 5, 20, 100 and 500 years periods). The results of calculations are raster data in which every raster cell includes information on Flood Intensity for individual scenarios. Flood Danger R_i for a given flood scenario i with the exceedance probability p_i and a return period of N_i years is evaluated using the so-called "risk matrix" based on the calculated flood intensity IP.

Maximal Flood Danger: the next phase means assessing the maximum value of danger R for individual partial dangers R_i corresponding to all hazard scenarios according to the relation:

$$R(x,y) = \max_{i=1}^{n} R_j$$

where n means the number of assessed flood hazard scenarios.

Flood Danger Map is the result of one raster containing maximum values of danger R in the studied area.

Danger R	Danger Category	Recommendation
$R \geq 0.1$ or $IP \geq 2$	(4) High (red color)	It is not recommended to either allow new or extend recent build-up area, where people or animal can live. For recent build-up areas suggest such flood protection, which will reduce risk to acceptable level.
$0.01 \leq R < 0.1$	(3) Middle (blue color)	Development is possible with some restrictions resulted from detailed analysis of potential flood threat. Build-up of sensitive objects (e.g. hospitals, schools, fire station etc.) is unsuitable there. It is not recommended to extend recent build-up area.
$R < 0.01$	(2) Low (orange color)	New development is possible. Estate owners have to be informed about potential flood threat. Sensitive objects have to be protected against flood.
$p < 0.0033$ $(N > 300)$	(1) Residual (yellow color)	Flood protection is solved by long-term planning of land use zoning focused on especially sensitive objects (health care institution, historical objects etc.).

2.4 Slovakia

Slovak Republic transposed FD into national legislation in a frame of the act no. 7/2010 Coll. on flood protection. Article 6 of the Flood Protection Act defines the obligation to present flood hazards caused by floods with return periods of 1000 years (as a flood with a low probability), 100 years (as a flood with a medium probability), 10 years as floods with a high probability. Flood hazard maps delineate flood extent, water depths or water level and flow velocity or discharge distribution.

The Flood Protection Act sets a rule whereby differences of flood extent shown at the flood hazard map compared to the real flood extent in the event of flood of a comparable probability does not constitute a right for claiming compensation to the damages. The areas of potentially significant flood risks caused by groundwater are given low probability on flood hazard maps. The Act complies with the requirements of the Flood Directive that it imposes an obligation to issue the flood hazard maps in transboundary river basin close to state borders following to previous mutual data exchange of bordering countries.

The water management authority responsible for flood risk maps production submits these to state administration and municipal authorities. The flood hazard maps made available to the public through the Ministry of Environment of the Slovak Republic. Municipality and

state administration have a duty to display the flood extent lines at spatial plans in the next update cycle.
Specific rules of processing the flood hazard maps in a framework of the Flood protection Act are set by the Decree of the Ministry of Agriculture, Environment and Regional Development of the Slovak Republic no. 419/2010 Coll.

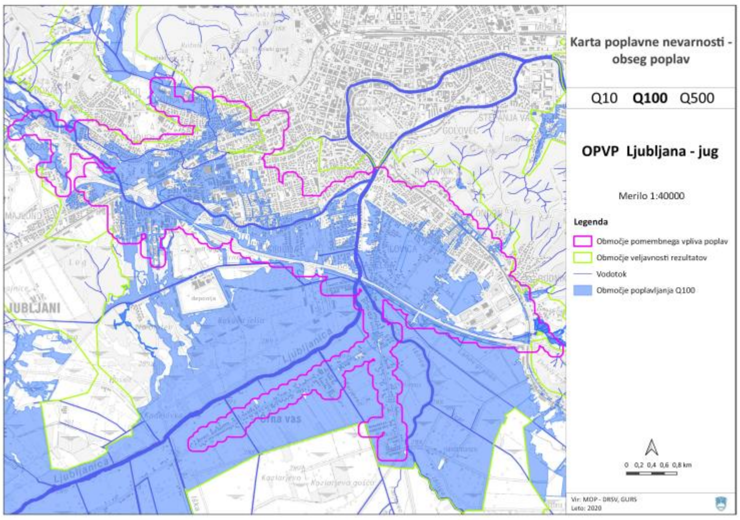
2.5 Hungary

The EU Flood Directive was implemented into the national legislation in 2010 by the 178/2010 (V.13.) governmental act. For the fulfilment of the requirements a national project started with a name “Flood risk mapping and development of strategic risk management plan (KEOP-2.5.0.B)”, also called as “ÁKK”.
The flood inundation analyses are based on a GIS platform-based fully integrated water management tool, where the digital terrain model has a 10x10 m resolution as a raster, but the specific objects (e.g. rivers, dikes, localization roads etc.) are presented as vectors, and burned into the elevation model.
The probable failure points of the dikes were investigated, and the specific flood curves were calculated from the available 80-120 years long data sets to the certain sections of the water outtake. Climate change effects were interpreted in the low probability events. Surface inundation was calculated with 2D numerical models for each floodplain. The hazard maps were exported to 50x50 meter raster layers for visualization, the boundaries were transformed to shape files. The mapping results were constructed in an aggregated form for the (national) Danube, Tisza, Balaton and Dráva sub-basins in line with the river basin management plans. The reporting format is a 1:2.000.000 scale map, but the appropriate view is 1:100.000.
The scenarios for fluvial flooding were likely 30/100/1000-year return probability. The inundation contours represent the three events’ maximum extents, the water depth categories are 0-0.5 m, 0.5-1 m, 1-2 m, 2-3 m, 3-5 m, >5 m. The velocities were quite low and considered not important in regard with the inundation hazard, so they were not indicated. The risk analysis is based on the water depth.
The effects of the groundwater floods are represented by the low probability events (Article 6.7) that have been extracted from the real observed inundations in the last decades.
The recent flood events and especially the Danube flood in June 2013 pointed out the necessity of a new statistical calculation of the design flood events. Furthermore, new terrain data is being incorporated into the existing surface models. The hazard and risk maps will be fine-tuned based on the new data sets during the flood risk management planning that was conducted in 2014-2015.

2.6 Slovenia

FD requirements concerning flood hazard and risk maps were transposed with a Decree on establishment of flood risk management plans (Official Gazette of the RS, No. 7/2010). This Decree refers to the Rules on methodology to define flood risk areas and erosion areas connected to floods and classification of plots into risk classes (Official Gazette of the RS, No. 60/2007), which define standard flood hazard scenarios by discharges with a 10-, 100- and 500-year return period, and since 2007 those scenarios are used in the process of flood modelling and hazard mapping for defining the spatial conditions and limitations for constructions and activities on flood risk areas. Preliminary flood risk assessment of the 1st

cycle of the FD implementation specified 61 APSFRs in Slovenia, and already available mapping data were collected for approximately half of the APSFRs and the remaining flood hazard maps were created afterwards to map the remaining, previously unmapped APSFRs. Flood mapping is generally based on one-dimensional hydrologic models for simulation of the rainfall-runoff processes, requiring meteorological, basin and controlling input components, and two-dimensional hydrodynamic models using mainly DTM1 derived from LiDAR survey data with the elevation accuracy of about 5 cm, as well as terrestrial survey of the river stream and hydraulically significant objects.
Flood hazard maps for each APSFR were created for three different flood scenarios (for discharges with 10-, 100- and 500-year return period flood scenario). For each flood scenario flood hazard maps showing flood extent, flood depth (flow depth is shown in classes of 0m, <0,5m, 0,5m-1.5m and >1.5m) and flow velocity were prepared.
Raising awareness objective is being achieved by publishing all the available flood hazard maps (not only ones done for the implementation of the 1st FD cycle) in the Slovenian Water Management Atlas (https://gisportal.gov.si/atlasvoda). Each individual flood hazard map is also publicly available on the homepage of the Ministry of the Environment and Spatial Planning (https://www.gov.si/teme/nacrt-zmanjsevanja-poplavne-ogrozenosti/).
For the purpose of the 2nd FD implementation cycle all of the flood hazard maps from the 1st FD cycle were checked, revised and done in a methodologically (colours used, legend, title, etc.) consistent way. Some of the APSFRs were changed (APSFRs were either reduced or enlarged) in the 2nd FD cycle so the mapping and flood hazard maps had to be appropriately adjusted.



Flood hazard map for Ljubljana-South APSFR.

2.7 Croatia

Flood hazard maps are primarily designed for clear communication of flood hazards to the public. For each APSFR, four maps will be delivered. First map depicts flood extents of all three scenarios overlapping. Other three maps display water depths for three scenarios as required by FD. Water depths are grouped in four categories (0-0.5, 0.5-1.5, 1.5-2.5 and >2.5 m). On all four maps, areas, which are not designed in this planning cycle as APSFR, are shaded. Maps are formatted in A3 landscape sheets with a scale of 1: 25 000 and available to the public free of charge from the web. Flood hazards are defined by use of 1D and 1D-2D hydraulic models and by other tools in certain special cases. For modelling purposes, DTM is provided by State Geodetic Administration of the Republic of Croatia.

2.8 Serbia

The FD was transposed into national legislation by the means of the Law on Water and bylaws containing methodologies for preparation, review and update of the preliminary flood risk assessment and flood maps.

Methodology for the development of flood hazard maps in Serbia has been defined in a rulebook adopted as a bylaw[1], which was published in 2017. Preparation, review and update of flood hazard maps for the APSFRs identified in the preliminary flood risk assessment are responsibility of public water management companies.

Flood hazard maps in case of fluvial floods are necessarily prepared for the:

- low probability flood scenario (likely return period of 1000 years) and
- medium probability flood scenario (likely return period of 100 years).

Flood hazard maps in case of fluvial floods may be prepared for a high probability flood scenario (likely return period of 10, 20 or 50 years), depending on characteristics of watercourses and flood protected areas), where necessary.

1-dimensional hydraulic models with simulation of steady or unsteady flow is recommended for computation of water levels, taking into account the existing flood protection infrastructure and by using terrestrial survey of river streams. Water levels are then projected to the digital terrain model of floodplains having sufficient accuracy to define flood extent for each scenario. This way the maximal extent of flood prone areas is obtained. Water depth is displayed in four categories (<0.5, 0.5-1.5, 1.5-4 and >4 m).

Flood hazard maps necessarily show position of flood protection structures and may show water velocities.

In the period prior to the first DFRM Plan, flood hazard maps were prepared within the EU funded projects - Danube FLOODRISK, 2009-2012 (the Danube River upstream of the City of Belgrade) and Study of Flood Prone Areas in Serbia, Phase 1 - SoFPAS 1, 2010-2012 (the Danube through and downstream of the City of Belgrade to Golubac and rivers in the Velika Morava River basin: Velika Morava, Južna Morava, Zapadna Morava, Ibar, Nišava and other 18 rivers) and project co-financed by Swedish EPA in 2010 (the Tamnava and Ub rivers in the Sava River basin).

