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PRELIMINARY FLOOD RISK ASSESSMENT FOR THE DANUBE RIVER BASIN

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	Prepared by	**Quality control by**
	Zdenka Ivanovic, Biljana Medenica and Darko Novakovic	**Patrick Reynolds** Key Expert 1 – Team Leader
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LIST OF PROJECT EXPERTS WHO PARTICIPATED IN THE PREPARATION OF THE DOCUMENT

Key Experts	
Patrick Reynolds	Key Expert 1 – Team Leader
Non-key Experts (in alphabetical order)	
Ana Medojević Pejović	Non-Key Expert for Hydrological Design
Andrea Lalic	Non-Key Expert for Hydrology
Biljana Medenica	Non-Key Expert for GIS
Darko Novakovic	Non-Key Expert for Hydrology
Ivan Boskovic	Non-Key Expert for Legal Issues
Jelena Krstajic	Non-Key Expert for GIS
Milan Vlahović	Non-Key Expert for MEICA[1]
Zdenka Ivanovic	Non-Key Expert for Hydrotechnical Engineering

[1] Mechanical, Electrical, Instrumentation, Control and Automation of existing flood defences

CONTENTS

LIST OF ABBREVIATIONS

APSFR	Area of Potential Significant Flood Risk
Art.	Article
CDD	Consecutive Dry Days
CORINE	Co-ORdinated INformation on the Environment
CWD	Continuous Wet Days
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EBU-POM	A fully coupled atmospheric-ocean regional climate model used for dynamical downscaling
EC	European Commission
EU	European Union
FD	EU Floods Directive (2007/60/EC)
FRMP	Flood Risk Management Plan
GEV	Generalized Extreme Value
GIS	Geographic Information System
GIZ	German Development Agency - Deutsche Gesellschaft für Internationale Zusammenarbeit
ha	Hectare
HEC-RAS	Hydrologic Engineering Center River Analysis System developed by the United States Army Corps of Engineers
HQ10	Refers to a 10-year flood which a 1/10 or 10% chance of being exceeded in any one year.
HQ100	Refers to a 100-year flood which a 1/100 or 1% chance of being exceeded in any one year.
HQ500	Refers to a 500-year flood which a 1/500 or 0.2% chance of being exceeded in any one year.
HS	Hydrological Station
ICPDR	International Commission for the Protection of the Danube River
In	Natural Logarithm, loge
km	Kilometre
m.a.s.l	Height in meters above sea level
OSM	Open Street Map
PFRA	Preliminary Flood Risk Assessment
R20mm	Annual number of days with daily precipitation ≥ 20 mm.
R60mm	Annual number of days with daily precipitation ≥ 60 mm
RBD	River Basin District
RBMP	River Basin Management Plan
RX5day	Max 5-day rainfall

SDII	Annual precipitation intensity
UNESCO	United Nations Educational, Scientific and Cultural Organization
WFD	EU Water Framework Directive (2000/60/EC)

EXECUTIVE SUMMARY

The transposition of requirements from the EU Floods Directive (2007/60/EC) into national legislative framework for the Preliminary Flood Risk Assessment in Montenegro has been fully achieved. The Preliminary Flood Risk Assessment (PFRA) is required to cover historical flood events and the potential for future flood events that may have a significant adverse consequence on either, human health, the environment, cultural heritage, or economic activity.

Flood-specific data such as historical flood information, geographic data, urban planning information, population statistics, economic activities, digital terrain models (DTM), hydrological and meteorological information, civil protection information and other national data is required to prepare the PFRA. This information is then used to identify the Areas of Potential Significant Flood Risk (APSFR), which are the areas that will be the priority for subsequent detailed flood risk management assessment in the flood maps and FRMP stages.

Historical hydrological data related to the recorded high (potential) flood waters on the network of hydrological stations in the Danube River Basin were analysed from 1952 when, following widespread flooding, water level measurements began. Six events have been registered to date with flows of a calculated return period of 100 years, with the most common high-water flows in the Danube basin calculated with a 10-year return period.

Despite the fact that the historical hydrological data assessment indicates that flooding in the Danube basin would have occurred on multiple occasions in the past, there are no official data before 2010 detailing the extent of the inundated areas of flood waters or damage to property.

The only information available that can be included for the PFRA relates to the historical flooding event that occurred in late 2010/early 2011.

Notwithstanding the lack of detailed data to document historical flood events, the data from late 2010/early 2011 proved invaluable for the Preliminary Flood Risk Assessment. The recorded data of late 2010/early 2011, where flood events were recorded within 8 municipalities encompassing 23 distinctly individual affected areas, includes the areas of inundation caused by flood waters, the number of persons affected, a description of the damage to residential and business properties together with a record of the damage to cultural assets in the area. The recorded data thereby allow for the determination of the significance of the potential risks in relation to human health, environmental and cultural criteria at each location of recorded flooding.

For the purpose of producing the PFRA, 21 existing and historical hydrological stations (HS) in the Danube River Basin were chosen as relevant for analysis to calculate the probability of return periods of 10, 100 and 500 years.

During the assessment, the expected impacts of climate change were considered by applying one extreme flood scenario (extreme flood recovery period ≥ 500 years), which included all proven or known, or estimated future impacts, including climate change impacts. The impacts of climate change on the identification of areas with potentially significant flood risk

are fully covered by working on scenarios of extreme flood events. With respect to future flooding, in general, it can be concluded that flood events will be both more frequent and more intense, as a consequence of climate change. Thus, although the reduction of total annual precipitation in most parts of the Danube River Basin is expected, in the future, short heavy rainfall, often combined with snowmelt and soil saturation, is expected to cause a higher risk of torrential floods caused by an increase in surface runoff.

Based on the analysis of all the above data, 19 APSFR in the Danube Basin area were defined and represented in GIS format. The APSFR are located as follows: the area of the small basin of the rivers Ibar (4), Lim (11), Tara (2), Ćehotina (1) and Piva (1).

Where flood defence infrastructure was installed after 2010, a positive effect was observed on the protection of urban areas in the Ćehotina, Ibar, Lim and Tara River Sub-Basins. Subsequent flood hazard and risk analysis will be used to clearly identify areas where further flood defence investment is needed together with the type of flood protection required.

1 OVERALL OBJECTIVE, PURPOSE AND SCOPE

Montenegro has defined its territories for the purposes of River Basin management in accordance with the EU Water Framework Directive (WFD, 2000/60/EC), within 2 River Basin districts (RBDs) (Adriatic River Basin District' and the 'Danube River Basin District'). The country must therefore produce 2 Flood Risk Management Plans (FRMPs), which are harmonized, in accordance with Article 9 of the EU Flood Directive (FD, 2007/60/EC) with its 2 River Basin Management Plans (RBMPs) prepared under the EU WFD.

The process by which FRMPs are prepared is prescribed both in the EU FD and in Montenegro's Law on Water. Regulation No. 069/15 of 14 December 2015 defines the specific requirements of the Floods Directive related to the preparation of the FRMPs into Montenegrin law (Montenegro's Floods Regulation No. 069/15).

In short, the EU FD requires 3 distinct preparatory stages which are:

- **Stage 1**. Preliminary Flood Risk Assessment
  Article 4 of the EU FD requires a Preliminary Flood Risk Assessment (PFRA) for each River Basin districts. In the PFRA, areas which have the most significant flood risk or potential flood risk, known as Areas of Potentially Significant Flood Risk (APSFR) are identified. These areas then become the focus for more detailed mapping and planning in the next two stages.

- **Stage 2**. Flood Hazard and Risk Mapping
  Article 6 of the EU FD requires the preparation of Flood Hazard and Flood Risk Maps for all APSFR identified in Stage 1.

- **Stage 3.** The Flood Risk Management Planning
  Article 7 of the EU FD requires the preparation of FRMPs for each River Basin district that will include inter-alia a programme of measures that will be undertaken to address the flood risks.

This report is focussed on Stage 1, which encompasses the analysis of existing flood infrastructure in the Danube River Basin, together with the preparation of the preliminary flood risk assessment and the proposal for APSFR.

Article 3 of the Rulebook on the Closer Content of the Preliminary Flood Risk Assessment and the Flood Risk Management Plan ("Official Gazette of Montenegro", No. 069/15 of 14.12.2015) describes the legal requirements with respect to the content of the preliminary flood risk assessment. Table 1.1 shows the content of the PFRA in relation to the legal national requirements.

Table 1.1. Content of the PRFA in relation to the legal national requirements

Content Required[2]	Rulebook (Article)	PFRA (Section)
River Basin maps in appropriate proportion with Sub-Basin boundaries with topography and land use details	3 (1)	Section 3
Description of past flood events which had significant adverse impacts on human health, the environment, cultural heritage, and economic activity, for which it is probable to occur again in the future, considering the severity of flood events, runoff directions and assessment of adverse impacts caused by such events.	3 (2)	Section 4
Description of floods that occurred in the past in areas where significant adverse impacts can occur in the future due to changed conditions (urban development, proclamation of protected areas).	3 (3)	Section 4
Impact of climate change on occurrence of floods.	3 (4)	Section 5
Assessment of potential harmful impacts of future floods on human health, environment, cultural heritage, and economic activities, considering topography, position of water courses and their hydrological and geo-morphological characteristics, flood plains as natural retentions, efficiency of the existing flood protection facilities, position of settlements, areas of economic activities and long-term development plans, as necessary.	3 (5)	Section 6[3]
Conclusions on flood risks.	3 (7)	Section 7
Used data (records, long-term date sets)	3 (6)	Annex 1

[2] Rulebook on the Closer Content of the Preliminary Flood Risk Assessment and the Flood Risk Management Plan ("Official Gazette of Montenegro", No. 069/15 of 14.12.2015).

[3] Existing flood protection facilities are provided in Section 4.4.

2 LEGAL OVERVIEW

2.1 Introduction

The prime objective of this section is to provide a legal assessment of all relevant questions pertaining to transposition of the EU requirements on the preliminary flood risk assessment into national legislation in Montenegro. This section also provides an analysis of the main points of alignment of the national legislative acts with Directive 2007/60/EC on the assessment and management of flood risks, as the EU umbrella act on flood risk management.

With the aim of providing an all-encompassing legal overview, all relevant primary and secondary pieces of national legislation have been scrutinized as well as other policy papers which do not formally fall under legal acts, such as the Nation Plan of Protection and Rescue from Flooding etc.

The main points of entry for the transposition of the applicable provisions from the Directive 2007/60/EC have been identified in accordance with the chapters of the said act. Also, the Table of Transposition Relevance has been provided as the channel of the overview of the relevance of the concrete national acts with the specific requirements from the Directive.

2.2 Legal and Policy Acts

- Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.
- Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control.
- Law on Waters ("Official Gazette of Montenegro", no. 32/11, 47/11 48/15, 52/16, 02/17, 80/17, 84/18).
- Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan ("Official Gazette of Montenegro", no. 69/15).
- Nation Plan of Protection and Rescue from Flooding, December 2019.
- Water Management Strategy, 2017.

2.3 Definition of Terms

The Directive introduces only two authentic definitions of terms:

- ''flood'' means the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents.

- ''flood risk'' means the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage, and economic activity associated with a flood event.

At the same time, the Directive refers to terms ''river'', ''River Basin'', ''Sub-Basin' and ''River Basin district'' as defined in the Article 2 of Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy.

Both of aforementioned terms have been directly transposed into Article 5 of the Law, which prescribes the meaning of the terms. This has been achieved in the following manner:

- Article 5, paragraph 1, subsection 49 of the Law defines flood as the temporary water cover of land, which is not normally covered by water, including floods (in the DRB) caused by rivers, torrents, occasional watercourses, and lakes, except floods from sewage systems.

- Article 5, paragraph 1, subsection 50 of the Law defines flood risk as a combination of the probability of a flood event and the potential adverse effects of a flood event on human health, the environment, cultural heritage, and economic activities.

It is noteworthy that the Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan introduces additional flood related terms, such as:

- ''area significantly endangered by floods'' is an area where floods can cause significant harmful consequences for human health, the environment, cultural heritage, and economic activities.
- ''floods of low probability'' are floods from running waters with a flow of water for a return period of at least 500 years or floods from standing water with a water level for a return period of at least 500 years.
- ''floods of medium probability'' are floods from running waters with a water flow for a return period of 100 years or floods from standing waters with a water level for a return period of 100 years.
- ''floods of high probability'' are floods from running waters with a flow of water for a return period of ten years or floods from standing waters with a water level for a return period of ten years.

Overall, it may be concluded that all authentic terms from the Directive have been fully and accurately transposed into national legislation.

2.4 Preliminary Flood Risk Assessment

Chapter 2 of the Directive, consisting of Article 4 and Article 5, deals with assessment in regard to the preliminary flood risk assessment.

The preliminary flood risk assessment is to be performed for each River Basin district, unit of management or the portion of an international River Basin district lying within the territory of a certain state. This obligation is included in the Law through Article 95b by which preliminary flood risk assessment is to be done by the competent state authority for each water area. The Law defines water area in Article 5 (for the Danube River Basin) as the area of land, which consists of one or more adjacent River Basins, that is Sub-Basins, on the territory of Montenegro, with associated groundwater, in accordance with Article 21 of this

Law, which is defined as the basic water management unit. Article 21 determines that the water areas in the Danube River Basin as the following:

- The water area of the Danube basin is a part of the international water area of the Danube on the territory of Montenegro, which includes the basins: Ibar, Lim, Ćehotina, Tara and Piva, with the corresponding groundwater.