All maps were prepared by using previously described methodology, which was later adopted within a bylaw. Due to financial constraints, lidar surveys were not possible and DTM was produced by digitalisation of topographic maps 1:25,000 scale and then adjusted by using the available aerial or satellite data, digitalized maps of 1:5,000 scale, additional terrestrial surveys and the like. Thus, DTM had vertical accuracy of approximately 0.50 m at the 95% confidence level or RMSE of 0.25 m. Q100 and Q1000 were defined using one flood peak data per year, in the period 1950-2006, and LP III distribution. Impacts of the climate change were not considered. Flood hazard maps for the rivers with catchment areas above 4000 km^2 were delivered to the ICPDR in the first cycle of the DFRM Plan.

[1] Rulebook on determining the methodology for development of flood hazard maps and flood risk maps, with the methodology for development of flood hazard maps and flood risk maps, Official Gazette RS, 13/2017

Preparation of flood hazard maps for the identified APSFRs has continued to date, which is described in chapter 5.8 of this report.
Although the rulebook states that flood maps should be prepared for floods caused by excess inland waters (pluvial floods and floods caused by high groundwater level) and in case of a dam break, preliminary flood risk assessment in both cycles has only identified APSFRs where floods originate from rivers. PFRA has recognised that damages due to excess inland water are possible especially in the valleys of the rivers where drainage systems are present. However, these areas will be encompassed by flood extent of fluvial floods and therefore currently it is considered that it is not necessary to prepare additional maps in case of excess inland water. Potential dam break is recognised as a significant threat, however, this issue should be treated independently from the PFRA due to confidentiality issue and therefore no APSFRs were identified based on this cause.

2.9 Bosnia and Herzegovina

The EU Flood Directive requirements are transposed into the legislation of both entities in B&H.
The Federation B&H Government implemented the FD by adopting the Regulation on the types and contents of the plans for protection against harmful effects of water ("Official Gazette FBiH", No. 26/09), Republika Srpska by adopting the Regulation on content and key elements of flood risk assessment and flood risk management ("Official Gazette of Republika Srpska", No. 115/17), while in Brčko District a Regulation has not yet been adopted.
According to FD requirements, first step for the preparation of flood hazard maps and risk maps was adopting the areas of potential significant flood risk (APSFRs). APSFRs came as a result of Preliminary Flood Risk Assessment (PFRA). Although different methodologies were applied, PFRA has been developed for the whole country. For Federation of B&H, PFRA have been developed in 2013, for Republika Srpska in 2014 and for Brčko District in 2015.
Flood Hazard and Risk Maps Project in Bosnia and Herzegovina (FHRM) is currently implementing by WYG - IPF5 Consortium, contracted by the European Investment Bank (EIB) funded by the regional EU IPA II Multi-Beneficiary Programme. The Project foresees detailed hydraulic modelling of 129 APSFR. The expected results of the FHRM include flood hazard and flood risk mapping of APSFR for the whole country. The methodology for flood hazard and risk mapping will be in accordance with the FD. Expected completion date of the Project is January 2020.
Project scope is indicated in following table:

Entity	Count of APSFR	LiDAR surveying (km^2)	Lengths of the rivers to be modelled (km)
BD	2	111	128.3
FB&H	76	2730	1075.2
RS	51	2649	1160.4
Total	129	5490	2363.9

Process of FHRM consists of three steps:

1. Hydraulic modelling based on:
   - a digital terrain model incorporating aerial surveys (LiDAR) of the flood zones (APSFR) complemented where necessary by land surveys of river and flood plain cross-

sections, and hydraulic structures, with achieved accuracy vertical and horizontal ±10 cm.

- a quality assured georeferenced database of hydrologic and hydraulic data,
- calibrated and verified hydraulic models of the flood zones (APSFR),
- model simulations of Q_{20}, Q_{100} and Q_{500} design floods, i.e.
    - Extreme event scenario - floods with a low probability (return period 500 years);
    - Floods with a medium probability (return period 100 years);
    - Floods with a high probability (return period 20 years).

Hydraulic models are 1-dimensional or 2-dimensional, i.e. steady and unsteady calculation. Design peak discharges with return periods of 20, 100 and 500 years are based on hydrological models. The nature of those models depended upon the lengths of available data records. Two broad classes of models were applied: statistical models and rainfall-runoff models

2. Hazard mapping was done for all three scenarios (Q_{20}, Q_{100} and Q_{500})

Flood hazard is represented by a combination of modelled velocity and depth according to following formula:

$$O = h \bullet (v + 0.5)$$

where:

O – Flood hazard

h – Flood depth (m);

v – Flood velocity (m/s);

0.5 – Still water correction constant.

Flood hazard level are divided into four hazard severity classes:

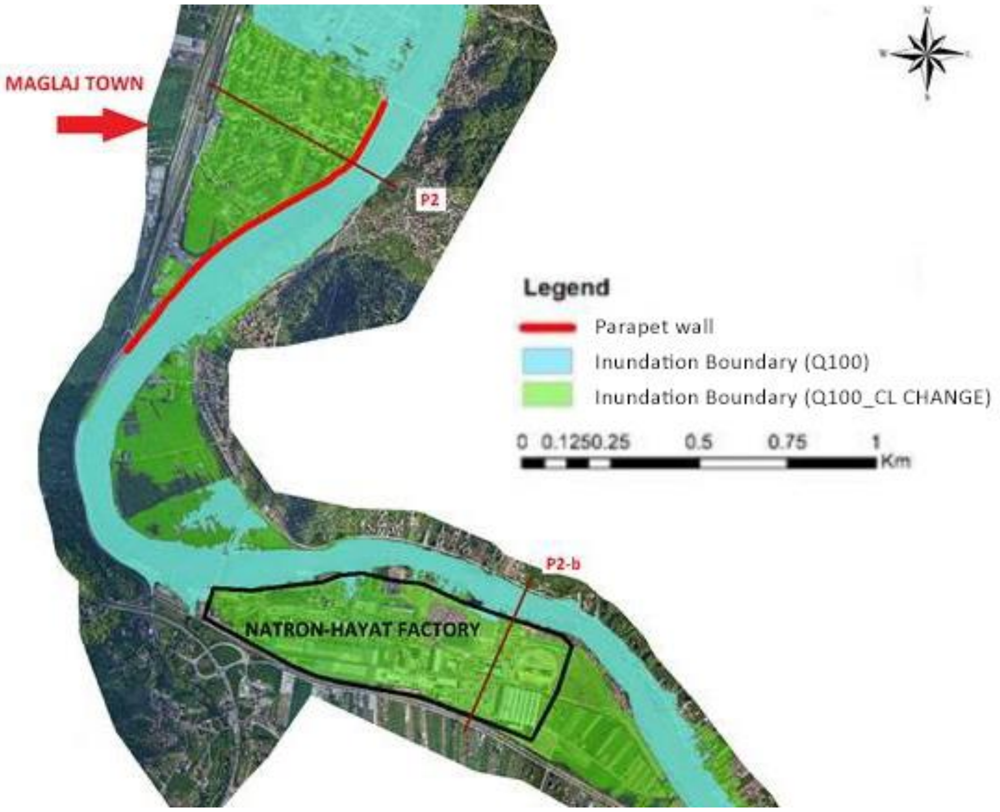
Category	O ≥	O ≤	Description
Category	0.00	0.75	Insignificant hazard
Category	0.75	1.50	Hazard to vulnerable minorities (children, elderly, sick, non-swimmers)
Category	1.50	2.50	Hazard to the majority
Category	2.50	25.00	Hazard to all

3. Risk mapping (see chapter **Error! Reference source not found.**)

Climate change impact

To assess the potential impact of future storms on floods in BiH, an existing HEC- HMS hydrological model of the Sava River basin, including the tributaries in BiH, was used. The assessment of the climate change impacts on the 100-year peak discharges (Q100s) in the BiH catchments necessitated the estimation of the potential climate change impacts on the design storms (P100s) on precipitation stations used in the HEC-HMS model.

1D hydraulic modelling of a pilot section of the Bosna River was carried out. The pilot river section was 51.5 km. The aim of the modelling was to identify which locations along the river are most vulnerable to future 100-year design discharges. A climate change scenario with 17% increases Q100 design floods was chosen, based on the 75th percentile increases in Q100 (14% during 2006-2056, 16% during 2036-2065, 19% during 2066-2095) in the Bosna catchment under RCP 4.5. Illustrative example of the differences in Q100 increase are presented in figure below.



Differences between Q100 and Q100 climate change scenario on one section along Bosna river

2.10 Romania

Development of flood hazard maps is carried out using an integrated system containing databases, digital maps in GIS and a specialized software.

GIS database has been created by collecting, processing and storing information and data required for (i) the topography and cartography of flood hazard areas, (ii) river basin characterization by geological, geomorphological, hydrogeological, hydrological, meteorological, land use and other information needed for improvement of watercourses, (iii) riverbed deforestation as well as afforestation/deforestation of slopes, (iv) anti-erosion and maintenance works on torrential valleys, (v) earthworks, (vi) construction in the floodplains changing vertically and/or horizontally the topography of the river.

The development of flood hazard map contains topographic, geodetic, hydrological and hydraulic studies, achievement of other complementary studies, and preparation of flood hazard maps showing floodable zone limits. Flood hazard maps are presented as hard-copy, usually in 1:25,000 scale (more detailed scales are used at local level).

Flood hazard map for each probability of exceeding the maximum flow shows the following elements: (i) flooding limit, which is the extension of water for each case (exceeding probabilities 0,1%, 1% and 10%, (ii) water depth (below 0,5 m, between 0,5-1,5 m and over 1,5 m). The water depth for each exceeding probability is shown in different shades of blue (from dark blue for large depths to light blue for small depths).

Flood hazard maps contain the following basic information: title (including the name of the river and river sector), scale, characteristics of flooding (limits, water depth, including water speed for 2D modelled areas), legend, class or interval for numeric values, geographic coordinates in Stereo projection system 70 and benchmark Black Sea 75, responsible authority and issuing institution, medallion presentation at reduced scale of the entire basin with location of analysed area.

2.11 Bulgaria

The flood hazard maps in Bulgaria are prepared according to the national methodology, developed by the National Institute of Meteorology and Hydrology and have been endorsed by the Minister of Environment and Water in April 2013. In line with the national legislation, flood-hazard maps include flood-scenarios with return periods 20, 100 and 1000 years.
The methodology defines the requirements for all type of data used for the mapping: hydrological data and methods of calculation; cross-section's measurement; terrain models. For the water-level calculation most commonly 1D-modelling is used, but for some river sections (where it is appropriate) 2D-modelling is applied.
For each APSFR, a flood-extent map indicating the inundated areas for all three scenarios was prepared. A flood depth map, showing the water depth by shades of blue colour in classification-boundaries 0; 0.5; 1; 1.5; 2; 2.5; 3 and 4 m was prepared for each scenario. A flood-danger map presenting the level of the flood–danger in different colours depending of the flood depth is to be prepared for each flood-scenario. Four levels of flood danger are determined:

Depth [m]	Danger-level	Map-colour
< 0.5	Low	green
0.5 ÷ 1.5	Middle	yellow
1.5 ÷ 2.5	Significant	orange
> 2.5	Very high	red

Additionally, where it was considered as appropriate (i.e. when 2D-modeling has been applied), a map representing the flow-direction and the flow-velocity is prepared. The flood-velocity is displayed by color arrows in three classes: 0.2 - 0.5 m/s (green); 0.5 - 2 m/s (yellow); >2m/s (red)
Flood hazard maps are presented in a scale 1: 2500 ÷ 1:10000 depending on the specifics of the mapped area.
The flood maps for all APSFR in Bulgaria (except The Danube) are prepared in the frame of the project "Development of Flood Risk Management Plans" funded by the Operational Program "Environment". The flood-hazard maps for the Danube River have been elaborated under the DanubeFloodrisk project according to the commonly agreed methodology and in close coordination with the Romanian partners.

3 Flood risk maps of the 1st cycle of implementation in the DRBD Countries

3.1 Germany

Flood risk maps are prepared for the same flood scenarios on the basis of the flood hazard maps. They show not only the flood hazards (extent of flooding) but also the adverse consequences of flooding.

The basic data for the number of potentially affected inhabitants are the number of inhabitants in each municipality (statistical data) and land use data (ATKIS-DLM or ALK/ALKIS). As a general rule, inhabitants' affectedness can be taken as a given if the inundation area overlaps with an area of housing or mixed use. The indicative number of inhabitants potentially affected can be determined by assuming that the inhabitants of a municipality are evenly distributed throughout the specified areas.

The type of economic activity can be derived from the ATKIS-Basis-DLM object types. The individual areas, groups and types of object must be summarized in categories. At least following categories are used, in addition to areas of water:

- housing and mixed use:
- industrial and commercial areas, areas of a special functional character
- all types of object of relevance to transport
- agriculture
- forestry
- all water-related object types
- all other object types

Installations of the types listed in Council Directive 2010/75/EU of 24th November 2010 that are located in inundation areas are included on the maps. Where this data is not available, the installations that are listed in E- PRTR or in Annex I of Council Directive 96/61/EC are used.

Bodies of water which, pursuant to Article 7 of the Water Framework Directive (WFD), are used for the abstraction of water intended for human consumption, bathing waters and protected areas under the Habitats Directive and bird sanctuaries are shown as protected areas.

Sites of particular cultural relevance (UNESCO world heritage data and if applicable museums, archives and cultural heritages from specific importance) are also included in the flood risk maps.

3.2 Austria

The main goal of Austria's flood risk maps is to communicate the risk and residual risk (where measures, which might be overtopped or might fail, are already implemented) to the public. Therefore, the maps need to be understandable and interpretable based on the information displayed in connection with the explanation provided.

The indicative number of inhabitants affected had been assessed by means of building register data, which is available on a daily basis considering inhabitants and employees. People exposed are displayed on municipality level in clusters of <50; 50 – 500; 500 – 5000 and > 5000, respectively. The type of economic activity affected is assessed based on Corine

Land Cover (2006) data, NAVTEQ data, data on infrastructure and UNESCO world heritage data. The location of IPPC installations is outlined based on the E-PRTR register and information on relevant landfills. The impact on WFD protected areas is assessed for protected areas, Natura2000 areas, national parks and bathing freshwater. Other information considered relevant are areas with floods with increased sediment transport (e.g. Alpine areas) or debris flow.

3.3 Czech Republic

Risk maps combine information about hazard and about vulnerability of objects in floodplains. Information about vulnerability is obtained from land use zoning plans, general maps and fieldwork. Based on this information classes of functional land use are set (see the column „Functional regulation“ in the Table below). The value of maximum acceptable risk is determined for each of the classes. Risk maps show areas where the maximum acceptable risk is exceeded. In these areas, the values of hazard are expressed based on the classification and description of hazard in floodplains using the Risk Matrix method.
Table: Classes of functional land use according to land use zoning plans

Notation	Functional regulation	Maximal acceptable hazard
BY	**Living**	**Low**
DO	**Transport and technical infrastructure**	**Low**
OV	**Civic amenities**	**Low**
VY	**Production**	**Low**
ZV	**Agricultural production**	**Low**
SR	**Sport and collective recreation**	**Middle**
LE	**Forests, greenery**	High
OP	**Arable land, meadows, grazing**	High

The methodology is focused on risk analysis in floodplains. It determinates the usable source of data in the Czech Republic, the procedures and methods for the assessment of flood hazard consequences. The methodology will be included in a Directive of the Ministry of Environment of the Czech Republic and in some other legislative and economic directives.

3.4 Slovakia

The legal framework for the elaboration flood risk maps is defined by the Flood protection Act no. 7/2010 Coll. The Article 7 thereof sets the content of the flood risk maps i.e. the flood extent of modelled scenarios, the number of affected inhabitants, types of economy activities, localities with industrial activities that potentially could cause water pollution accidence, localities of water use for consumption and recreation, localities of bathing waters, information about potential contamination of waters on a case of flooding and localities of the national nature conservation and those under NATURA 2000. The flood risk maps are elaborated following to a previous mutual exchange of data between neighbouring countries for the areas of potentially significant flood risks located close to the state border.

Specific rules of the flood risk maps elaboration and processing are set by the Decree of the Ministry of Agriculture, Environment and Regional Development of the Slovak Republic no. 419/2010 Coll. The Flood protection Act and the Decree define as subsequent type of flood hazard map the inundation maps, that are issued by the water management authority and provided to the state administration and municipality with the aim to define the areas of potential flood extent and applied inundation areas in a frame of spatial planning. For these areas, the Flood protection Act very strictly defines the prohibited and permitted activities as a tool for elimination of potential damages.

3.5 Hungary

Based on the different scenarios' extents the necessary risk evaluation was carried out in separate maps for proper visualization.

- Population affected: estimated number of inhabitants who live in settlements that are spatially overlapping with the inundation (2001 data). The indication of the value is the size of the dot mark.
- Economic activity: the classification is based on the CORINE land cover data set. The important roads and railways, SEVESO objects, power plants, sewage treatment plants, harbours, airports and other industrial facilities were added from the river basin management plans.
- IED installations: E-PRTR facilities were taken in account on the maps with harmonized classification.
- WFD protected areas: updated data from the river basin management plans were used, such as freshwater sources, recreational areas and protected landscapes. The surface water affected groundwater is also presented.

3.6 Slovenia

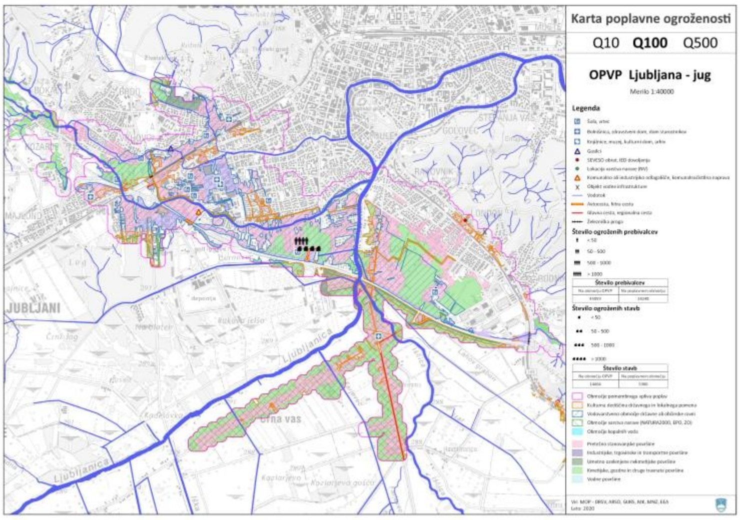
For each APSFR from the 1st cycle of the FD implementation three flood risk maps were created. One for the 10-year return period (high probability) flood scenario, one for 100-year return period (medium probability) flood scenario and finally one for the 500-year return period (extreme or low probability) flood scenario. Maps were done in line with the requirements of the Decree on establishment of flood risk management plans (Official Gazette of the RS, No. 7/2010) and Rules on methodology to define flood risk areas and erosion areas connected to floods and classification of plots into risk classes (Official Gazette of the RS, No. 60/2007).

Flood risk maps initially show the endangered residential, industrial, traffic and economy areas by using the Corine Land Cover data. Flood risk maps also show number of endangered people and buildings for each of the flood scenarios. Additionally, the following official national databases were used to be shown on the flood risk maps:

- Central population register and Business Register of Slovenia combined with Register of spatial units,
- Building cadastre and Real estate register,
- Cultural heritage register,
- Register of Natura2000 areas,
- Register of protected areas,
- Register of ecologically important areas,

- Register of natural values,
- Register of water protection zones,
- Register of bathing water areas,
- IED (IPPC and SEVESO) register,
- Cadastre of public infrastructure (2011) and
- other relevant national databases defining locations of schools, kindergartens, hospitals, health resorts, retirement homes, archives, museums, libraries, emergency and rescue services, etc.

For the purpose of the 2nd FD implementation cycle all of the flood risk maps from the 1st FD cycle were checked, revised and done in a methodologicaly (colors used, legend, title, etc.) consistent way. Some of the APSFRs were changed (APSFRs were either reduced or enlarged) in the 2nd FD cycle so the flood risk maps had to be appropriately adjusted.
Raising awareness objective is being achieved by publishing all the available flood risk maps in the Slovenian Water Management Atlas (https://gisportal.gov.si/atlasvoda). Each individual flood risk map is also publicly available on the homepage of the Ministry of the Environment and Spatial Planning (https://www.gov.si/teme/nacrt-zmanjsevanja-poplavne-ogrozenosti/).