Also, Article 95b of the Law introduces mandatory 6-year revisions period for all prepared assessment with special focus on the impact of the climate changes on potential flooding in the basin covered by any specific assessment. In this way, the flooding precautionary measures tap into the broader scope of protection from adverse effect of climate change.

Article 4 of the Directive goes on to provide through guidelines on the content of the preliminary flood risk assessment. Based on the said Article, such content should entail following:

- Maps of the River Basin district at the appropriate scale including the borders of the River Basins, Sub-Basins, showing topography and land use.
- Description of the floods which have occurred in the past, and which had significant adverse impacts on human health, the environment, cultural heritage, and economic activity and for which the likelihood of similar future events is still relevant, including their flood extent and conveyance routes and an assessment of the adverse impacts they have entailed.
- Description of the significant floods which have occurred in the past, where significant adverse consequences of similar future events might be envisaged.

In addition to the aforesaid, should specifically needs of the state require so, assessment might also include information on the potential adverse consequences of future floods for human health, the environment, cultural heritage, and economic activity.

The stipulations on the content of the preliminary assessment have been incorporated into Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan. Article 3 of the said Act specifies that the assessment should include following:

- Maps of water areas in the appropriate scale, with the boundaries of Sub-Basins showing the topography and land use.
- Description of floods that have occurred in the past, which have had significant adverse effects on human health, the environment, cultural heritage, and economic activities and are likely to recur in the future, considering the extent of the floods, runoff routes flood waters and an assessment of the adverse effects of the floods.
- Description of significant floods in the past in areas where due to changes in conditions (urbanization, declaring areas protected) significant damage may recur.
- The impact of climate change on the occurrence of floods.
- Assessment of potential harmful consequences of future floods on human health, environment, cultural heritage, and economic activities, considering the topography, position of the watercourse and its hydrological and geomorphological characteristics, floodplains as natural retention areas, efficiency of existing flood

defense facilities, the location of populated areas, areas of economic activity and long-term development plans, as appropriate.
- Used data (records, long-term development studies).
- Conclusions on flood risks.

The Rulebook incorporates all three major Directive's guidelines on the content of preliminary assessments. Also, it includes the optional guideline on the information on the potential adverse consequences of flooding. Finally, the scope of the requited information is broadened by the inclusion of data related to impact of climate change on the occurrence of floods. The Rulebook provides thorough and comprehensive guidance on the information and data that is to be included in the preliminary assessments mirroring the requirements from the Article 4 of the Directive and in some instances going even beyond them. Therefore, it can be concluded that all the stipulations on the content of the preliminary flood assessment have been successfully incorporated into national legislative framework though the provisions of the said Rulebook.

Article 4(3) of the Directive establishes obligation of the cooperation of the states in the exchange or relevant information in the case of international River Basins. In line with that, Article 95b of the Law prescribes that when preliminary assessments are prepared for the River Basin districts which are part of an international River Basin districts, exchange of information with the countries within whose territories such basins are lying shall be provided.

Obligation of the state, based on the preliminary assessments, to identify areas for which, potential significant flood risks is existent or might be considered likely to occur is set by the Article 5.1 of the Directive. This obligation is included in the Law though Article 95c. By the said Article the Government is to determine areas for which there are significant flood risk, or their occurrence may be considered probable by using the findings from preliminary flood risk assessments. In addition to this, Article 5.1 sets obligation of the states to coordinate their efforts in identifying areas under potential significant flood risk when it comes to international basins. This obligation is also incorporated in the Article 95c of the Law (paragraph two of the said Article) by which determining of the international River Basin areas endangered by floods, shall be done through coordinated activates with the states on whose territory parts of that River Basin district are located. Both stipulations of the Article 5, regarding the identification of the endangered areas and cooperation of the states when identifying such areas for international basins, have been adequately transposed in the national legislative framework through Article 95c of the Law.

Given the above elaboration, it can be derived that all applicable stipulations on the preliminary flood risk assessments set by the articles comprising the Chapter 2 of the Directive have been fully and accurately transposed into relevant national legislative acts.

In addition to this, Water Management Strategy includes the comprehensive set of measure for prevention and mitigation of risk of flooding. The Strategy introduces four areas of intervention:

1. Flood protection from surface waters.
2. Flood protection from ground waters.
3. Regulation of water regimes and flood protection.

4. Protection against erosion and torrents.

For each of the said, operation goals are set and withing those goals set of measures aimed at achieving the goal in question.

The Strategy was adopted in 2017 and it points out that the national strategic Plan for protection against the harmful effects of water which was in force at that time is not fully aligned with the requirements from the Directive. As the Strategy points out, the General Plan for Protection Against the Harmful Effects of Water, for waters of importance for Montenegro, was adopted for the period from 2010 to 2016. In accordance with that Plan, local and state authorities adopt every year Operational protection plans to determine the measures necessary for the effective implementation of protection from flooding. These annual plans did define the preventive and operational implementation of flood protection but did not provide a framework for long-term flood risk planning and management.

Aforesaid observation from the Strategy underlines the need for better coordination at the level of the Strategic policy documents in Montenegro. In this concrete example, the Strategy shed light on the shortcomings from the General Plan for Protection Against the Harmful Effects of Water and deriving annual protection plans as it was the case back in 2017. However, in meantime the new Nation Plan of Protection and Rescue from Flooding has been adopted resolving many of the said issues, so the recommendations from Strategy should be amended accordingly. This example is just one of many which emphasizes the need for better synchronization and updating in the national framework of strategic policy documents.

2.5 Institutional Responsibilities

Institutional competencies for flood risk management are divided between Ministry of Agriculture Forestry and Water Management, which is mostly in charge of policy level, and the side Government and the Water Administration as the state authorities charged with executive responsibilities.

The Ministry of Agriculture Forestry and Water Management is in charge of adopting relevant procedures by prescribing more detailed rules pertaining to content of the preliminary flood risk assessment content and manner of making flood danger maps and flood risk maps as well as the content of the risk management plan. This has to be carried out through adoption of the Decree on the detailed content of preliminary flood risk assessments and the flood risk management plan ("Official Gazette of Montenegro" No. 69/15).

As for the execution, in accordance with Law on Waters ("Official Gazette of Montenegro", Nos. 32/11, 47/11 48/15, 52/16, 02/17, 80/17, 84/18) the flood risk management plan is developed on the basis of:

- A preliminary flood risk assessment,
- Identified areas significantly endangered by floods and
- Hazard maps and flood risk maps.

A Preliminary Flood Risk Assessment for each river basin district is prepared by the competent administrative body which is in this case the Water Administration. Based on a preliminary flood risk assessment, the Government identifies areas for which there are significant flood risks or their occurrence may be considered probable.

Grounded on the findings from the Preliminary Flood Risk Assessment the Government identifies areas significantly endangered by floods, or within which the occurrence of floods is considered probable.

Following the identification of the endangered areas, the Water Administration is in charge of preparing flood hazard maps and flood risk maps for selected areas, taking into consideration each river basin district separately.

Finally, for areas deemed as endangered by floods the Government shall adopt Flood Risk Management Plan which is to be developed at the level of the river basin district. It is worth noting that the Flood Risk Management Plans need to be aligned with River Basin Water Management Plans.

In accordance with the procedure set by the aforementioned Decree, Flood Risk Management Plan shall be updated if there is a change in the data determined by the Plan, taking into account the impact of climate change on the occurrence of floods.

The implementation of the Flood Risk Management Plan is done in accordance with the Action Program, which is an integral part of the plan and contains priorities for the implementation of the plan with deadlines, actions to be taken to inform and consult the public and competent authorities for the implementation of the plan.

For a river basin district which is part of an international river basin district, Flood Risk Management Plan shall be drawn up as a jointly with others states in whose territory parts of that river basin district are located.

2.6 Public Participation and Public Information

Involvement of the general public in flood risk management is buttressed thorough Articles 10.1 And 10.2 of the Directive. Article 10.1 determines that preliminary drafts of flood risk assessment are to be approachable to wider public for consideration.

Public participation in the process of adoption of flood risk management documents has been recognized by the Law through Article 95f. The Law makes a mandatory stipulation regarding the drafting process of the flood risk management plan by which the participation of all interested persons and the public must be ensured in such process. Also, the process is to be opened for commenting. Accessibility of the other flood management documents is provided by the stipulation that set of those documents (including preliminary flood risk assessment, list areas significantly endangered by floods, hazard maps, flood risk maps and flood risk management plan) shall be made publicly available through the websites of the Ministry and other competent authorities.

The Law provides legal platform for effective public participation when it comes to adoption and revising of the flood risk management documents, in the manner that is fully aligned with the Articles 10.1 and 10.2 of the Directive.

The Law provides a platform for adequate public participation in line with the relevant requirements from the Directive.

In addition to the aforementioned, the National Plan for Protection and Rescue from Floods also included the section on informing the public. The Plan introduces well-structured division of duties of the state local and state authorities, by which:

1. Within the Directorate for Protection and Rescue of the Ministry of Interior, the Operational - Communication Center 112 - OKC 112 has been established, which is in charge of informing other competent authorities about potential flood risks. It is also in charge of officially informing the public about emergencies. related to floods, its extent and activities and measures to be taken..

2. Institute of Hydrometeorology and Seismology is in charge of providing the information on the occurrence of floods to the Operational - Communication Center 112.

3. Municipalities are responsible for informing the public about the occurrence of floods within their territories. Local authorities are also in charge of gathering all relevant data on floods and their potential consequences for people, material, and cultural goods and to pass on such information to the Operational - Communication Center 112.

2.7 Table of Transposition

It can be concluded that high level of the transposition of requirements from the Directive into national legislative framework on the preliminary flood risk assessment in Montenegro has been achieved in all relevant areas. The table of transposition with relevance to the PFRA is shown in Table 2.1. Some additional work may be done regarding the content of information on adverse consequences and alignment with stipulations set by the Annex I of the Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control. However, this can be regarded as just a minor omission that does not influence overall successful level of transposition.

Apart from strictly legislative framework, there is a clear need for better alignment and consistency in regard to the within national framework of strategic policy papers. Proposals of policy interventions and correlated implementation of activities pertaining to the management of flood risks are scattered in several policy papers, without clearly defined synchronization or interdependence of those documents. Flood risk management measures and policy interventions are foremost set by the National Plan of Protection and Rescue from Flooding, December 2019, and the Water Management Strategy from 2017. However, even recommendations from these two most prominent policy papers lack mutual synchronization. In addition to the said two policies, objectives pertaining or relating to flood

risk management are defined in several other strategic document such as and a Strategy to reduce the risk of disaster with the Dynamic Action Plan for the period 2018-2023 and National Strategy for Sustainable Development until 2030. Most of these documents have been prepared at the different points in time when the levels of the transposition of EU requirements varied. For that reason, they have different starting points which may result in different recommendations. Consequently, there is a clear need for streamlining the objectives and recommendations by identifying one umbrella strategy, most likely the National Plan of Protection and Rescue from Flooding. All other strategy documents should be aligned with the objectives set by the chosen overarching policy and update regularly in accordance with latest amendments of such policy.

Table 2.1. Table of transposition relevance with relevance to the PFRA

Legal Act	Article	Relevance
Law on Waters	Art. 5. paragraph 1. Subsection 49.	Transposition of the definition of term 'flood''
Law on Waters	Art. 5. paragraph 1. Subsection 50.	Transposition of the definition of term 'flood risk''
Law on Waters	Art. 5. paragraph 1. Subsection 80.	Definition of the water areas
Law on Waters	Art. 21.	Determination of the water areas in the territory of Montenegro
Law on Waters	Art. 95b.	Stipulates preparation of PFRA for each River Basin district and exchange of information for international basins
Law on Waters	Art 95a. paragraph 4.	Provides legal basis for adoption of the Rulebook on Detailed Content of the Preliminary Flood Risk Assessment
Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan	Art 3.	Determines the content of the Preliminary Flood Risk Assessments
Law on Waters	Art. 95c.	-Sets obligation of the Government to identify areas for which, potential significant flood risks are existent or might be considered likely to occur; -Stipulates cross-border cooperation in identifying the areas significantly threatened by floods when it comes to international basins.
Rulebook on Detailed Content of the Preliminary Flood Risk	Art 4.	Further develops mandatories elements which shall be provided for each of the three

Legal Act	Article	Relevance
Assessment and Flood Risk Management Plan		scenarios defined by the article 95d of the law and as a direct requirement from the Article 6.4 of the Directive.
Rulebook on Detailed Content of the Preliminary Flood Risk Assessment and Flood Risk Management Plan	Art. 6.	Defines in detail mandatory content of the flood hazard map
Law on Waters	Art.95f.	Enables transparency and public participation in the process of developing a flood risk management plan and during their updates.