Flood risk map for Ljubljana-South APSFR

3.7 Croatia

The main purpose of flood risk maps is to enable as clear communication to the public as possible. For each APSFR three maps, one for each scenario is delivered. Potentially affected people are displayed on settlement level as symbols, grouped in four categories (0, 1-100, 100-1000, >1000 inhabitants). Locations with a significant number of more vulnerable population such as hospitals, elementary schools, pre-school institutions and homes for elderly are marked as symbols. Economic activities and land cover is displayed in flooded areas only and grouped in five categories (residential areas; significant economic activities and industry; agriculture; forests and other natural areas; water). Potential significant polluters, the IPPC and SEVESO II installations, waste dumps and wastewater treatment plants are displayed as symbols. Significant transport infrastructure and other landmarks are included being not only risk receptors but also serving as an aid for the orientation for general public. Maps are formatted in A3 landscape sheets in a scale of 1: 25 000 and available to the public free of charge from the web. Main data sources for flood risk maps are the population census 2011, land cover from various sources, Register of protected areas and other official spatial databases with national coverage.

3.8 Serbia

Methodology for the development of flood risk maps in Serbia has been defined in a rulebook adopted as a bylaw, which was published in 2017. Preparation, review and update of flood risk maps for the APSFRs identified in the preliminary flood risk assessment are responsibility of public water management companies.
According to the methodology, risks for the inhabitants, residential buildings, infrastructure, economic activities, protected areas, cultural heritage and potential pollutants within the flood extent defined by flood hazard maps are assessed based on the data collected from the competent institutions and they include:

- administrative boundaries of the local government units, cadastral municipalities and settlements, number of inhabitants (by age and gender), facilities housing vulnerable population groups (hospitals, schools, kindergartens, nursing homes, etc.) including their capacity,
- industrial, commercial and service activity units, roads, railways, bus and train stations, airports, river docks, energy infrastructure (substations, gas, oil, product and heat pipelines, etc.), telecommunication infrastructure,
- agricultural areas, forests and other natural areas,
- hydraulic structures, facilities important for organisation and implementation of flood defence and of the activities during emergency situation (levee guard houses, warehouses for flood defence equipment, fire and police stations, military barracks),
- protected areas identified according to the Law on Water and Law on Nature Protection, protected cultural heritage identified according to the Law on Cultural Property,
- installations undertaking the industrial activities which are required to operate in accordance with a permit (IED installations), facilities (and activities) where storage, use, production or handling of hazardous materials is carried out (Seveso facilities), sewage treatment plants, solid waste sanitary landfills and abandoned mine tailings dumps.

Prior to the adoption of the official methodology flood risk maps were prepared within the projects (mentioned in chapters 2.8 and 5.8) which applied different methodologies.

3.9 Bosnia and Herzegovina

Flood risk maps are to be prepared for all 129 APSFRs through FHRM Project, for the same flood scenarios indicated in chapter **Error! Reference source not found.**, based on the flood hazard maps. Flood risk maps will show not only the flood hazards (extent of flooding) but also the adverse consequences of flooding associated with flood scenarios.
The methodology applied recognises five risk categories: 1. people, 2. economy, 3. protected areas, 4. cultural and historic heritage and 5. IPPC installations.
Within each category, subcategories will be defined and assigned weight factors. Risk category classes are presented below.

Population

FR	Class
0-50	0
50-500	0,25
500-1000	0,5
1000-1500	0,75
>1500	1

Economy

FR	Class
0-500	0
500-3500	0,25
3500-7000	0,5
7000-10000	0,75
>10000	1

Protected areas

FR	Class
0-500	0
500-1500	0,33
1500-2500	0,67
>2500	1

Kultural and historic heritage

FR	Class
0-50	0
50-250	0,33
250-500	0,67
>500	1

IPPC instalation

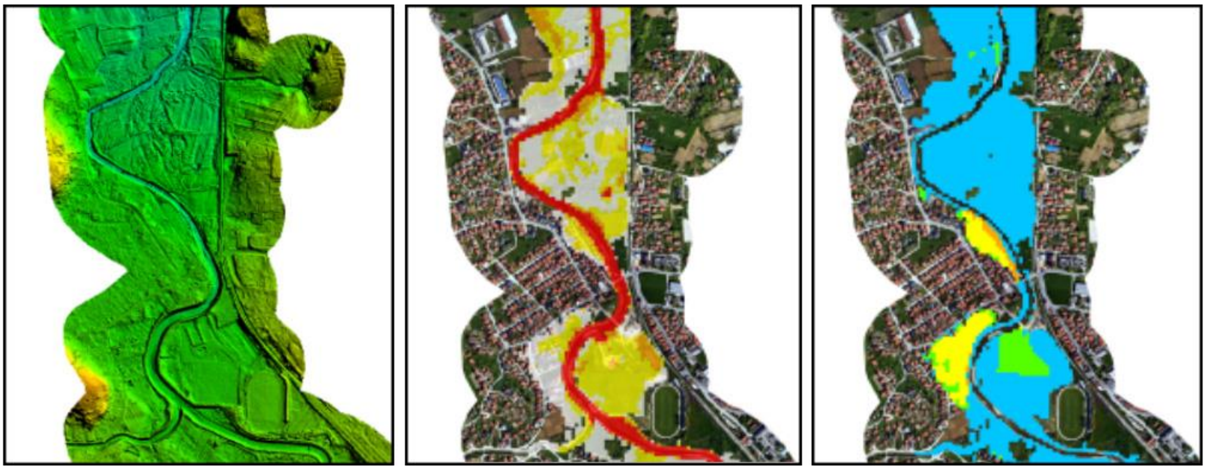
FR	Class
0-150	0
150-300	0,5
>300	1

So, five thematic risk maps can be prepared.

$$Risk = \sum n \bullet Weight \bullet Hazard$$

where n is subcategory. The calculated risk is normalized, where minimal, or no risk is 0 value and maximal risk is 1.

In addition, map of final (total risk) will be prepared. For all five categories, weight factor was assigned so that maximal risk is 1 and no risk is 0 value. All risk calculations results will be presented on 10x10 m grid. An example of proposed visualisation of calculated risks for Tinja River is presented in the Figure below.



Hybrid DTM   Hazard map   Risk map - total risk

3.10 Romania

Development of flood risk maps is based on flood hazard maps and data analysis of the exposed elements and their vulnerability (people and property that may be affected by flooding).

The risk is quantified based on functions "depth - damage”. Qualitative assessment is based on risk classes function of the exceeding probability of maximum flow and water depth in the flooded area.

Developing flood risk maps at the county level consists of: (i) making map of flood limits for discharges with different probabilities of exceeding, (ii) determining potential affected targets, (iii) assessment of hazard vulnerability of the exposed objectives, (iv) estimation of potentially affected population (numerically), (v) assessment of quantitative or qualitative risk depending on the vulnerability of the exposed elements and hazard characteristics, (vi) establishing the GIS database of flood risk at the county level and detailed map of flood risk at the local level.

Producing risk maps includes identifying of following risk receptors: human settlements, potentially affected population, economic and social units: hospitals, schools, industrial plants, water treatment plants, infrastructure: airports, roads, railways, railway stations,

bridges, hydraulic structures, forests, wetlands, IPPC installations, cultural heritage, monuments and archaeological sites.
Vulnerability assessment is made taking into account the water depth and produced damages. The ranges of values of water depth that will determine vulnerability of floodplain property are: water depth below 0.5 m, between 0.5 m and 1.5 m and more than 1.5 m.
GIS database related flood risk map is created by collecting, processing and storing information and data on flood hazard maps, flood hazard exposed elements (buildings, land, etc), present use of the main floodplains (residential, industrial and agricultural areas, forests, dams and water supply networks, sewers, pumping stations, roads and railways, electrical and telephone lines, dams and other objects that may be affected), evacuation areas and the ways of access.
The county flood risk map is developed at 1:25,000 scale and for regional and local level at the appropriate scale. Surveying and mapping base for flood risk map uses the projection system Stereo 70 and the baseline Black Sea 75.
Flood risk map is produced for the exceeding probability of 10 %, 1 % and 0.1 % flows at least, depending on the importance of the objectives in the area of risk and compliance with the classes and the corresponding importance thereof.
Flood risk map covers mainly the following delineation of flood risk areas: major risk areas (areas where a definitive construction ban should be set), medium-risk areas (areas to be protected by structural and non-structural measures), low risk areas (where the damage is low and measures are required only locally). The colours used to represent the three areas of flood risk maps are: red for high, orange for medium and yellow for minor risk areas.

3.11 Bulgaria

According to the adopted national methodology, risk maps are prepared for each flood-scenario (20, 100, 1000 years) for all APSFR. The risk maps indicate:

- Number of inhabitants potentially affected, classified in four classes (<100; 101-2000; 2001-10000; >10 000); represented by symbols;
- Type of economical activity (out of eight main types) demonstrated by colour polygons by type of activity; potentially affected area is calculated for each type;
- Pollutants affected - in two types: IPPC- installations; other potentially polluting installations;
- Protected areas – Natura2000 sites; other national protected areas;
- Cultural objects –UNESCO world heritage sites; Cultural objects of national significance;
- Other critical infrastructure objects (hospitals; schools; railways; state-administration buildings; police stations; railway stations; etc.)

The flood-risk maps were prepared within the project “Development of Flood Risk Management Plans” funded by the Operational Program “Environment”.
The flood-risk maps for the Bulgarian Danube stretch have been developed under the Danube Flood risk project. The methodology on risk assessment used in the project is similar to the national one and the results of the flood risk assessment at the national level are sufficiently comparable with the project results.

4 Flood maps for the DRBD

4.1 Transboundary cooperation in DRBD

The technical cooperation in implementation of FD at the level of DRBD is carried out by the ICPDR Flood Protection Expert Group (FP EG). The FP EG meets twice a year to discuss the modalities of FD implementation. The preparation of flood hazard and risk maps on the level A according to the FD Article 6 has been discussed by the FP EG since 2010 and it was a follow-up process to the concept of minimum recommendations for flood risk mapping in the Danube River Basin agreed by the ICPDR in 2007 in the frame of implementation of the ICPDR Action Programme for Sustainable Flood Protection in DRB adopted in 2004. In September 2012, an ICPDR Workshop on Flood Hazard and Flood Risk Maps for the Danube River Basin District was organized having the following objectives:

- To present the views of the European Commission and international river basin commissions in responding to the requirements of the Article 6. of the Directive 2007/60/EC.
- To review the current status of the preparation of flood hazard and flood risk maps at the national level.
- To discuss the modalities of reporting to EC by the international river basin commissions in relation to Article 6. of the Directive 2007/60/EC.
- To further discuss the flood hazard and flood risk maps for the Danube River Basin District (level A) proposed at the 21st FP EG meeting and the availability of the necessary data.
- To examine the modalities of collection of the national data for preparation of flood hazard and flood risk maps for the Danube River Basin District.
- To agree upon the time plan for map preparation and for reporting to EC.