2.8 Transboundary Flood Management

Montenegro's cooperation with neighbouring countries and the wider international environment in water management is regulated by interstate agreements and signed conventions and agreements in the field of water, which are part of the legal framework for water management in Montenegro. In the Danube River Basin, the Lim River Basin covers the territories of Montenegro, Bosnia and Herzegovina, Albania, and Serbia, and is partly the border river between Montenegro and Serbia. The Tara and Ćehotina Rivers are part of the border river between Montenegro and Bosnia and Herzegovina. The Ibar River covers the territories of Montenegro and Serbia.

Montenegro became a candidate for membership in the European Union in December 2010, and the negotiation process between Montenegro and the European Union officially began in June 2012.

On Montenegro's path to the European Union, the negotiating chapter 27 - Environmental protection and climate change, within which the sub-area - Water quality, is one of the most demanding. The former Ministry of Sustainable Development and Tourism, i.e., the current Ministry of Ecology, Spatial Planning and Urbanism, is responsible for coordinating the negotiation process in Chapter 27.

International cooperation related to the Danube basin is related to the cooperation of Montenegro in the Danube. Namely, Montenegro has been a member of the International Commission for the Protection of the Danube River (ICPDR) since 2008.

Cooperation at the level of the Sava River Basin in Sava Commission, is realized in accordance with the Memorandum of Cooperation between the International Commission for the Sava River Basin and Montenegro. Namely, the Memorandum of Understanding on Cooperation Concerning Regular Functioning and Maintenance of the Flood Forecasting and Warning System in the Sava River Basin was signed of July 1, 2020. Whereas the Protocol on Flood Protection to the Framework Agreement on the Sava River Basin was signed on June 1, 2010. The obligation of Bosnia and Herzegovina, the Republic of Croatia, the Republic of Serbia, and the Republic of Slovenia to establish a coordinated or joint system for

forecasting, warning, and alerting from floods in the Sava River Basin in coordination with the International Sava River Basin Commission has been established. Montenegro, being non-party to the Protocol, took part in the establishment on the basis of the Memorandum of Understanding on cooperation between the International Sava River Basin Commission and Montenegro, signed in Belgrade on 9 December 2013, and as a beneficiary of the Project. The signing of the said memorandum is only a continuation of these activities.

An agreement on the Condition of use of the Flood Forecasting and Warning System in the Sava River Basin was also signed by Ministry of Agriculture and Rural Development, the current Ministry of Agriculture, Forestry and Water Management and the Institute of Hydrometeorology and Seismology. The Flood Forecasting and Warning System in the Sava River Basin is established within the implementation of the Protocol on Flood Protection to the Framework Agreement on the Sava River Basin. The effective joint operational structure and procedures of regular maintenance and performance control of the system are regulated by the provision of the Memorandum of Understanding.

In addition to international cooperation for Montenegro, due to the transboundary nature of most watercourses, cooperation with neighbouring countries in the field of transboundary water resources management is of great importance.

In the forthcoming period, it is necessary to further develop bilateral and multilateral cooperation with neighbouring countries in the field of water management, and especially in the field of flood management.

Regional Projects

The Ministry of Agriculture, Forestry and Water Management, in cooperation with the World Bank, is implementing the regional project "Management of the Drina River Basin in the Western Balkans". The project is funded by a grant from the Global Environment Facility (GEF) and the Special Climate Change Fund (SCCF).

Part of this project is the preparation of project documentation for the regulation of the Lim River (with Grnčar) in order to combat climate change and integrated management of natural resources. The municipalities covered by the project are: Gusinje, Plav, Andrijevica, Berane and Bijelo Polje. This project will create conditions for the realization of capital infrastructure works on the construction of multi-purpose coastal fortifications on Lim and Grnčar.

3 DESCRIPTION OF THE DANUBE RIVER BASIN

3.1 Hydrogeographical Overview

The total surface of Danube watershed in 7,260 km^2 or 52.5 % of state territory. From this surface river Ibar flows into the Western Morava while rivers Tara, Piva, Lim and Ćehotina flow into the Drina River (Table 3.1). The Danube watershed in Montenegro is the southernmost part of the Black Sea drainage basin encompassing the main Sub-Basins of the Ćehotina, Ibar, Lim, Piva and Tara and Rivers (Figure 3.1).

Table 3.1. Major rivers within the Danube River Basin

River Name	Length (km)	Drainage Area (km^2)
Tara	148	2,040
Ćehotina	99*	810*
Lim	98*	2,280*
Piva	85	1,784
Ibar	35*	413*

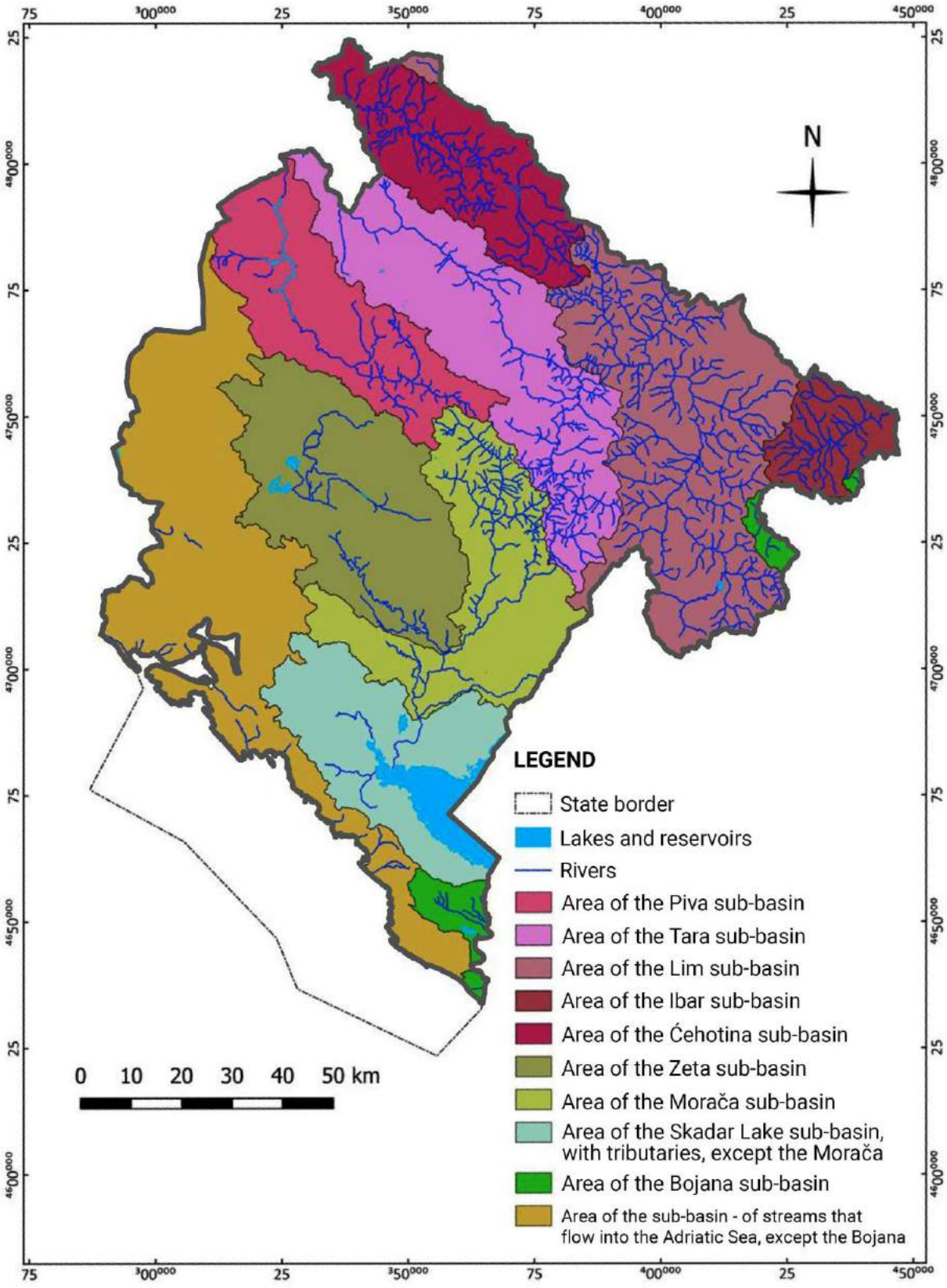
*length and surface area within MNE

The Tara River springs below the peaks of Maglić Kariman (about 2,400 m above sea level). From the source to the mouth of river Drcka, the right bank of the Tara River is much more developed than the left. The larger left tributaries are Opasanica, Pčinja, Plašnica, Štitarica, Ravnjak and the spring of Ljutica. On the right side, the Tara receives Drcka, Skrbuša, Svinjača, Jezerština, Rudnjiča, Bjelojevićka and Selačko rivers. The surface of the Tara River Basin is 2,040 km^2. The length is 148 km.

The Ćehotina River originates from beneath the Stožer mountain. After the Lim river it is the largest tributary of the Drina river. Ćehotine's influences the are Koričić, Maočnica, Vezišnica and Voloder. The surface of the Ćehotina basin to H.S. Gradac is 809.8 km^2.

The Lim River originates from the Plavsko Lake, although its source is the Vruja and Grnčar Rivers, which are forming the Ljuča river and bring almost all water in Lake Plavsko. Prior to Andrijevica on the left side in Lim flows Murinska and Zlorečica rivers, while the right are the tributaries are Đurička, Rženička, Velička and Komarača rivers. From Andrijevica to Berane, the Lim receives left tributaries Kraštica, Trebić, Ševarinska and Bistrica rivers, while the right tributaries are Šekularska and Kaludra rivers. From Berane to Bijelo Polje, there are the Brzava and Ljubovića tributaries on left side while from the right side there are Dapsićka and Lješnica rivers. From Bijelo Polje to Dobrakov on the left side there is the Bjelopoljska Lješnica river and on the right side the Bjelopoljska Bistrica river. The total length of Lim within MNE is 98 km with drainage area of 2,280 km^2.

Figure 3.1. Sub-basins and river network in Montenegro



The Piva River is formed from the high Montenegrin mountain ranges. This river, along the stream, has several names. Its source, under the south-western slopes of Durmitor, to Šavnik, is called Bukovica. Merging with Bijela in Šavnik, the watercourse continues under the name Pridvorica, retaining the name to the mouth of the Upper Komarnica in Pridvorica. The further downstream watercourse continues under the name Komarnice until the Pivski Monastery, where it receives the tributary of the Sinjaci and change of the name to Piva. The watercourse flows to Šćepan Polje, where it meets the Tara River and from there begins the Drina River. The surface of the Piva River Basin is estimated at about 1,784 km^2 to Šćepan Polje. The upper Komarnica springs from under Durmitor and then runs through a canyon with a depth of 600 m and about 4 km long. Along the Komarnica stream there are pronounced karst phenomena, with insufficiently studied underground leakage and numerous hot springs.

The Ibar River originates from the north-eastern slopes of Hajla mountain at an altitude of 1,760 m. The main tributaries are the Županica, Limnička, Ibarac, Grahovska, Bukovačka, Baltička, Crnja and Bačka rivers. The shape of the Ibar basin to the hydrological station Bać is in a form of array with very prominent hydrography and possibilities for rapid formation of flood waves. The surface of the Ibar basin within MNE up from hydrological station at Bać is 413 km^2 while the length of flow within MNE is 35 km.

Lake Plavsko is the biggest glacial (mountain) lake in Montenegro. It is placed in Plav/Gusinje valley at an altitude of 906 m. The average depth of this lake is about 4m while the biggest dept is 10m in central part of the lake. The shoreline is about 8 km while the surface is 2 km^2. It fills with water from river Ljuča, which brings water from surrounding Prokletije massif, and it empties with Lim River which starts from this Lake. It is ellipse like shaped with length of 2.1 km and width of 1 km.

Lake Crno is one of the highest mountain lakes placed on Durmitor massif on altitude 1,416 m above sea level. It consists of two parts, small and big Crno lake kidney shaped subunits. The smaller subunit is deeper with maximum depth of 49 m, while the largest part is shallower with maximum depth of 24 m. The total length of the whole lake (both subunits) is 1.15 km with a maximal width is 0.6 km. It fills with water from the well called Čeline, several smaller underwater wells as well as from the several smaller mountain brooks. The water from lakes goes underground and appears in two regions as wells in Tara and Komarnica valleys. It is placed in National Park “Durmitor”.

Lake Biogradsko is situated at an altitude of 1100 m on the Bjelasica mountain. It is surrounded with Biogradska gora ancient-forest and it is one of the most beautiful mountain lakes in MNE. The lake is 1.1 km in length and 0.41 km in width with average depth of 4.5 m. The maximum dept is about 12 m in central part of the Lake. It is fed with water from the small Biogradska river and from the Bendovac brook while from the Lake it flows out small river Jezerštica which ends into the Tara River. It is placed in National Park “Biogradska Gora”.

Table 3.2. Natural lakes in the Danube River Basin

Lake Name	Lake Surface Area (km^2)	Lake type
Lake Plavsko	2	Glacial (mountain)
Lake Crno	0.53	Glacial (mountain)
Lake Biogradsko	0.27	Glacial (mountain)

The topographical map at a scale of 1:300,000 of the basin is illustrated in Figure 3.2[4]. An example of the level of detail that will used for the flood hazard and flood risk maps is provided in Figure 3.3[5]. A slope map of the region is shown in Figure 3.4.