At this workshop, the general design of the flood hazard and flood risk maps has been agreed by the FP EG, which was then adopted by the ICPDR at the 15th Ordinary Meeting in December 2012.

4.2 Flood hazard map

MAP 1 Hazard and flooding scenarios

The agreed format is as follows: A3 map of flood hazard and flooding scenarios, showing the DRBD and rivers with catchment areas >4000km^2, lakes >100km^2, transitional and coastal waters. The large flood hazard areas are reported and displayed as polygons, while smaller areas are reported as lines or points (the same criteria as used for the APSFR map[2]). The map shows the flood hazard area polygons using zero outline thickness.

The ICPDR agreed that two scenarios (flood hazard areas with medium and low probabilities) are relevant for the level of the international river basin district. Red color is used on the map for the low probability floods (extreme events) and orange color for the medium

[2] Areas >=100km² as polygons, areas < 100km² and river stretches >= 50 river-km as lines, and areas < 100km² and river stretches < 50 river-km as points

probability floods. Medium probability scenario is shown on top of the low probability scenario, so in some cases it can overlay the low probability scenario. If no information is available, the whole country's area is displayed with a grey overlay.

The national definitions of floods with medium and low probability are as follows:

Country	Medium probability	Low probability
DE	HQ100	HQ1000 / HQextreme
AT	HQ100	HQ300
CZ	HQ100	HQ500
SK	HQ100	HQ1000/extremely dangerous flood
HU	HQ100	HQ1000
HR	HQ100	HQ1000 with no flood protection facility, protected systems considering dike failure
SI	HQ100	HQ500
RS	HQ100	HQ1000
BA	HQ100	HQ500
BG	HQ100	HQ1000
RO	HQ100	HQ1000
UA	HQ100	HQ500
MD	HQ10-20	HQ100

Some countries announced problems with the agreed catchment threshold as the most significant inundation areas are not located on the major rivers and will therefore not qualify for the level A map.

The ICPDR discussed the issue of the application of the catchment size threshold and agreed that the level A map has to show all inundated areas placed on the river network with catchments >4000km^2 and can also show the significant inundation areas in the smaller catchments if a country decides for such option. In such a case, an explanation has to be provided on the map - that the areas which are not placed on the displayed river network, are on the rivers with catchments <4000km^2, and are being considered to be of a major importance at the national level.

4.3 Flood risk maps

MAP 2 Risk and population

The agreed format is as follows: A4 map on Risk and population is prepared using white background and showing country borders, the DRBD, the Danube River and country capitals.

The number of affected population in each country is shown by a bar chart with 3 bars per each country (one bar for each scenario). 2D bars are used, data for high probability scenario are shown on the left side of the graph and the number of affected population is indicated in the bars in thousands for each scenario. If the number is less than thousand then the label “<1000” is displayed. If no data were provided by a country, then the label “NO DATA” is displayed instead. Red color is used for low probability floods, orange for medium probability floods and yellow for high probability floods. Percentage of the affected population is shown in a separate table. An explanation is provided that data are given for the part of the country belonging to the Danube River Basin District.

No tributaries are displayed on maps 2-4 and 5b.

MAP 3 Risk and economic activity

The agreed format is as follows: Three A4 maps are presented (one for each scenario) using white background and showing country borders, the DRBD, the Danube and country capitals. Each map shows a 2D pie chart for each country displaying the share of inundated area by class of economic activity. If no data were provided by a country, then the label “NO DATA” is displayed instead. The size of the affected total area in thousand km² is shown below each pie chart. Corine LC colors are used in the chart. An explanation is provided that data are given for the part of the country belonging to the Danube River Basin District.

ICPDR agreed on the following aggregation of Corine Land Cover classes to be used for reporting of economic activities:

- Agriculture: 211 - 244 (all agricultural areas);
- Industry: 121 (industrial and commercial units);
- Infrastructure: 122 - 124, 131 - 132 (road and rail networks, seaports, airports, mineral extraction sites, dumps);
- Urban areas: 111, 112, 141, 142 (urban fabric, green urban areas, sport and leisure facilities);
- Others: all other classes.

MAP 4 Risk and installations with the potential to cause pollution

ICPDR agreed that this map should have the same layout as the Map 2. The charts show the number of IPPC and Seveso installations in each country.

MAP 5 WFD protected areas

ICPDR agreed on two maps: One is based on the available Danube RBMP map of areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant NATURA 2000 sites. The other map of affected areas designated for the abstraction of water intended for human consumption under WFD Article 7 and of the affected bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 2006/7/EC follows the layout of the other risk maps as indicated above.

MAP 5a

This is an A3 map, showing protected areas (based on DRBMP Map 9) superposed by the flood hazard areas (for low probability floods scenario). Only the overlapping flood hazard areas are displayed (in red). The different types of protected areas (Bird, Habitat and other protected areas) are not distinguished.

MAP 5b

This is an A4 map with the same layout as the map 2. The number of affected protected areas in each country is shown by a bar chart - with 3 bars per each country (one bar for each scenario). The total numbers of affected areas designated for the abstraction of water intended for human consumption under WFD Article 7, and of the affected bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 2006/7/EC, is indicated in the bars.

The ICPDR agreed that the >4000km^2 catchment threshold has to be applied also for all risk maps, to keep the consistence between the hazard and risk maps.

MAP 6

The FP EG agreed at its 34th meeting to show on the map of cultural heritage sites only UNESCO sites, numbered downstream. Information on the next page would contain site/name, coordinates, photo and the description of potential impacts (few sentences on what can be damaged).

All maps are shown in the **ANNEX 1**. For their preparation RO, RS, SK, SI and BG used the data from the 1st FRM cycle and AT, BA, HU, HR, CZ and DE used the new data. The data from MD, ME and UA is missing.

5 Revisions during the 2nd flood risk management cycle

5.1 Germany

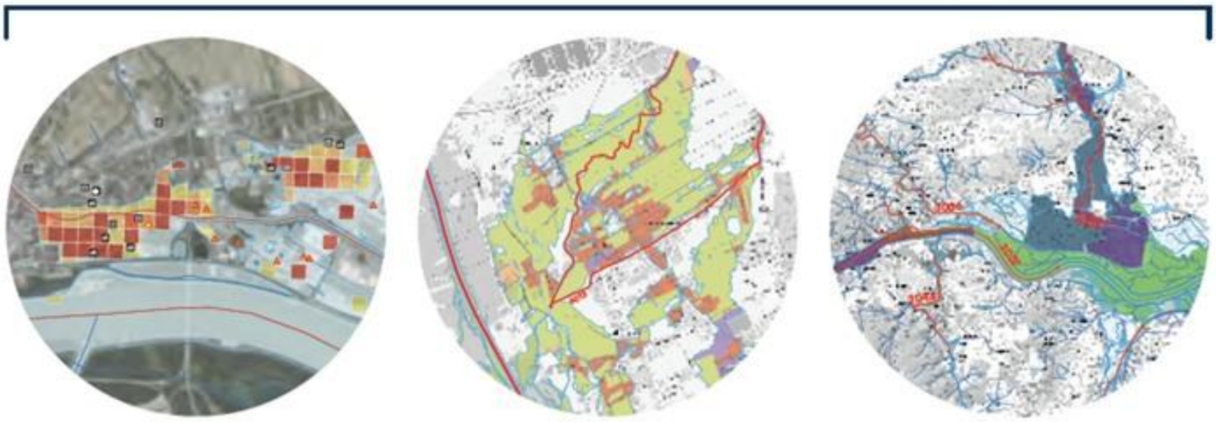
Because of the renewed preliminary flood risk assessment in the 2nd flood risk management cycle the number and total length of rivers reported increased significantly. Flood hazard maps and flood risk maps have been updated if necessary, depending on expert judgement and local situation. Transboundary coordination was done between Bavaria and Baden-

Wuerttemberg as well as with Austria. All German maps are published in a national mapping service: (https://geoportal.bafg.de/karten/HWRM)

5.2 Austria

The first cycle of implementing the EU floods directive in Austria outlined a lack of data availability and data accuracy for hazard delineation and risk estimation in APSFRs. This conclusion initiated a process to close the gaps of 2D hydrodynamic modelling with special focus on areas of potential significant flood risk. Further, a substantial increase in exposure data reliability can be reported. For the second cycle, preparation of the flood hazard and risk maps in Austria a broad bundle of high-resolution data was used. The classification of inundation areas, water depth and flow velocity, however, stayed the same.

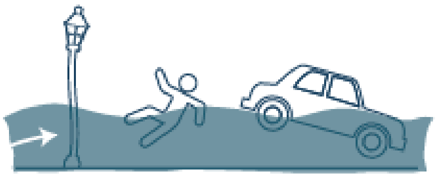
Flood hazard maps in Austria: Inundation area, water depth and flow velocity



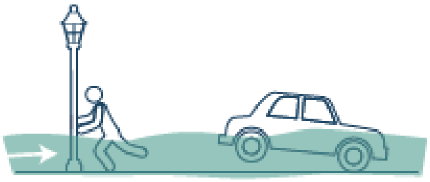
Flood risk maps in Austria: Potential affected per grid, exposed land use, exposed protected areas

To assess the risk a set of maps was produced to not only inform the public and raise their awareness, but also to support emergency management and sectors like spatial planning and building regulation to fostering flood aware planning and implementation of measures. For better understanding and interpretation of the maps, tutorials are provided to explain technical terms and make them more comprehensible.

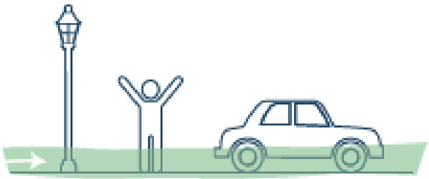
Auch bei geringen Wassertiefen besteht bei hohen Fließgeschwindigkeiten (>2 m/s) Gefahr für Leib und Leben. Von Strömungen und Gegenständen, die vom Wasser mitgeführt werden, geht eine besondere Gefahr aus. Fahrzeuge sollten im Hochwasserfall auf keinen Fall in Betrieb genommen werden. Strukturelle Schäden an Gebäuden können beträchtlich sein und bis zum Einsturz führen.



Die Wasseroberfläche ist bei mittleren Fließgeschwindigkeiten (0,6 - 2 m/s) zwar bewegt, es sind jedoch kaum Turbulenzen sichtbar. Bei einer mittleren Fließgeschwindigkeit kann es schon bei einer geringen Wassertiefe zum Aufschwimmen, Kippen und Versatz von PKWs kommen. Personen sollten im Ereignisfall diese Bereiche sofort verlassen.



Trotz geringer Fließgeschwindigkeiten (<0,6 m/s) ist in diesen Bereichen Vorsicht geboten, da unterhalb der Wasseroberfläche – beispielsweise ausgehend vom Kanalnetz oder anderen Öffnungen – Sogwirkungen entstehen können. Die Wasseroberfläche zeigt in der Regel bei geringen Fließgeschwindigkeiten kaum Bewegung.



Tutorials (in German language) to support the public to assess their exposure and vulnerability.
For more information, please visit https://maps.wisa.bmlrt.gv.at/gefahren-und-risikokarten-zweiter-zyklus (in German language)

5.3 Czech Republic

Preliminary flood risk assessment in the 2nd flood risk management cycle was carried out with updated financial damage criteria reflecting inflation. Flood hazard maps and flood risk maps have been updated for APSFRs based on hydraulic calculation with updated set of input data (DMT, hydrology). The set of flood hazard maps and flood risk maps for the 2nd flood risk management cycle is published on https://www.cds.mzp.cz/

5.4 Slovakia

In the frame of the second flood risk management cycle and in compliance with the Amendment to the Flood Protection Act no. 7/2010 Coll., flood hazard maps and flood risk maps are elaborated in Slovakia for flood return periods of 1000 years (as a flood with a low probability), 100 years (as a flood with a medium probability), and 10 years as floods with a high probability. Revision of flood hazard and flood risk maps are provided on 119 areas of potentially significant flood risk with aggregated 518 former areas (so-called “localities” in a frame of the second cycle) identified in the frame of the first flood risk management cycle. The second cycle of flood risk management includes flood hazard and risk maps for 76 new areas with potentially significant flood risk, which were identified in the frame of reviewing and updating the preliminary flood risk assessment in the Slovak Republic. The flood risk management planning in the second cycle covers the potential adverse consequences associated with scenarios of fluvial and pluvial floods, including climate change scenarios.

5.5 Hungary

The implementation of the Floods Directive (2007/60/EC) in Hungary is set out by the Government Decree number 178/2010 (V 13), which requires to draw up a preliminary risk assessment, flood hazard and risk maps and measures to manage and reduce flood risk, which shall be reviewed every six years. This work is being coordinated by the General Directorate of Water Management in Hungary in the frame of the implementation of the project KEHOP-1.1.0-15-2016-00006 entitled “Preliminary flood risk assessment, hazard and risk maps, first review of risk management plans”. The Flood risk and hazard maps have been prepared in accordance with the requirements of the Directive for three probability for rivers (30/100/1000 years) and small watercourses (pluvial floods) (5/20/100 years).

For protected floodplains by flood protection dikes: Flood events with a frequency of thirty-three years (3%) were chosen as a high probability flood event, because the flood level and durability resulting from this frequency already put a significant load on the defences and areas along the river, as well as human life. it has a noticeable effect during. We chose the flood event with a frequency of 100 years (1%) as the load case with a medium probability of occurrence, because in Hungary, compliance with floods with such a frequency is currently a legal requirement to planning flood facilities. The flood event with a frequency of 1000 (0.1%) was chosen as the load case with a low probability of occurrence,

Pluvial floods: The hydrological scenarios are based on the freshly updated Koris formula, which takes into account the catchment area in the runoff calculation. The range of events examined in detail: high probability (5-year return), medium probability (20-year return), and low probability (100-year return).

Climate change:

In the modelling, the effects of climate change can be taken into account primarily by analysing the hydrological time series. The longest possible time series were taken into account when recording the hydrological edges, thus ensuring that both the recorded load levels and the shape of the flood wave were as accurate as possible. Since even the longest time series were up to 112 years old, in many cases we had to extrapolate from the available time series. This was done using the available data, taking into account the changes. Thus, we were also able to take into account the effects of climate change, as trends in the data sets outline the changes.

Affected population:

- The affected population was determined for water depth maps belonging to the medium and low probability occurrence event range. The number of inhabitants living in the endangered area was determined from the GIS data set of the housing density used for risk mapping and planning used in flood risk management. Housing density stock is data derived from population data, data for the area of residential real estate. Specifies the calculated housing density on municipal properties. Dwelling density was determined for two types of properties, low and high buildings.
- Two methods were used to determine the affected population. In the case of the possibilities of installing a residential centre of less than 20,000 people at that time,

the Central Stastic Office ordered the data of the resident population with 2017's data, if it were installed in the cell number of residential buildings. To differentiate the population of the settlements with a population of over 20,000 and the district headquarters, Hungary used the 20 * 20-meter cell data within the settlement called NÖSZTÉP (National ecosystem service mapping and assessment). These are a NÖSZTÉP basic image of residential buildings requiring 20 * 20-meter raster, with the help of amley we get differentiated data for a residential population main / cell value within the installation. In the endangered way, you will find real estate account data and data collection data aimed at endangered living counts.

Economic activities:

- From an economic point of view, the land use base map prepared by the previous flood risk management was used. The land use map is easy to find on the real estate building and the real estate market, and economic activities continue. In the category of economic activity we listed the building stocks where it is important in business, trade and service activities continue, as well as the agricultural infrastructure buildings. Areas of arable land, orchards, vineyards, mining areas, ports, airports and energy plantations were classified as economic activities.

IED installations:

- The IED installation refers to the definition of the flood event for scenarios where the set point representation and the flood map must have a section.

WFD protected areas:

- Ramsar sites, National Parks, Landscape Protection Areas, Nature Reserves, National Ecological Network, Natura 2000 sites - SPA - Bird protection areas, Natura 2000 sites - SCI – Habitats

Pollution points: Seveso plants, Livestock holdings and livestock farms, Land Mines, Incineration, Landfills

5.6 Slovenia

In the 2nd flood risk management cycle in Slovenia 86 APSFRs were identified (61 APSFRs were identified in the 1st flood risk management cycle), which meant additional flood hazard and flood risk mapping for additional and new APSFRs had to be done. Besides additional or new APSFRs some of the existing APSFRs were changed (APSFRs were either reduced or enlarged). These changes were mainly based on the usage of new and better flood risk data and on the usage of new and additional flood risk knowledge. Usage of the results of climate change modelling was also one of the main drivers for the changes in number and areas of APSFRs.

While flood hazard maps were not changed significantly (area of mapping had to be adjusted due to area changes for some of the existing APSFRs), the flood risk maps were all revised and updated by using the newer and updated data from the official national databases and updated Corine Land Cover.

For the purpose of the 2nd FD implementation cycle all of the flood hazard and all of the flood risk maps from the 1st FD cycle were checked, revised and done in a methodologically (colours used, legend, title, etc.) consistent way. Some of the APSFRs were changed (APSFRs were either reduced or enlarged) in the 2nd FD cycle so the flood risk maps had to be appropriately adjusted

5.7 Croatia

During the second flood risk management cycle, flood hazard maps are not subject of major changes. Most activities are related to mapping of new areas of potential significant flood risk introduced in Preliminary Flood Risk Analysis 2018. In addition, correction, consolidation and refinement of existing hazard maps is performed with minimal changes in map templates. However, flood risk maps are updated significantly as improved data about various risk receptors such as population, cultural heritage and buildings are available as well as more detailed land cover. Therefor certain corrections of flood risk map templates from first cycle is needed. As several national flood hazard mapping and flood risk mapping projects are under way or planned, further improvements are expected and will be included in later phases of second or third flood management cycle.

5.8 Serbia

In the period after the adoption of the first DFRM Plan, Serbia has prepared flood hazard maps for the parts of the APSFRs at the territory of the City of Belgrade (2015) and flood hazard and flood risk maps for the APSFRs identified in the Kolubara River basin (Study on Flood Management Improvement in the Kolubara River Basin; donation of the Government of Japan, implemented by the UNDP, 2015-2016). However, like in the previous projects mentioned in chapter 2.8, DTM used did not have appropriate accuracy and an official methodology was not available so risks in the Kolubara River basin were assessed by using methodology developed by the project.

Later on, a Flood Hazard and Flood Risk Mapping project (Component 2 of the Serbian National Disaster Risk Management Program supported by the EU and implemented by the World Bank, 2018-2020)[3] was initiated with an aim to prepare flood hazard and flood risk maps for the APSFRs identified in the PFRA in 2012, for which the maps were not prepared within the SoFPAS 1 project (see chapter 2.8). This included APSFRs at the territory of the City of Belgrade and in the Kolubara River basin. Also, the project included an update of some flood maps prepared within the SoFPAS 1 project (for the Danube through and downstream of the City of Belgrade, upstream section of the Zapadna Morava, Nišava and 10 more rivers).

Based on the experiences from the previous projects the ToR stated that flood mapping must be based on a high resolution DTM and therefore the necessary equipment and software (on behalf of the Military Geographic Institute - MGI) for the development of LiDAR-based DTMs was procured. It was noted that prior to the project a LiDAR-based DTM of the Tisza River floodplain (surveyed by the Republic Geodetic Authority) was collected, while others were yet to be surveyed by the MGI. The first to be surveyed were the APSFRs in the Kolubara River basin, which was completed. However, due to technical constrains further LiDAR survey was not possible within duration of the project. To overcome this issue, a LiDAR based DTMs were collected for parts of the Sava (courtesy of the Sava Commission) and the Drina River floodplains (through the Ministry of Foreign Affairs of Bosnia and Herzegovina), for the use within the project. For other APSFRs (and lacking parts of the Sava floodplains), an EU-DEM with resolution of 25 m provided by Copernicus Land Monitoring Service was used as the best alternative considered by the project, which resulted in somewhat uncertain accuracy of flood extent and flood depths. These maps will be updated

[3] The project is ongoing during the preparation of this report.

in the next cycle by using a high resolution DTM as the MGI will fulfil obligation to do a LiDAR survey of all areas planned by the project in due course.
Flood hazard maps and flood risk maps were then prepared by using an official methodology. The project provided additional deliverables in terms of risk assessment, as required by the ToR.
Climate change was considered by defining flood extent and water depth resulting from simulation of a 100-year flow increased by 5 to 20% depending on the river (while preserving the shape of hydrograph and taking into account correspondingly increased water levels at the downstream boundary of the model) and assessing additional risks in enlarged flood hazard areas.
Review of the PFRA in 2019 resulted in a few new APSFRs and a few APSFRs extended to the upstream river sections, which will require additional map preparation.