[4] Map prepared by the Military Geographical Institute of Yugoslavia in the 1980s.

[5]All APSFR in the Danube River Basin will be prepared during the development of flood hazard and risk mapping at the same level of detail shown in Figure 3.3.

Figure 3.2. Topographical map of Montenegro

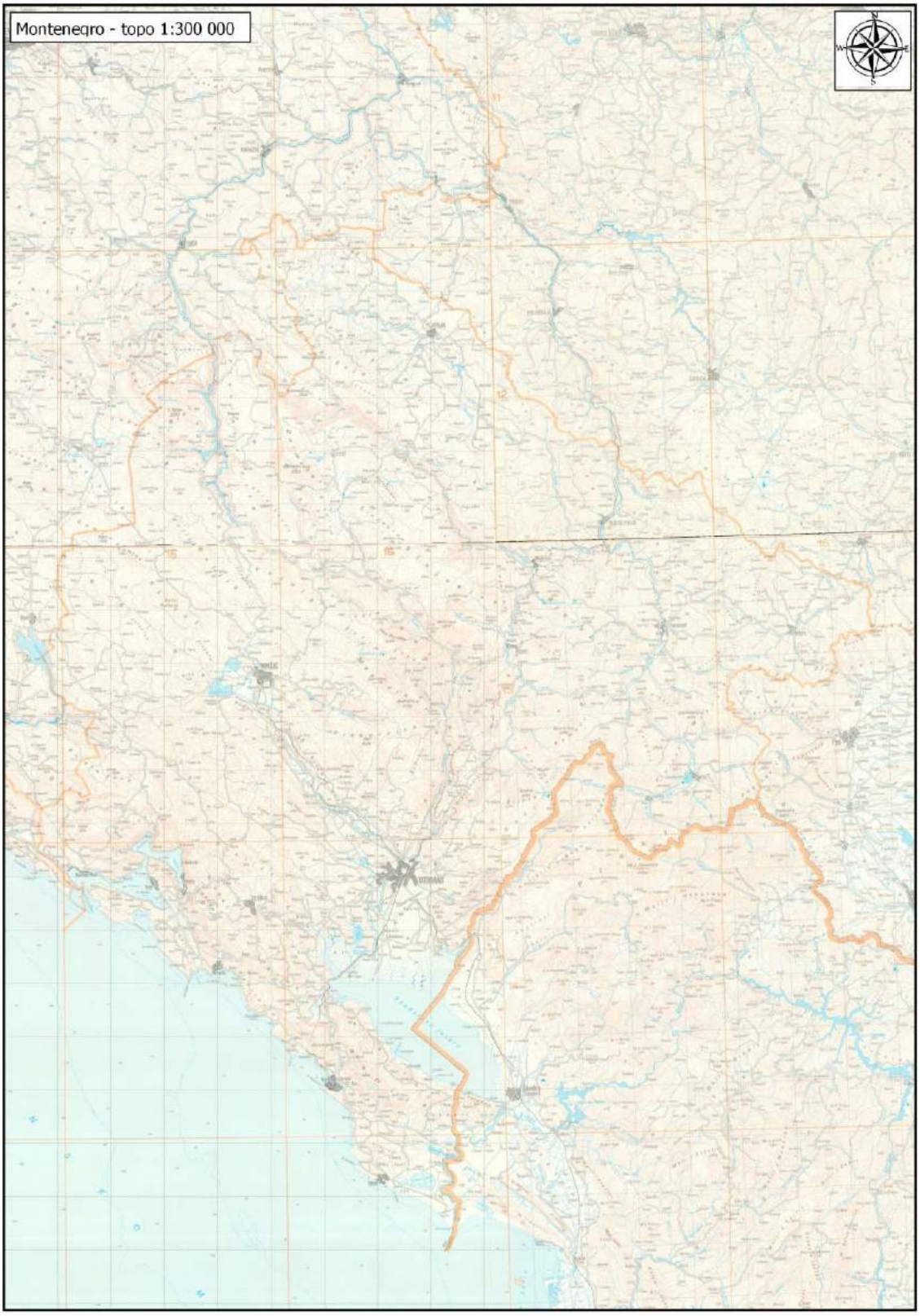


Figure 3.3. Example of the level of topographic detail for each APSFR[6]

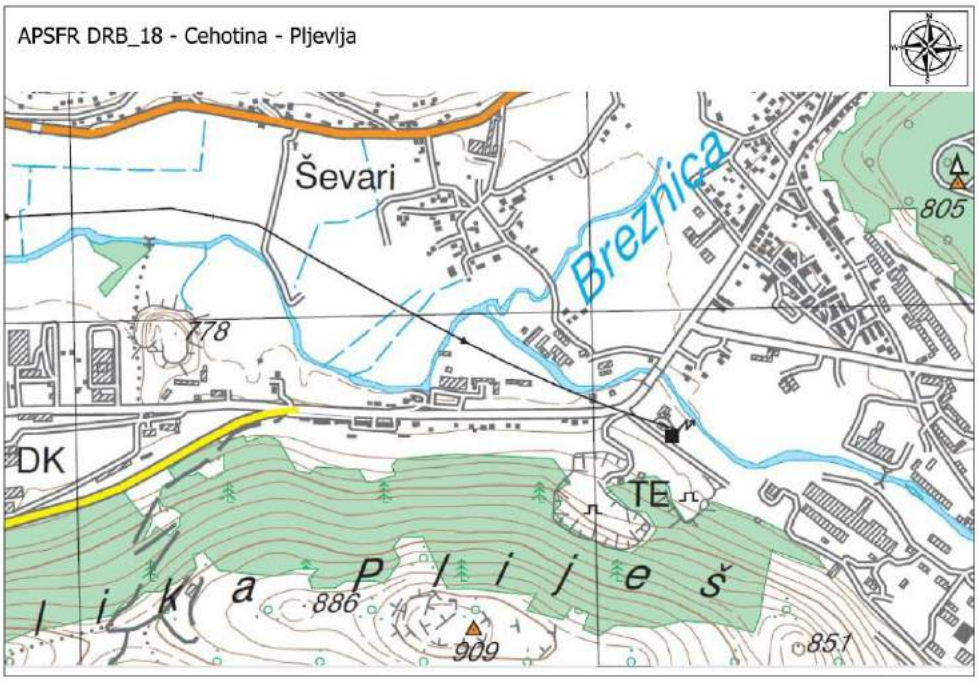
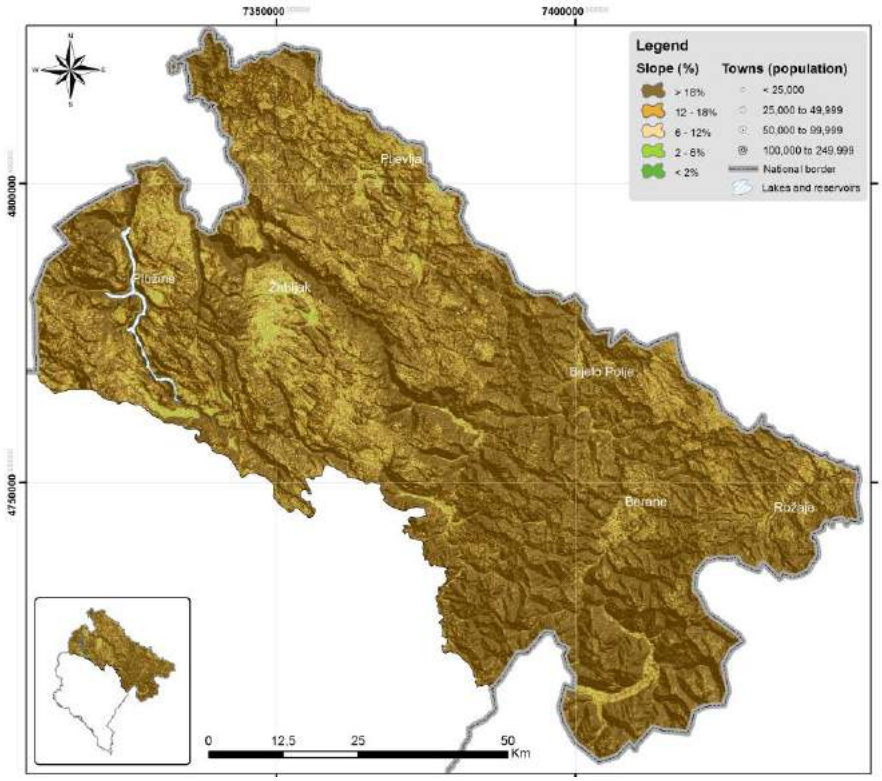


Figure 3.4. Slope map the Danube River Basin



[6] See footnote 5

3.2 Land Use

Land use was analysed based on the European Corine Land Cover dataset (2012) and Open Street Map (2018). The land cover and land use classes were summarised to create land use classes that match the needs of the preliminary flood risk assessment.

Figure 3.5 shows (exemplary in small scale) the land use map which was applied for the risk assessments. The Corine Land Cover classes are shown in Table 3.3.

The category of Class 1 includes all artificial surfaces indicating the higher level of potential pressures, mostly related to urban areas, industries, or mining activities. Class 1 covers all urban, industrial and constructions. Class 2 covers the agricultural activities, which highlight the agricultural activities that are more likely to include a higher level of pressures (mostly from diffuse pollution; irrigated and non-irrigated arable lands, vineyards, orchards) as well those including pastures and non-intensive agricultural practices. The third class incorporates the types, such as forest covers, bare rocks and natural areas. Classes 4 and 5 refer to inland wetland and inland waters.

Forest and semi-natural areas are the main land use types in mountainous regions. In river valleys land is used for agricultural production. The big number of cities and villages are situated along the rivers.

Figure 3.5. Land use map of the Danube River Basin (Corine Land Cover classes)

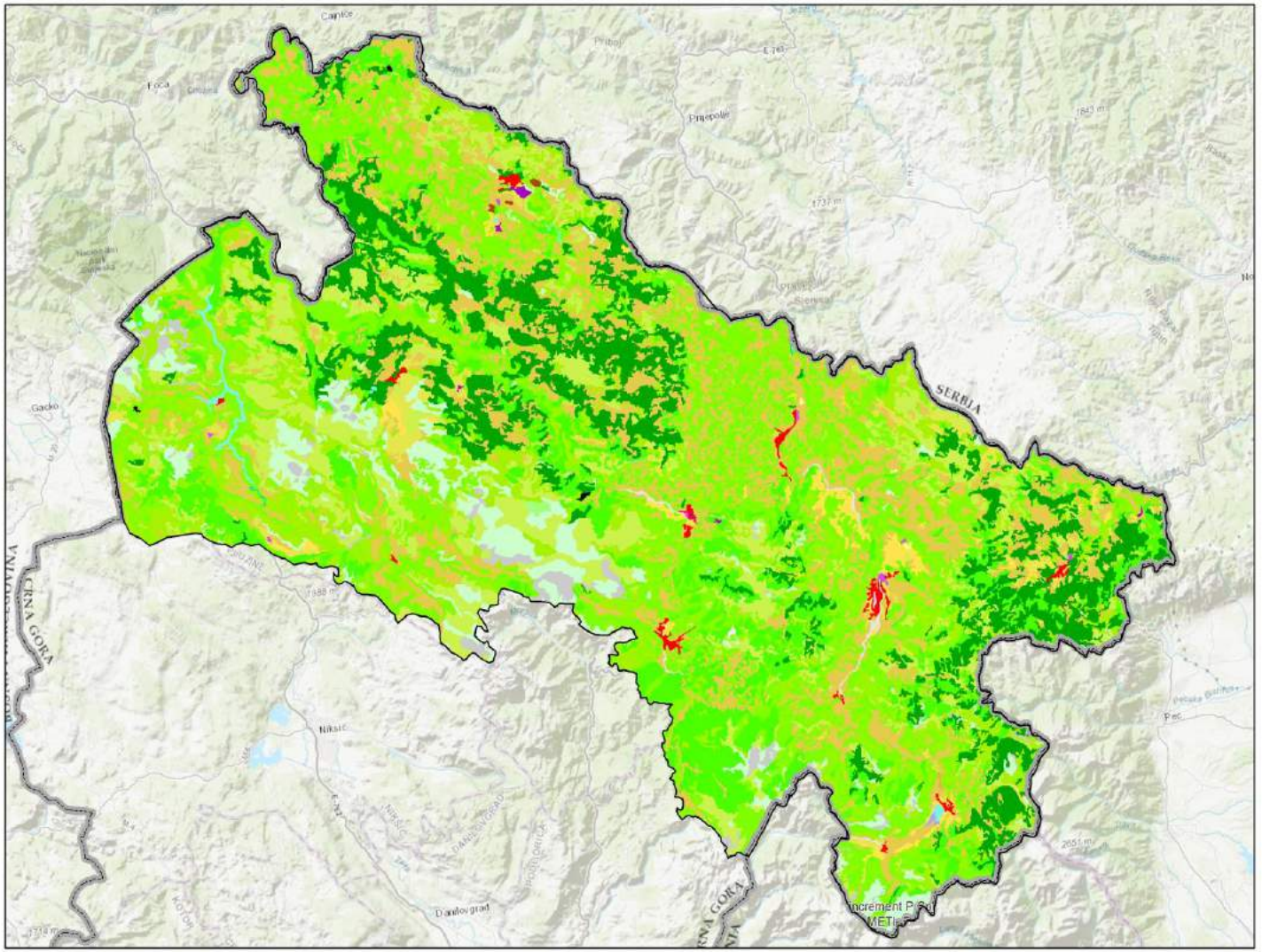


Table 3.3. Corine Land Cover classes

1. Artificial surfaces

1.1 Urban fabric

- 1.1.1. Continuous urban fabric
- 1.1.2. Discontinuous urban fabric

1.2 Industrial, commercial and transport units

- 1.2.1. Industrial or commercial units
- 1.2.2. Road and rail networks and associated land
- 1.2.3. Port areas
- 1.2.4. Airports