5.9 Bosnia and Herzegovina

Since in Bosnia and Herzegovina the 1st cycle of flood hazard maps and flood risk maps preparation is underway, there are no revisions made.

5.10 Bulgaria

Flood hazard maps

The second-cycle flood hazard maps in Bulgaria will be prepared according to a national methodology, originally developed by the National Institute of Meteorology and Hydrology in 2013 and consequently updated in 2020 in the frame of the *Reimbursable advisory services (RAS) Agreement* between the Bulgarian Ministry of Environment and Water (MoEW) and the World Bank.
As a part of the services under the agreement, the national methodology for PFRA was also updated so that the pluvial and flash floods to be considered in the process of APSFR designation.
Flash flooding in Bulgaria can be from pluvial, fluvial or a combination of both. The Floods Directive classifies pluvial and fluvial flooding as different flood sources and flash flooding as a characteristic of flooding. According to the updated methodology, a different approach has to be followed depending on whether the hazard is flash flooding or pluvial surface water flooding. The flash flooding method can be applied to fluvial, pluvial or integrated sources of flooding. As a rule in the methodology, if an upstream catchment area to a flash flood APSFR is greater than 10km^2, the source is likely a fluvial flash, but with possible pluvial sources along the linear APSFR. If smaller than 10 km^2 then the source is likely a pluvial flash. For the smaller catchments, in most cases, the general assumption will be that any ditches, culverts or other drainage infrastructure will be blocked or exceeded, and overland flow paths only will be modelled.
The updated flood-mapping methodology defines the requirements for all type of data and methods used for the mapping: hydrological data and methods of calculation; geodetic works, including cross-section’s and structure’s measurement; digital terrain models, hydrological data for pluvial and flash-flood analysis. As a part of the activities related to the flood risk assessment, an update of existing and development of new digital terrain models of higher quality by field surveys and aerial photogrammetry for all internal APSFRs is under preparation.

In line with the national legislation, flood-hazard maps include fluvial flood-scenarios with return periods 20, 100 and 1000 years.
The water levels corresponding to the specified return periods will be obtained via unsteady 1D-modelling in the predominant part of the APSFRs, but in some river sections (where necessary) 2D-modelling will be applied. For each APSFR, a flood-extent map indicating the inundated areas for all three scenarios shall be prepared. A flood-depth map, illustrating the water depth variation by shades of blue colour in classification-boundaries 0; 0.5; 1; 1.5; 2; 2.5; 3 and 4 m shall also be prepared for each scenario. A flood-hazard map presenting the level of flood–hazard in different colours depending of flood depth is to be prepared for each flood-scenario as well. Four levels of flood hazard are determined:

Depth [m]	Danger-level	Map-colour
< 0.5	Low	green
0.5 ÷ 1.5	Middle	yellow
1.5 ÷ 2.5	Significant	orange
> 2.5	Very high	red

Additionally, where 2D modelling is applied, maps representing the flow-direction and the flow-velocity shall be prepared. The flow-velocity is to be displayed by colour arrows in three classes: 0.2 - 0.5 m/s (green); 0.5 - 2 m/s (yellow); >2m/s (red).
The flood maps for all APSFR in Bulgaria will be prepared under the scope of the RAS Service Agreement between the MoEW and the World Bank. The real implementation of the task would start in June this year
The flood hazard maps for the Bulgarian section of Danube River, elaborated under the Danube Flood risk project were produced for floods with return periods of 33, 100 and 1000 years (corresponding to a probability of occurrence 3%, 1% and 0.1%). The flood extents and depths obtained under the project will be used for flood hazard and risk assessment within the second cycle of mapping. New flood hazard maps will be developed for flood with high probability, which according to the Bulgarian legislation is 5% (flood with a return period of 20 years). The water levels would be calculated by 1D-numerical modelling and for the corresponding hazard elements – flood extents and flow depths, the existing LIDAR-data, obtained under the Danube Floodrisk project will be used.

Flood risk maps

An update of the methodology for flood risk assessment will be used in the second cycle of flood risk mapping in Bulgaria.
According to the updated national methodology, a risk map will be prepared for each flood-scenario (20, 100, 1000 years) for all APSFR.
Flood risk assessment will cover as minimum the categories listed in Art.146g of the Water Act and should be done for the following indicators:

- approximate number of potentially affected residents;
- type of economic activity in the affected area;
- installations under Appendix 4 to Art. 117 of the Environmental Protection Act, which may cause additional pollution as a result of an accident in case of flooding;
- protected areas under Art. 6 of the Biodiversity Act, which are at risk of being affected;
- other significant sources of pollution;
- public drinking water supply sources;

- cultural heritage sites;
- linear infrastructure sites of importance (roads, highways, railroads, etc.)

Within the updated FHRM Methodology, based on an assessment regarding data availability, guidelines are provided regarding quantitative risk assessment. In the cases where sufficient data is not available, a semi-quantitative approach will be followed.

5.11 Romania

In order to fulfill the provisions of the Floods Directive, the Ministry of Environment, Waters and Forests developed the project on "Strengthening the capacity of the central public authority in the field of water in order to implement the 2nd and 3rd stages of Cycle II of the Flood Directive - RO-FLOODS". This project will produce the flood hazard and risk maps and the flood risk management plans of the 2nd cycle.

Romania will maintain the unitary approach for these outputs for all 12 UoM reported to the EC. Taking into consideration the comments of the EC on the first cycle products, new methodologies for flood hazard and risk mapping were developed to improve the previous approach and to cover the identified gaps.

The flood hazard and risk maps will be developed for all the 526 APSFR reported in the 2nd cycle to EC. Romania will update the fluvial flood hazard maps based on simplified hydraulic modelling in the first cycle and also will customize the hazard maps for fluvial, pluvial, coastal, dyke breaches and flash-flood cases.

In order to develop the flood risk maps, a database on risk receptors and flood damages will be created. Based on damage models, the flood risk will be quantified. The first cycle maps will be also updated, taking into account the new methodology.

Climate change will be integrated in the maps for all APSFR and for the new maps the uncertainties will be assessed.

The deadline for the elaboration of hazard and risk maps is 1st half of 2022.

5.12 Ukraine

The State Service on Emergencies of Ukraine as responsible agency for Floods Directive ensures provision of the measures on Flood Hazard and Flood Risk Map development based on the results of Preliminary Flood Risk Assessment.

Methodology on flood hazard and flood risk map development, approved by the Order #153 of the Ministry on Interior Affairs from 28.02.2018, foresees that flood hazard maps and flood risk maps should be developed for different types of flooding source – fluvial, pluvial, groundwater, sea water, artificial water- bearing infrastructure and others.

Flood hazard maps and flood risk maps shall cover the geographical areas, which could be flooded according to the following scenarios:

(a) floods with a low probability (likely return period ≥ 500 years);
(b) floods with a medium probability (likely return period ≥ 100 years);
(c) floods with a high probability (likely return period ≥ 10 years).

Flood hazard maps and flood risk maps shall be prepared for each APSFR separately in the scale not less than 1:25000.

Two types of flood risk maps should be developed – flood risk maps showing the potential adverse consequences for population and flood risk maps characterizing the hazard for environment, cultural heritage and economic activity.
Ukraine is at present in the first cycle, a new project on flood mapping started in 2020. The data for flood hazard maps will be available by mid-2022, flood risk maps will be available later.

6 Related international activities

6.1 AT – SK INTERREG Project "Protect Danube and Morava – ProDaM"

The bilateral initiative aims at joint flood risk management projects along the bordering river Morava and parts of the Danube in which the Morava is flowing. The main targets are to build a data base consisting of a trans-boundary digital elevation model and a hydrodynamic 2D model. Further, the analysis and common view on residual risk and residual risk management shall be supported. Finally, flood protection measures shall be implemented based on the knowledge obtained.
The project covers the whole Morava and Danube bordering river stem including a total of approximately 500 km² of inundation area.
The first phase of the project is in its finalisation and comprises of the elaboration of the terrain data. This was done based on airborne laser scanning and measuring via echo sounding. The derived digital elevation model is now being incorporated to a 2D hydrodynamic model.
For the second phase to come it is anticipated to discuss the residual risk scenarios based on model results to ensure efficient planning of trans-boundary flood risk management measures.
The project supports sustainable results with reference to the common, trans-boundary implementation of the EU Floods Directive, especially in analysing the scenario with low probability. Further, trans-boundary flood protection and flood risk management measures shall reduce adverse consequences for the border region.

6.2 Danube Floodplain project

Through this project, the transnational water management and flood risk prevention simultaneously with preservation of the benefits for biodiversity conservation will be developed and improved.
The specific objectives of the project were to improve knowledge, among the countries within the Danube River Basin, related to water management through restoration of floodplains, combination of classical and green infrastructure, natural retention measures, involving all related stakeholders and to commonly agree further actions on floodplain restoration and preservation.
The main activities within the project were:

- to update the floodplain areas inventory and their ranking using the Floodplain Evaluation Matrix-FEM method;
- to assess, by using the pre-selected pilot areas, the efficiency of floodplain restoration projects in the Danube District and,
- to develop tools for increasing the knowledge and cooperation of experts, practitioners, decision makers and stakeholders on floodplain restoration.

The mapping related results are coming from the 3rd work package aim of which was to develop a transnational Danube Floodplain GIS (DFGIS) on active and potentially restorable floodplains along the entire Danube and selected tributaries and to create a Danube Floodplain Inventory (DFInv) of hydraulically predefined floodplains. The selection was focused on common agreed parameters and attributes enabling a standard multicriteria and multiscale assessment of floodplain functionality and to visualize these functional parameters by generating maps. The DFGIS will be integrated within DanubeGIS.
Data from the Danube FLOODRISK project available at the Danube Atlas have been also considered.
Hence the return period of 100, widely accepted as the design level for flood protection measures along the Danube River, it was chosen as the data basis for the identification of the *active floodplains* in the Danube Floodplain project.
To identify not only the inundation outlines of a given scenario, but to identify the Danube floodplains itself, a methodology was applied which consider three different criteria, that had to be fulfilled:

- ratio factor of floodplain width/river width >1:1 (to identify the beginning and end of a floodplain);
- minimum size of 500 ha an active floodplain (to avoid too small floodplains for the evaluation);
- floodplain must be hydraulically connected, and characteristic flow behaviour is given.

After the identification of all active floodplains along the Danube, a methodology for the identification of *potential floodplains* developed by BOKU has been performed. In case of potential floodplains HQ extreme was relevant for the delineation and 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.

6.3 UA-SK project FLOODUZH

In September 2019, the Tisza River Basin Water Resources Directorate (UA) together with Slovak Water Management Enterprise (SK) started implementation a project «Joint activities for the prevention of natural disasters in the transboundary Uzh River Basin» under the Hungary-Slovakia-Romania-Ukraine ENI Cross-border Cooperation Programme 2014-2020. The Uzh River basin covers the territory of Ukraine and Slovakia, forming a transboundary catchment area of 2 750 km². The main challenges for the common catchment area are frequent floods for mostly mountain area. Also, part of project activity is focused on abnormal lack of water during long periods for the lowland.

The purpose of the project is to use modern information technologies to manage flood risks and droughts in the common transboundary basin of Uzh River.
Main project activities include aerial photography of the Uzh River basin, development of DEM, 2D hydrodynamic model, flood hazard maps for UA part of Uzh basin, flood risk maps for Uzhhorod and Lekarovce, strategic flood management documents, Feasibility study for regulating structure within Uzhhorod with the purpose of watering the territory during low water periods, information campaign and purchase of equipment. Project duration is 36 months. Project budget - 1 149 106 Euro.

6.4 IT-HU project LIFE+ SandBoil

The topic of the LIFE19 ENV/IT/000071 „Natural-based solution to mitigate flood risk due to SAND BOILS reactivations along the Po River" project is to investigate the possible mitigation of backward erosion piping due to high water events. The project is supported by EUSDR Environmental Risks Priority Area (Letter of Merit).
As a consequence of the climate change, over the last decades flood events in Italy and other European countries in the Danube Basin have become increasingly frequent, intense and long lasting, with an increase of the risk of riverbank instability, including failure mechanism triggered by backward erosion piping. In Italy, sand boils are often observed along the Po river and its major tributaries. The traditional engineering measures to mitigate the phenomenon have mainly consisted in landside berms or impermeable diaphragm walls: however, these strategies turn out to be costly, in terms of both materials and land use, and often ineffective. In the operational area of North-Transdanubian Water Directorate (ÉDUVIZIG) has catalogued several number of phenomena in the last two decades (especially during the flood events in 2002 and in, 2013) due to similar subsoil conditions in the right side of the Danube River around 1806 rkm section. The most common emergency measure consists in promptly ringing sand boils with sandbags to reduce hydraulic gradients and to stop migration of sand particles, the aim being to avoid subsequent damage to the adjacent structures. These interventions only give temporary solutions but do not prevent the activations/reactivations of sand boils.
The main objective of the project is to mitigate the risk of backward erosion piping by means of an innovative, sustainable, natural-based and cost-effective engineering solution. Activities will focus on the design, modelling and installation of the intervention. Based on the preparation of a large-scale experimental basin at the hydraulic laboratory, the prototype will be constructed and installed firstly along the Po river, than in Hungary in the operational area of ÉDUVIZIG two sites have been selected for replications; Danube river right side and Marcal river left side. Both are primary defense line. Following the validation of the prototype, development of guidelines and description of the numerical tools for the design of the intervention in various site conditions.
The project coordinator is the University of Bologna (UNIBO) and the total eligible project budget is 2,822 million Euro, the EU financial contribution is 55% of total eligible budget. The associated beneficiaries are Interregional Agency for the Po river (AIPO), Officine Maccaferri Italia and from Hungary the North-Transdanubian Water Directorate (ÉDUVIZIG). The Hungarian deductible is supported by the Ministry of the Interior, Ministry of Foreign Affairs and Trade and Ministry of Agriculture. Link to the project website: https://lifesandboil.eu/
It is a definite goal of the project to continuously inform the Danube basin-wide institutes - like ICPDR or EUSDR - and report the progress or results of the activities in any possible

occasion for the benefit of the whole region. The other strategical goal is to straighten the cooperation between the other river basin (like Po river), and on the macro-regional level the LIFE SandBoil project is facilitating dialogue and interaction between the Alpine Region (EUSALP) and Danube Region (EUSDR).

7 List of national links for finding more detailed information

7.1 Germany
www.hochwasser.baden-wuerttemberg.de
www.lfu.bayern.de/hochwasserrisikomanagement

7.2 Austria
https://maps.wisa.bmlrt.gv.at/gefahren-und-risikokarten-zweiter-zyklus

7.3 Czech Republic
http://hydro.chmi.cz/cds

7.4 Slovakia
http://www.minzp.sk/oblasti/voda/ochrana-pred-povodnami/

7.5 Hungary
http://www.vizugy.hu/index.php?module=content&programelemid=62
https://www.vizugy.hu/index.php?module=vizstrat&programelemid=145
http://akkzaroutem.ovf.hu/
http://vizeink.hu/akk/

7.6 Slovenia
https://gisportal.gov.si/atlasvoda
https://www.gov.si/teme/nacrt-zmanjsevanja-poplavne-ogrozenosti/

7.7 Croatia
https://www.voda.hr/hr/upravljanje-vodnim-podrucjima-upravljanje-rizicima-od-poplave
https://www.voda.hr/hr
https://www.voda.hr/hr/karte-opasnosti-od-poplava-karte-rizika-od-poplava-2019

7.8 Serbia
http://www.rdvode.gov.rs/uredjenje-vodotoka.php
http://www.rdvode.gov.rs/doc/PPRP_ZPP_2019_karta.pdf (APSFR map)
http://www.rdvode.gov.rs/doc/ZPP_2019_tabela.pdf (APSFR list)

7.9 Bosnia and Herzegovina

"Sava River Watershed Agency", Sarajevo
https://www.voda.ba/mape-rizika

https://avpsava.maps.arcgis.com/apps/View/index.html?appid=2c56327132ee4f72b13fb7394adf2331 - (GIS viewer for flood hazard maps)

https://avpsava.maps.arcgis.com/apps/View/index.html?appid=c39813c7433944168c7c76339286f758 - (GIS viewer for flood risk maps)

http://www.voders.org (Public Institution "Vode Srpske", Bijeljina).

7.10 Romania

https://rowater.ro/despre-noi/descrierea-activitatii/managementul-situatiilor-de-urgenta/directiva-inundatii-2007-60-ce/epri/ (Preliminary flood risk assessment)
https://rowater.ro/despre-noi/descrierea-activitatii/managementul-situatiilor-de-urgenta/directiva-inundatii-2007-60-ce/harti-de-hazard-si-risc-la-inundatii/ (Flood hazard and risk maps)

7.11 Bulgaria

https://www.moew.government.bg/bg/vodi/planove-za-upravlenie/planove-za-upravlenie-na-riska-ot-navodneniya-purn/planove-za-upravlenie-na-riska-ot-navodneniya-2016-2021/
http://www.bd-dunav.org/content/upravlenie-na-vodite/plan-za-upravlenie-na-riska-ot-navodneniia-2022-2027/

7.12 Ukraine

https://www.dsns.gov.ua/ua/Vprovadghennya-Directiva-2007-60-EC-of-the-European-Parliament-and-of-the-Council-of-23-october-2007-on-the-assessment-and-management-of-flood-risks.html

8 Conclusions

FD stipulates that in order to have available an effective tool for information, as well as a valuable basis for priority setting and further technical, financial and political decisions regarding flood risk management, it is necessary to provide for the establishing of flood hazard maps and flood risk maps showing the potential adverse consequences associated with different flood scenarios, including information on potential sources of environmental pollution as a consequence of floods.
As required by FD, the ICPDR Contracting Parties are cooperating on the level of the international Danube River Basin District and they use the ICPDR as the cooperation platform for this purpose. The Summary report on implementation of Article 6 of the

Directive 2007/60/EC in the Danube River Basin District – Update 2021 presents the practical outcomes of this cooperation in line with the provisions of the FD.
This report informs about the methods used in the ICPDR Contracting Parties for preparation of flood hazard and flood risk maps. It also highlights the revisions of these maps carried out during the 2nd flood risk management cycle. The existing links to national flood hazard and risk maps as well as to other relevant documents at the national level are provided in a separate chapter. The key item of this report is presentation of flood hazard and flood risk maps for the Danube River Basin District including a detailed description of the agreed criteria.
ICPDR agreed that two scenarios (flood hazard areas with medium and low probabilities) are relevant for the flood hazard maps on the level of the international river basin district. The medium probability floods are almost unanimously based on 100-year recurrence period (with the exception of MD, where the lower recurrence period stems from shorter data series) and the respective hazard area covers 54,046 km^2 in the Danube River Basin. The recurrence interval of floods with low probability varies mostly from 300 to 1000 years (with the exception of MD) and the respective hazard area covers 82,116 km^2 in the Danube River Basin. The delineation of the flood hazard areas is based on the national methodologies. The flood hazard map for the Danube River Basin District has been prepared in the scale of 1: 4,500,000 and the goal of the map is to provide a general overview for the whole basin. For more detailed information including flow velocity and water depth it is necessary to view the national maps.
The map on risk and population shows the population potentially affected by floods with low, medium and high probability in the parts of the countries belonging to the Danube River Basin District. In the inundation areas addressed on the basin-wide level there are at least 1,008,273 people potentially affected by floods with high probability, at least 2,909,609 people potentially affected by floods with medium probability and at least 5,411,397 people potentially affected by floods with low probability.
The maps on risk and economic activity display the share of inundated area by class of economic activity (according to Corine Land Cover) for low, medium and high probability floods. The agricultural areas have the major share among the different types of the economic activity followed by the category “others” which however combines a number of various activities. Approximately 33,059 km^2 of agricultural areas are potentially affected by low probability floods in the Danube River Basin District. The largest urban area potentially affected by low probability floods is in Hungary (905 km^2).
The map on risk and installations with the potential to cause pollution shows the number of IPPC and Seveso installations affected by floods with low, medium and high probability in the parts of the countries belonging to the Danube River Basin District. Floods with high probability potentially affect at least 90 installations, floods with medium probability potentially affect at least 241 installations and floods with low probability potentially affect at least 548 installations in the Danube River Basin District.
There are two maps displaying risk and WFD protected areas. One map is showing Natura 2000 protected areas superposed in a semi-transparent way on the flood hazard areas (for low probability floods scenario). Only those flood hazard areas that are overlapping (partly or entirely) the protected areas, are displayed. The second map displays the total numbers of affected areas designated for the abstraction of water intended for human consumption under WFD Article 7, and of the affected bodies of water designated as recreational waters,

including areas designated as bathing waters under Directive 2006/7/EC by floods with low, medium and high probability in the parts of the countries belonging to the Danube River Basin District. Floods with high probability affect intersect with at least 886 drinking water and recreational water areas, floods with medium probability affect intersect with at least 1073 drinking water and recreational water areas and floods with low probability affect intersect with at least 1356 drinking water and recreational water areas in the Danube River Basin District.