1.3 Mine, dump and construction sites

- 1.3.1. Mineral extraction sites
- 1.3.2. Dump sites
- 1.3.3. Construction sites

1.4 Artificial, non-agricultural vegetated areas

- 1.4.1. Green urban areas
- 1.4.2. Sport and leisure facilities

2. Agricultural areas

2.1 Arable land

- 2.1.1. Non-irrigated arable land
- 2.1.2. Permanently irrigated land
- 2.1.3. Rice fields

2.2 Permanent crops

- 2.2.1. Vineyards
- 2.2.2. Fruit trees and berry plantations
- 2.2.3. Olive groves

2.3 Pastures

- 2.3.1. Pastures

2.4 Heterogeneous agricultural areas

- 2.4.1. Annual crops associated with permanent crops
- 2.4.2. Complex cultivation patterns
- 2.4.3. Land principally occupied by agriculture
- 2.4.4. Agro-forestry areas

3. Forest and seminatural areas

3.1 Forests

- 3.1.1. Broad-leaved forest
- 3.1.2. Coniferous forest
- 3.1.3. Mixed forest

3.2 Shrub and/or herbaceous vegetation associations

- 3.2.1. Natural grassland
- 3.2.2. Moors and heathland
- 3.2.3. Sclerophyllous vegetation
- 3.2.4. Transitional woodland shrub

3.3 Open spaces with little or no vegetation

- 3.3.1. Beaches, dunes, and sand plains
- 3.3.2. Bare rock
- 3.3.3. Sparsely vegetated areas
- 3.3.4. Burnt areas
- 3.3.5. Glaciers and perpetual snow

4. Wetlands

4.1 Inland wetlands

- 4.1.1. Inland marshes
- 4.1.2. Peat bogs

4.2 Coastal wetlands

- 4.2.1. Salt marshes
- 4.2.2. Salines
- 4.2.3. Intertidal flats

5. Water bodies

5.1 Inland waters

- 5.1.1. Water courses
- 5.1.2. Water bodies

5.2 Marine waters

- 5.2.1. Coastal lagoons
- 5.2.2. Estuaries
- 5.2.3. Sea and ocean

4 DESCRIPTION OF FLOODS THAT OCCURRED IN THE PAST IN AREAS WHERE SIGNIFICANT ADVERSE IMPACTS CAN OCCUR IN THE FUTURE DUE TO CHANGED CONDITIONS

4.1 Introduction

The Rulebook on the Closer Content of the Preliminary Flood Risk Assessment and the Flood Risk Management Plan ("Official Gazette of Montenegro", No. 069/15 of 14.12.2015) specifies the following requirements with respect to the description of past flood and the adverse impacts which could occur with future flooding events:

- Description of past flood events which had significant adverse impacts on human health, the environment, cultural heritage, and economic activity, for which it is probable to occur again in the future, considering the severity of flood events, runoff directions and assessment of adverse impacts caused by such events (Section 4.4).
- Description of floods that occurred in the past in areas where significant adverse impacts can occur in the future due to changed conditions (urban development, proclamation of protected areas). This is also covered in Section 4.4.
- The Impact of climate change on occurrence of floods (see Section 5).
- Assessment of potential harmful impacts of future floods on human health, environment, cultural heritage, and economic activities, considering topography, position of water courses and their hydrological and geo-morphological characteristics, flood plains as natural retentions, efficiency of the existing flood protection facilities, position of settlements, areas of economic activities and long-term development plans, as necessary (see Section 6).

4.2 Definition of Source of Floods

The following types of floods (or: “source of flood”) shown in Table 4.1 have been considered in the Danube River Basin when identifying the areas of potential significant flood risk.

The primary focus of the preliminary flood risk assessment was agreed during a Working Group meeting in June 2020 to be focused on the potential risks resulting through floods along surface waters from rivers and streams (fluvial).

Where the territory of Montenegro is concerned, in addition to the types of floods presented in the Guidance for reporting under the EU Floods Directive, the PFRA takes account of the specificities of the terrain in the Danube River Basin and therefore an adequate representation of the types of flooding reflecting the natural conditions.

Table 4.1. Source of floods

Type / Source[7]	Description[8]
Fluvial	Flooding of land by waters originating from part of a natural drainage system, including natural or modified drainage channels. This source could include flooding from rivers, streams, drainage channels, mountain torrents and ephemeral watercourses, lakes and floods arising from snow melt.
Pluvial	Flooding of land directly from rainfall water falling on, or flowing over, the land. This source could include urban storm water, rural overland flow or excess water, or overland floods arising from snowmelt.
Groundwater	Flooding of land by waters from underground rising to above the land surface. This source could include rising groundwater and underground flow from elevated surface waters.
Artificial Water-Bearing Infrastructure	Flooding of land by water arising from artificial, water-bearing infrastructure or failure of such infrastructure. This source could include flooding arising from sewerage systems (including storm water, combined and foul sewers), water supply and wastewater treatment systems, artificial navigation canals and impoundments (e.g., dams and reservoirs) and activation of landslides.

Pluvial / heavy rain / flash flooding (also: torrential flooding)

For the rivers of the Danube River Basin (Lim, Tara Ćehotina, Ibar) pluvial floods are not modelled and thus a systematic risk assessment is not possible based on existing information. However, due to the importance of this type of flood, according to the increasing damages in recent years, flash flood events are documented and considered in the evaluation of potential risk areas. If recurrent past events occur in one location or one region this is regarded as a significant risk in the light of this PFRA.

The determination of flash floods in the context of this study is based on the characteristic of the specific location in which the flood occurs. If the size of the catchment that drains water to this location is <20 km², and no permanent river or stream exists, and if there is a rapid response (less than 6-8 hours) of runoff to precipitation in the basin, it is be defined as heavy rain event or flash flood. If the catchment is >20 km² and a permanent river or stream exists, it is defined as river flood.

Groundwater

Risks from groundwater often occur in lowland areas, marshland or meadows that are at the same time regularly flooded from rivers (fluvial floods). Thus, the potential risk areas are already identified under fluvial floods. If large areas that are not flooded from rivers have been flooded just from groundwater, and if these events have been recorded, those areas

[7] Guidance for reporting under the EU Floods Directive; EU 2013. Technical Report-2013-071.
[8] The possible mechanisms of previous flooding events in Montenegro based on hydrological data are shown in Annex 1.

are additionally documented and evaluated according to the significance criteria. In the PFRA for the rivers of the Danube River Basin no such areas were identified.

Artificial Water-Bearing Infrastructure

Damage due to dam failure is especially high due to the high speed of the flood water. Demolition often occurs within hours of the first visible signs of dam failure, leaving little or no time to evacuate.

The technical working group agreed that it considers the risk of dam failure to be significant risk, as the probability of dam failure is less than 1:10,000, according to the dam design and dam failure studies. Compared to the probabilities of fluvial floods (1:100, 1:500), this cannot be called significant in the PFRA methodology for determining the APSFR for FRM. However, there is a risk of structural failure of dams in the Danube part of the basin in Montenegro (Mratinje-Piva, Otilovići-Ćehotina). This risk should be regularly assessed (dam failure studies) and considered in maintenance plans and risk management scenarios. Retroactive effects of reservoir management upstream of the reservoir (increase in water levels upstream as a result of low water consumption in HPPs in wet seasons) are considered as fluvial floods due to rising lake/reservoir levels. The effects of reservoir management downstream (discharge of water from reservoirs in flood situations) are also considered with fluvial floods, as downstream reservoir channels are also the focus of fluvial flood risk below dams. Drainage channels are considered fluvial floods because they are closely related to water levels and floods in the riverbed and create areas of additional risk.

4.3 Existing Flood Infrastructure

In the process of preparation of the Flood Risk Management Plan, i.e., Preliminary Flood Risk Assessment, the document Inventory of existing flood defence infrastructure was prepared. This document contains all existing information on the built flood protection infrastructure given descriptively and graphically presented in the GIS. A summary of the information in this document is provided below.

The scope of work performed so far on the regulation of watercourses and flood defence on all watercourses in Montenegro is very modest and they were mostly performed in the 70s of the last centuries. Due to the partial approach to this issue, most of the constructed facilities are of a local character, so that the lengths of defensive embankments and regulated riverbeds are very short - from a few hundred meters to 1-2 km.

At the end of 2010, great consequences were caused by floods in the valley of the river Lim from Gusinje to Zaton, on the river Tara near Kolašin and Mojkovac, the river Ćehotina near Pljevlja and in the valley of the river Ibar in Rožaje. Flood protection systems were built in the period 2011-2015 in order to repair the consequences of the catastrophic floods that occurred in 2010, and as a prevention of future floods.

Since 2011, the Public Works Directorate has been implementing the project "Emergency Aid and Flood Prevention", which is financed from the credit funds of the European Investment Bank. Within this project, in the period from 2011 until today, 61 projects have been

realized. In addition to the construction of 3 bridges on the river Lim, the reconstruction of the main city bridge in Berane and the bridge on the Marsenića river, the riverbed was regulated, i.e., the construction of stone embankments in the length of approximately 10 km.

Table 4.2 summarizes the overview of existing facilities for passive and active flood defence in the Danube River Basin. The location of the flood defence are shown in Figures 4.1 to 4.5.

Table 4.2. Summary of existing facilities for passive flood protection in the Danube catchment area

	No.[9]	Watercourses	Location	Type of infrastructure	Year of construction
1	1.1.	Ibar	Rožaje	Regulation[10] 500m+700m	1979, 2018
2	2.1.	Lim	Plav	Regulation of Plav river 300m	2013-2014
	2.2.	Lim	Gusinje	Regulation Grnčar rijeke 200m	2012-2015
	2.3.	Lim	Gusinje	Regulation of river Vruje 1015m	2012-2014
	2.4.	Lim	Andrijevica	Regulation of river Lim 660m	2012-2014
	2.5.	Lim	Andrijevica	Regulation of river Zlorečice 350m	2012-2014
	2.6.	Lim	Berane	Regulation of river Lim 1200m	2012-2014
3	3.1.	Ćehotina	Pljevlja	Regulation of river Breznice 300m	2005-2008
	3.2.	Ćehotina	Pljevlja	Relocation of the Ćehotina riverbed near the coal mine Potrlica	
4	4.1.	Tara	Kolašin	River dikes[11] 3000m; River dikes Svinjače 355m	2012-2014
	4.2.	Tara	Mojkovac	Tailing's protection Brskovo -Tara 600m	2012-2014
	4.3.	Tara	Mojkovac	Regulation Rudnice, tributaries of the Tara River 1.000m	2013

[9] The numbers 1.1 to 4.3 are referenced in Figures 4.1 to 4.5.

[10] Riverbed regulation: This includes measures and works on maintaining riverbed flow and flood protection. It may include dredging of the riverbed, construction of embankments and other hydraulic structures.

[11] Dike: These are regulatory structures outside the riverbed and serve to prevent the spillage of large amounts of water into the inundation, which for some reason has become construction or agricultural land.

The constructed facilities were built in urban areas only on the most critical sections where human lives and material goods are most endangered. Although in the period after 2010, at some hydrological stations related to the flood prevention works, Q10 or above were evident (see Section 4.4, Table 4.9), floods were not registered. It can be concluded that where flood defence infrastructure was located after 2010, a positive effect was observed on the protection of urban areas in the Ćehotina, Ibar, Lim and Tara River Sub-Basins. However, this does not mean that further flood defences are not required in the Danube River Basin. Since the results of the PFRA are only indicative, further flood hazard and flood risk analysis and mapping will be used to clearly identify areas where further flood defence investment is needed together with the type of flood protection required.

Figure 4.1. Existing flood protection facilities on the rivers Ibar, Plavska, Grnčar and Vruja

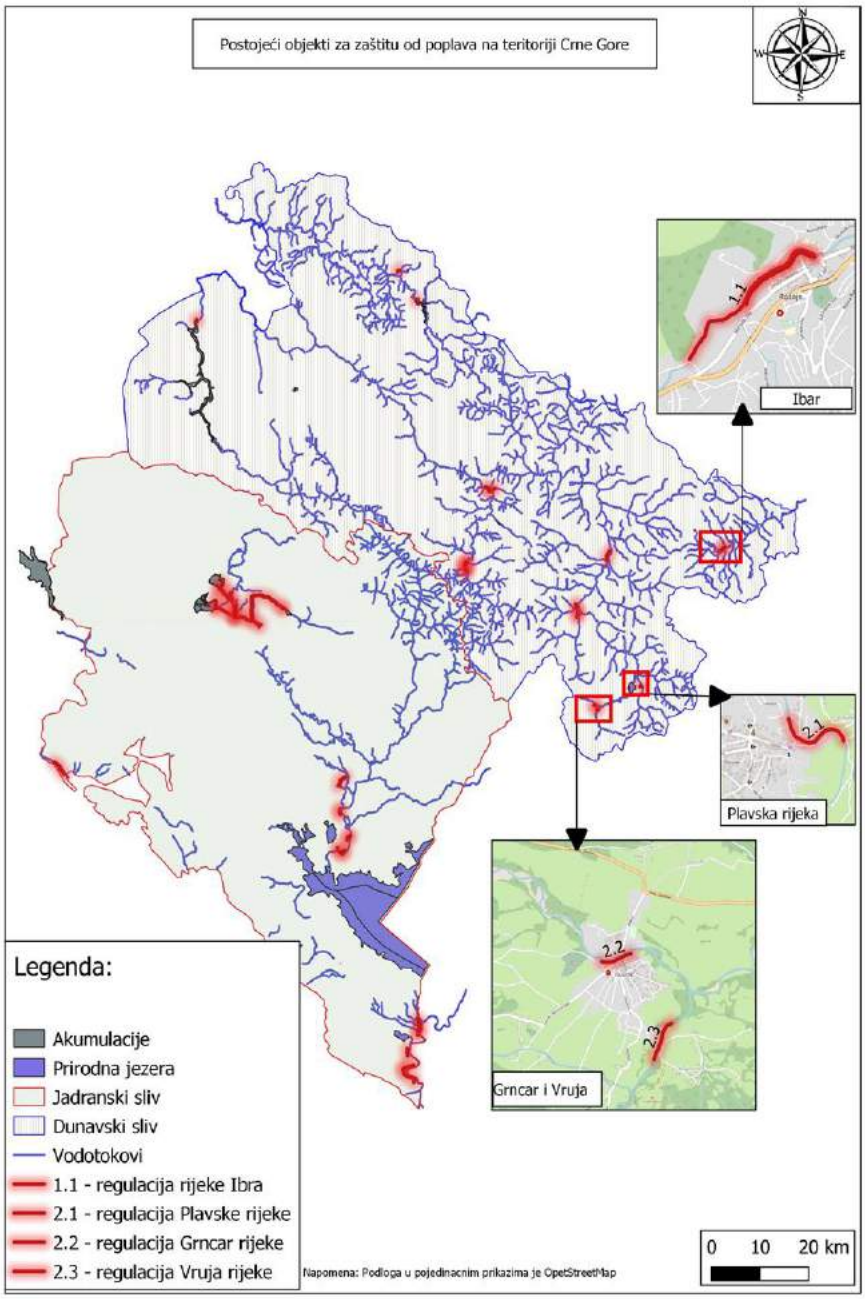


Figure 4.2. Existing flood protection facilities on the rivers Piva, Ćehtina and Breznica

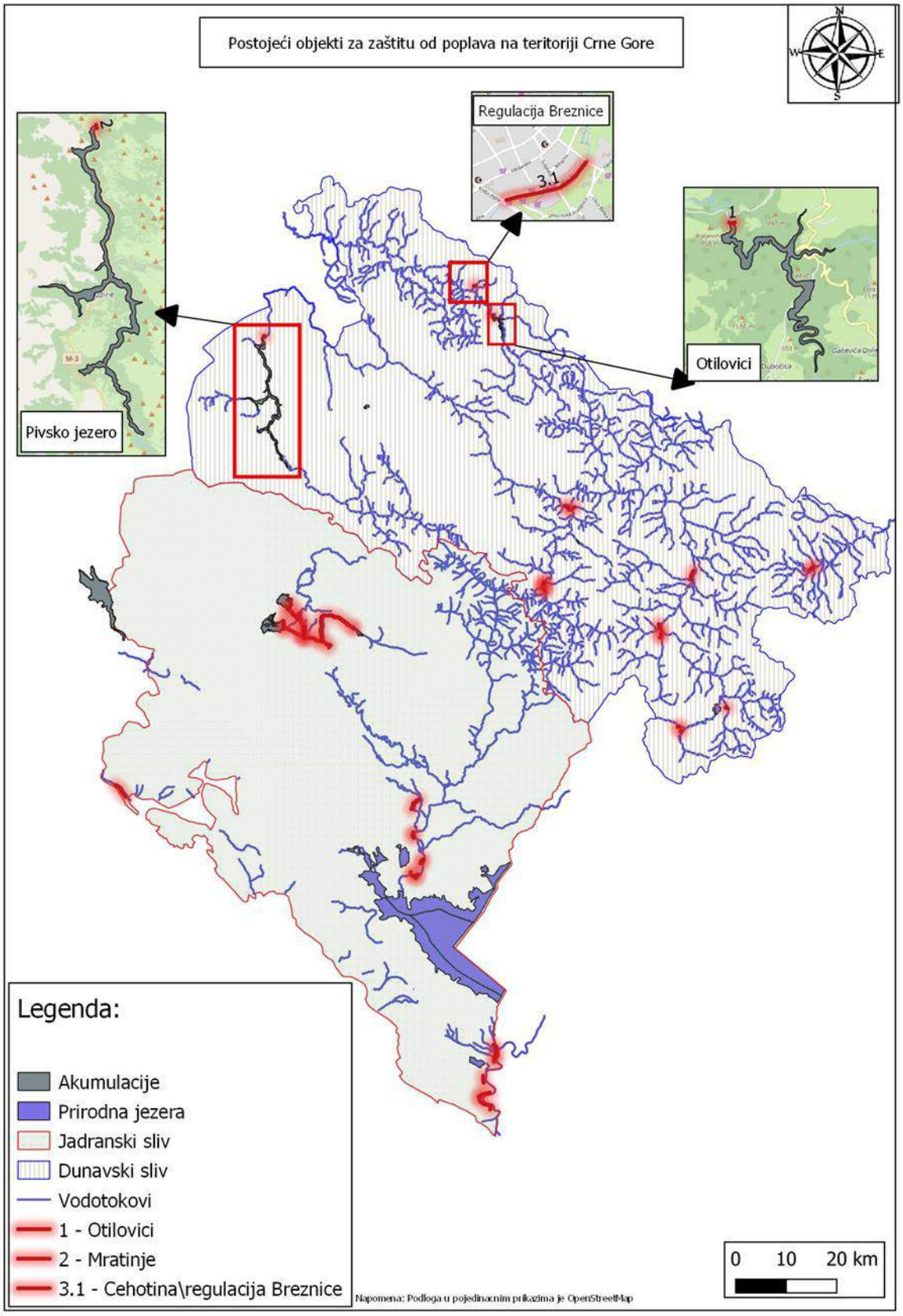


Figure 4.3. Existing flood protection facilities on the Lim River

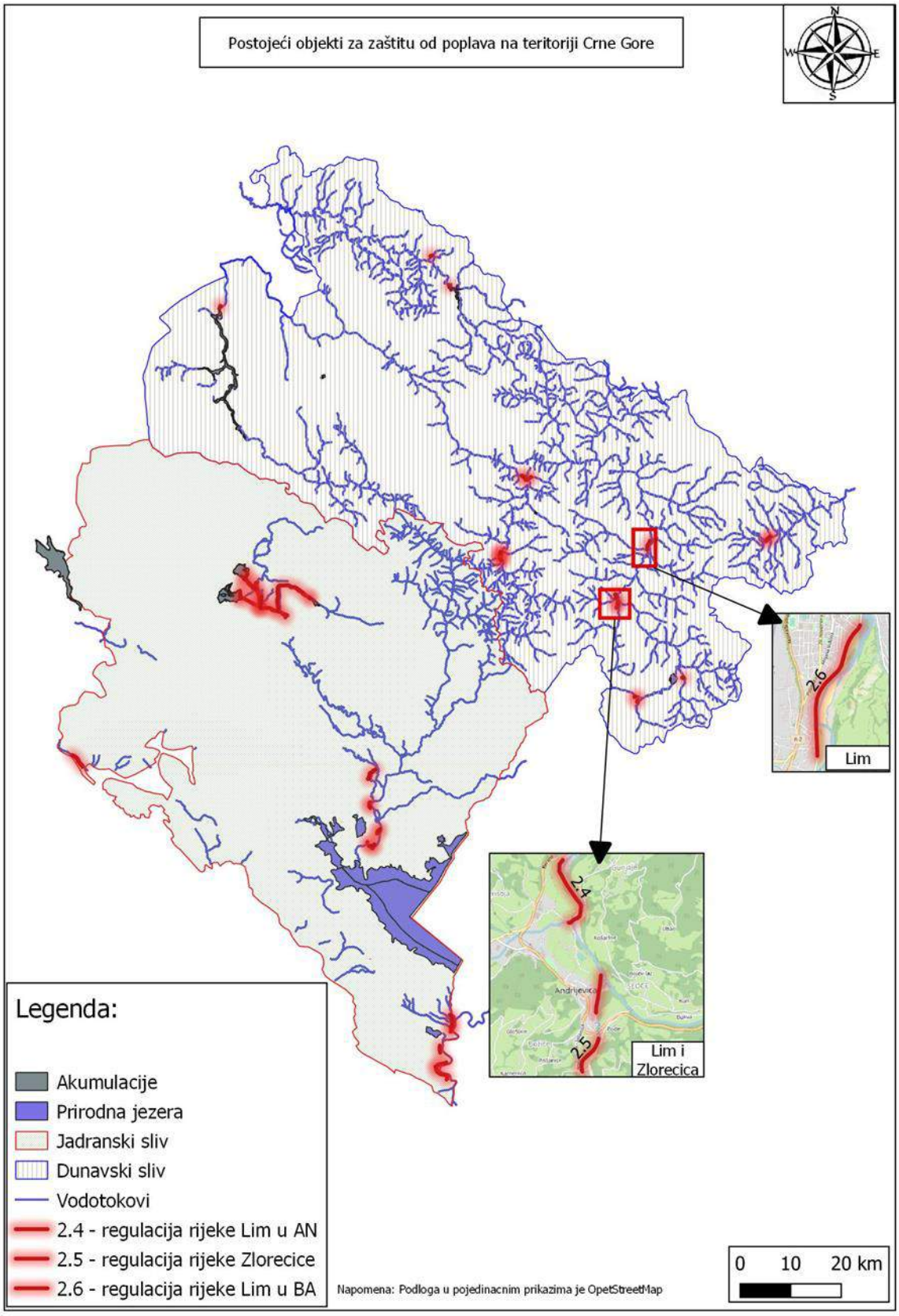


Figure 4.4. Existing flood protection facilities on the Tara River

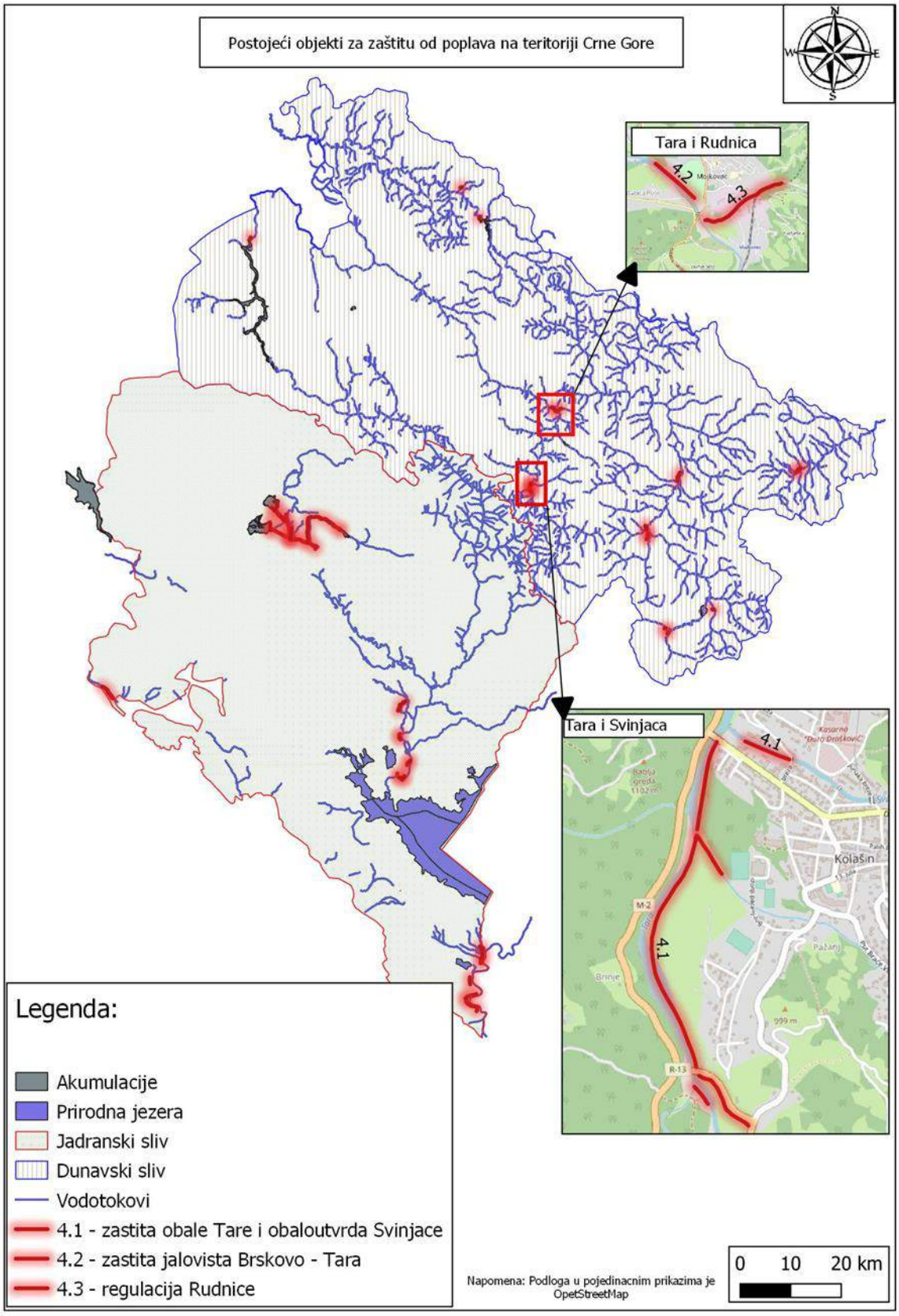
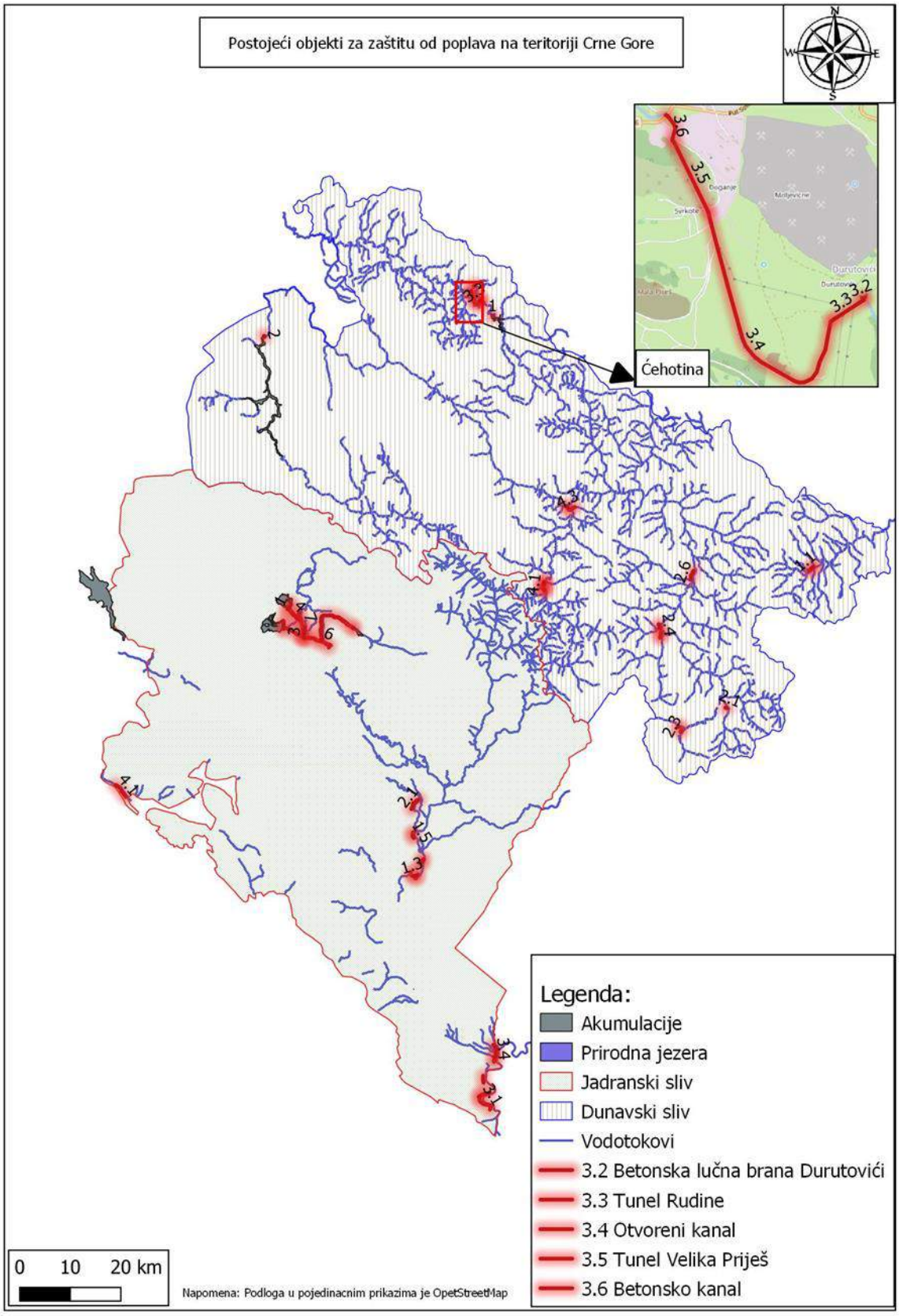


Figure 4.5. Existing flood protection facilities on the Ćehotina River



4.4 Description of past flood events which had significant adverse impacts

Given the geomorphological characteristics of the territory of the Danube basin, floods can endanger settlements, agricultural areas, and roads in river valleys. A large number of towns and settlements in Montenegro are located on the banks of larger rivers (Kolašin, Mojkovac, Pljevlja, Plav, Berane, Bijelo Polje, Rožaje) and most of them are potentially endangered by the overflow of large waters from riverbeds.

Historical hydrological data related to the recorded high (potential) flood waters on the network of hydrological stations in Montenegro were analysed from 1952 when water level measurements began on rivers. The complete set of data relating to the exact dates (years) of the high-water flows and the calculated return periods for each of the hydraulic stations in the Danube River Basin is provided in Annex 1. Table 4.3 provides a summary of the hydrological data. Since 1952, six events have been registered with flows of a calculated return period of 100 years. The most common high-water flows in the Danube basin are calculated with a 10-year return period, occurring 146 times since 1952.

Apart from the historical hydrological data there are no other official data detailing the extent of the inundated areas of flood waters or damage to property caused in the past other than those that occurred in 2010.

Table 4.3. Flood return periods of 10 to 100 years measured at hydrological stations in the Danube River Basin since 1952

Watercourse, location HS[12]	Return Period[13]		
	≥ 10 < 50 Years	≥50 < 100 Years	≥ 100 Years
Grlja, “Vusanje”	8	1	-
Vruja, “Gusinje”	7	1	-
Grnčar,“Gusinje	7	-	-
Lim, “Plav”	10	1	-
Zlorečica, ”Andrijevica	5	-	-
Lim, ”Andrijevica	18	-	-
Lim, “Berane”	2	-	-
Lim “Zaton”	6	-	1
Lim “Bijelo Polje”	11	-	1
Bistrica, “Gubavač”	8	-	1

[12] HS: Hydrological stations

[13] A 10-year flood has a 1/10 = 0.1 or 10% chance of being exceeded in any one year. A 50-year flood has a 0.02 or 2% chance of being exceeded in any one year. A 100-year flood has a 0.01 or 1% chance of being exceeded in any one year.

Watercourse, location HS[12]	Return Period[13]		
	≥ 10 < 50 Years	≥50 < 100 Years	≥ 100 Years
Lim, "Dobrakovo	5	-	1
Tara, "Crna poljana"	12	-	-
Tara, "Trebaljevo"	11	-	-
Štitarica, "Podbišće"	5	-	1
Tara, "Bistrica"	6	-	-
Ćehotina, "Pljevlja"	10	-	-
Ibar, "Rožaje"	5	-	1
Bukovica, "Šavnik"	7	-	-
Bijela, "Šavnik"	3	-	-
Total	**146**	**3**	**6**

High waters registered in late 2010/early 2011

Despite the hydrological data assessment, which indicates that flooding in the Danube basin would have occurred on multiple occasions, the only information available that can be included for the PFRA relates to the historical flooding event that occurred in 2010. Despite the paucity of detailed data to document historical flood events, the data from 2010 is invaluable for the preliminary flood risk assessment. After the 2010 floods, major damage was recorded to housing, bridges, and road infrastructure, as illustrated in Figure 4.6.

Data and information on the November 2010 /January 2011 flood events are available in the Flood Protection and Rescue Plans prepared by the municipalities in 2012. These data are summarized in Table 4.4 for the 8 municipalities encompassing 23 distinctly individual affected areas in total. 4 areas were located in the Ibar Sub-Basin, 13 in the Lim Sub-Basin, 4 in the Tara Sub-Basin and 2 in the Ćehotina Sub-Basin.

Further details for each of the 23 affected areas are shown in Tables 4.5 to 4.8, which include a description of the damage, the potential risks/assets in the area of the flooding together with the significance of the potential risks in relation to human health, environmental and cultural criteria.

In total, during the November 2010 /January 2011 flood event, a minimum surface area of 7.98 km^2 in the Danube River Basin was inundated by the flood waters, which directly affected 4,600 people and caused damage to 1,205 dwellings and 60 small businesses[14]. Fortunately, there were no fatalities. 2,785 people were affected in the Lim River Sub-Basin and 1,153 people were affected in the Ibar River Sub-Basin. 615 and 47 people were affected

[14] The number of small business affected is underestimated since in many affected areas the data was not recorded.

in the Tara River and Ćehotina River Sub-Basins, respectively. 2 drinking water supplies were affected in the Lim River Sub-Basin. 2 cultural assets were damaged in the Ibar Sub-Basin.

Table 4.4. Summary of data from municipal flood protection plans for the floods in November 2010 to January 2011

Catchment Area	Municipality	Flood type[15]	Flood mechanism/ characteristics[16]	Affected Regions / locations
Ibar	Rozaje	A11, A12	A21/A31, A34	Locations in the Rozaje city, Suho Polje, Županica, Ibarac. Hurije, Donja Lovnica, Kalače, Skarepača, Koljeno, Rasadnik
Lim (Tributaries Grnčar, Vruja, Dolja,Ljuča)	Plav	A11, A12	A21/A34	• River Lim: Settlements: Brezojevice, Rambalovi lugovi, • River Grncar: Dosuđe, • River Duricka: Prnjavor, Bogajiće, Malo selo, Jesenice • River Ljuca: Hakanje, Vojno Selo, Martinoviće • Plav river and lake: Urban area, Prnjavor, Novšiće, Gornja Ržanica i Mašnica
Lim (Tributaries Zlorečica, Kraštica, Trepačka)	Andrijevica	A11, A12	A21/A34	Seoce, Zoriće, , Košutiće, Kuti, Bradavac, Furune, Andželate, Djuliće, Trepča, Trešnjevo, Slatina, Prljanije, Luge, Ulotina
Lim	Berane	A11, A12	A21/A34	Vinicka, Buče, Ulica Mira i slobode, Hareme, Gornji i Donji Talum, Riversajd, Donje Zaostro, Skakavac, Crvljevine, Štitari , Lukavica, Bioča

[15] Flood type is based on guidance for reporting under the EU Floods Directive; EU 2013. Technical Report-2013-071. A11: Fluvial; A12: Pluvial

[16] Flood mechanism and flood characteristics are based on guidance for reporting under the EU Floods Directive; EU 2013. Technical Report-2013-071. A21: Natural Exceedance: Flooding of land by waters exceeding the capacity of their carrying channel or the level of adjacent lands; A31: Torrential flood: A flood that appears and disappears fairly quickly, with little or no warning, usually as a result of intense rainfall over a relatively small area; A34: Medium-Rapid Flood: The onset of flooding that occurs more slowly than a sudden flood; A40 - Flood characteristics data not available.

Catchment Area	Municipality	Flood type[15]	Flood mechanism/ characteristics[16]	Affected Regions / locations
Lim	Bijelo Polje	A11, A12	A21/A40	Bioča, Srđevac, Šćepanica, Zaton, Loznice, Strojtanica, Voljavac, Dobrakovo, Boljanina, Mokri Lug, Kahve, Lug, Presečenik, Ušanovići, Voljavac, Pavino Polje
Tara	Kolasin	A11, A12	A21/A31	Urban area of Kolasin, Bećova Bara, Luge, Uvač, Han, Garančići, Jabuka, Jasen, Mateševo, Bijeli Potok, Skrbuša, Pješčanica, Donja Breza, Trebaljeva, Sjerogošte
Tara	Mojkovac	A11, A12	A21/A31	Zakršnica, Barice, Ambarine, Podbišće, Uroševina, Slatina, Polja, Gojakovići, Štitarica, Rudnica, Lepenac, Babića Polje
Ćehotina	Pljevlja	A11, A12	A21/A34	Ševari, Židovići

Figure 4.6 Examples of Damage from floods in late 2010/early 2011

River Lim-location Rijeka Marsenića, Andrijevica

River Lim, location Donji Talum, Berane

River Lim, Main road Berane - Bijelo Polje

River Lim, Settlement "Riversajd

Table 4.5(i). Documented historical flood Events in the area of the small basin of the river Ibar [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
1.	Ibar	Ibar	Rozaje	Rozaje-Suho Polje - Zeleni	0.12	391	0	89	7
	Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31, A34								
	Description of Damage: The floods endangered residential and business facilities, road, sewage, and underground PTT infrastructure. The potential risk area is about 12 ha. In the flood zone, there are 89 residential buildings in which 391 people live, the Cultural and Historical Monument of Ganić Tower and the Religious Building - mosque. Also, in this zone is the Furniture Factory and some other business and commercial facilities.								
	Possibility of future significant damage[19]			**Urbanization[20]**: No		**Declaring the area protected**: No		**Other Reasons**: No	
	Risk Assessment / Significance of Potential Risks[21,22]:								
	A) Human health, economic values			**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
	No. of houses			Contaminated sites		Nature Protected areas		UNESCO heritage sites	
	Settlement area (in ha)			Locations of substances		Drinking Water supply areas		Other cultural heritage sites	

[17] Flooding events during November 2010 to January 2011

[18] Based on guidance for reporting under the EU Floods Directive; EU 2013. Technical Report-2013-071

[19] In accordance with Article 3 (3) of the Rulebook on the Closer Content of the Preliminary Flood Risk Assessment and the Flood Risk Management Plan (OG", No. 069/15).

[20] Determination if significant adverse impacts would occur in the future due to urban development.

[21] According to threshold of significance criteria detailed in Section 6, Table 6.2. The red colour indicates a value equal to or above the threshold criteria, while green indicates a value below the threshold criteria. Risk assessment is in accordance with Article 3 (2) of the Rulebook on the Closer Content of the Preliminary Flood Risk Assessment and the Flood Risk Management Plan ("OG", No. 069/15 of 14.12.2015).

[22] The extent of the flood was given descriptively stating the settlements that were endangered, which was later confirmed by maps showing the boundaries of floodplains for ten-year, hundred-year and five-hundred-year waters. It should also be noted that the runoff of flood waters is carried out over the riverbed and inundation land.

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
	Industrial objects		IED / PRTR-location		Bathing waters				
	Industrial area (in ha)								

Table 4.5(ii). Documented historical flood Events in the area of the small basin of the river Ibar [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
2.	Ibar	Ibarac	Rozaje	Rozaje-Ibarac	0.25	249	0	54	5

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31, A34							
Description of Damage: The river Ibarac in the length of about 1500 meters overflows on both banks and causes damage in the settlement of Ibarac on residential and auxiliary facilities, local road, sewage, and PTT infrastructure and on agricultural land.							
Possibility of future significant damage[19]		**Urbanization[20]:** No		**Declaring the area protected**: No		**Other Reasons**: No	
Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)							
A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.5(iii). Documented historical flood Events in the area of the small basin of the river Ibar [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
3.	Ibar	Lovnicka	Rozaje	Hurije, Donja Lovnica	0.18	171	0	46	11

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31, A34

Description of Damage: In the settlement of Hurije, Lovnička rijeka were caused the biggest problems to the population by flooding their residential and auxiliary facilities, private plants for primary wood processing, road infrastructure, agricultural land. In the settlement of Donja Lovnica, the river flooded agricultural land, individual residential and auxiliary facilities, a plant for the production of concrete elements, a village mosque and road infrastructure.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.5(iv). Documented historical flood Events in the area of the small basin of the river Ibar [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
4.	Ibar	Zupnica	Rozaje	Kalače, Skarepača, Koljeno, Rasadnik	0.5	342	0	108	37

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31, A34

Description of Damage: The Županica River, in its length of about 6 km, threatens individual residential buildings, agricultural areas, wood processing plants, local road infrastructure and the underground PTT network by overflowing from its bed. In the flood zone there are 108 residential buildings in which 342 people live. Also, in this zone, there are 37 business and economic facilities and the elementary school "Bratsto i Jedinstvo" in Skarepača.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(i). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
1.	Lim	Grncar	Gusinje	Gusinje, Grncar Dosusje	0.67	585	0	146	NR[23]

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: The Rivers Grnčar, Vruja and Dolja in the town of Gusinje endanger the town center and the refugee settlement of Vruja (80 residential buildings, i.e. 320 inhabitants).The village of Grnčar - the river Grnčar floods the left and right banks and endangers 40 residential buildings, i.e. .160 inhabitants. The village of Dosuđe - the river Grnčar endangers 15 residential buildings, i.e. 50 inhabitants. The village of Dolja - the river Dolja endangers 10 residencies.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

[23] NR: Not recorded

Table 4.6(ii). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
2.	Lim	Vruja	Gusinje	Gusinje	0.1	223	0	61	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: The village of Vusanje - the river Vrulja endangers 15 residential buildings, i.e. 75 inhabitants. The villages of Kruševo and Koljenovići - Potoci flows into Ljuća Grnčar endanger 10 residential buildings, i.e. 30 inhabitants in each village.

Possibility of future significant damage[19] | **Urbanization[20]:** No | **Declaring the area protected**: No | **Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		B1) Water polluting substances / sites		B2) Protected areas		C) Risk for cultural heritage sites	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(iii). Documented historical flood Events in the area of the small basin of the river Lim[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
3.	Lim	Djuricka	Plav	Bogajiće, Malo selo, Jesenice	1.3	184	0	46	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: A part of the Plav water supply system was damaged. In the village of Jasenice, a 500 m long asphalt road and a 600 m long macadam road were completely destroyed.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(iv). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
4.	Lim	Plavska	Plav	Plav - the town center, Prnjavor	0.15	160	0	40	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: In the village of Prnjavor, a road 150 m long was taken away, and the water supply and sewerage system were interrupted.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(v). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
5.	Lim	Ljuca River and Plav Lake	Plav	Martinovićе, Hakanje, Vojno Selo, Latek Šarkinovića	NR	199	0	48	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: Ljuča River and Plav Lake endanger the village of Hakanje and Vojno Selo (30 residential buildings, i.e. 120 inhabitants). Flooded part of the Damjanova Kula hotel and part of the Aqva restaurant. Plav Lake endangers the village of Šarkinovića (5 residential buildings, i.e. 14 inhabitants). Rijeka Ljuča endangers the village of Martinovićе (13 residential buildings, i.e. 65 inhabitants).

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(vi). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
6.	Lim	Lim	Plav	Plav, Brezojevica, Rambalovi lugovi	0.21	180	0	50	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: The Lim River threatens the village of Brezojevica and the settlement "Rambalovi lugovi" (50 residential buildings, i.e. 180 inhabitants).

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(vii). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
7.	Lim	Lim	Plav	Murino, Pepice		90	0	30	NR
	Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34								
	Description of Damage: No information is available								
	Possibility of future significant damage[19]		**Urbanization[20]:** No		**Declaring the area protected**: No		**Other Reasons**: No		
	Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)								
	A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**		
	No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites		
	Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites		
	Industrial objects		IED / PRTR-location		Bathing waters				
	Industrial area (in ha)								

Table 4.6(viii). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
8.	Lim	Lim	Andrijevica	Andrijevica, Prljnije	0.45	200	0	48	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: The Lim River, by leaving its bed, significantly endangered the residential buildings in the settlement of Prljnije. There was a flooding of private residential and auxiliary buildings and there was a danger that the refugee settlement Lim2 would be completely taken away.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(ix). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
9.	Lim	Lim	Lima Valley	Novšiće, Gornja Ržanica i Mašnica	NR	135	0	45	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34									
Description of Damage: No information is available.									
Possibility of future significant damage[19]		**Urbanization[20]:** No			**Declaring the area protected**: No			**Other Reasons**: No	
Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)									
A) Human health, economic values		**B1) Water polluting substances / sites**			**B2) Protected areas**			**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites			Nature Protected areas			UNESCO heritage sites	
Settlement area (in ha)		Locations of substances			Drinking Water supply areas			Other cultural heritage sites	
Industrial objects		IED / PRTR-location			Bathing waters				
Industrial area (in ha)									

Table 4.6(x). Documented historical flood Events in the area of the small basin of the river Lim[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
10.	Lim	Lim	Berane	Berane, Talum, Riversajd, Hareme	0.3	595	0	182	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: In the settlement of Hareme on the right bank of the river Lim, 18 residential buildings with 75 people are endangered. In the settlements of the upper and lower Talum, on the left bank of the Lima, 131 residential buildings are endangered, in which a total of 809 people live. In addition to residential buildings, a total of about 13 ancillary buildings (private zoo, garages, barns, pantries, etc.) are endangered at this location. The Riversajd refugee settlement is located on the right bank of the Lima and is completely endangered by floods. At this location there are 43 residential buildings, in which 279 people live. The entire settlement was flooded in 2010, although a gabion fortification was built upstream from it earlier, in the length of 200 m. In addition to the high-water level, groundwater also contributes to the flooding of the settlement to a good extent.

Possibility of future significant damage[19]	**Urbanization[1720]:** Yes	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(xi). Documented historical flood Events in the area of the small basin of the river Lim[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
11.	Lim	Lim	Bijelo Polje	Rakonje	0.5	27	0	5	NR
	Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A40								
	Description of Damage: No information is available								
	Possibility of future significant damage[19]		**Urbanization[20]:** No		**Declaring the area protected**: No		**Other Reasons**: No		
	Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)								
	A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**		
	No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites		
	Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites		
	Industrial objects		IED / PRTR-location		Bathing waters				
	Industrial area (in ha)								

Table 4.6(xii). Documented historical flood Events in the area of the small basin of the river Lim [17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
12.	Lim	Lim	Bijelo Polje	Zaton, Loznice, Strojtanica	NR	42	0	3	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A40

Description of Damage: Location Strojtanica is located below the chapel and cemetery in the length of about 200 m on the right bank. Two residential buildings of a Roma settlement in which 11 people live are endangered by the spill of Lim. Location Loznica near the pedestrian bridge Loznica-Pruška, a residential building in which 17 people live is endangered. At the location of Zaton near the old school in the length of 800 m, two-apartment buildings in which 14 people live are endangered.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.6(xii). Documented historical flood Events in the area of the small basin of the river Lim[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
13.	Lim	Ljesnica	Bijelo Polje	Ljesnica, Rijek	0.1	165	0	26	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A40

Description of Damage: The river Lješnica causes problems in the lower course in the last 3 km, in the urban settlements of Lješnica and Rijeka. In the city settlement of Lješnica, 5 residential buildings in which 25 people live are endangered, and in the city settlement of Rijeka, 21 residential buildings in which 140 people live are endangered.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.7(i). Documented historical flood Events in the area of the small basin of the river Tara[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
1.	Tara	Tara	Kolasin	Kolasin – Donji Razanj	0.3	310	0	80	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31

Description of Damage: The settlement on Lug with about 50 residential buildings is endangered by the floods, as well as the sports zone with a sports hall and football and tennis courts. Also, the settlement near the bridge on Tara with about 15 residential buildings is endangered.

Possibility of future significant damage[19] | **Urbanization[20]:** No | **Declaring the area protected**: No | **Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		B1) Water polluting substances / sites		B2) Protected areas		C) Risk for cultural heritage sites	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.7(ii). Documented historical flood Events in the area of the small basin of the river Tara[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
2.	Tara	Svinjaca	Kolasin	Kolasin - Dunja Djokic Street	0.05	62	0	16	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31

Description of Damage: No information is available

Possibility of future significant damage[19] | **Urbanization[20]:** No | **Declaring the area protected**: No | **Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		B1) Water polluting substances / sites		B2) Protected areas		C) Risk for cultural heritage sites	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.7(iii). Documented historical flood Events in the area of the small basin of the river Tara[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
3.	Tara	Tara	Mojkovac	Gojakovici, Polja Urosevina	2	34	0	11	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31

Description of Damage: Location Uroševina - at this location due to the overflow of the river Tara and the inability to receive torrents, 11 buildings with 24 inhabitants may be flooded. In this part of Tara, it also endangers the local road Mojkovac - Slatina in the length of about 4000 m

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.7(iv). Documented historical flood Events in the area of the small basin of the river Tara[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
4.	Tara	Tara	Mojkovac	Podbisce, Ambarine	0.6	209	0	53	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A31

Description of Damage: At the Podbišće location, six buildings with 22 inhabitants may be endangered in the event of the Tara River overflowing. Borovnjački potok often knows how to swell, thus endangering the local road Mojkovac - Podbišće, five residential buildings with 20 inhabitants and a small part of agricultural land. Due to the failure to maintain the culvert, there is a possibility of endangering the railway. Location of Ambarine 1 - a settlement above the railway with 15 apartments and 44 people, flooded by stream that passes through that settlement. The location of Ambarine - a settlement with 26 residential buildings with about 110 people may be endangered due to the overflow of the river Tara.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.8(i). Documented historical flood Events in the area of the small basin of the river Ćehotina[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municipalities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
1.	Ćehotina	Breznica	Pljevlja	Sevari	0.12	15	0	8	NR

Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34

Description of Damage: River Breznica in the part of the settlement Ševari in the length of 1300 m floods arable land, meadows, orchards, auxiliary and residential buildings owned by locals.

Possibility of future significant damage[19]	**Urbanization[20]:** No	**Declaring the area protected**: No	**Other Reasons**: No

Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)

A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**	
No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites	
Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites	
Industrial objects		IED / PRTR-location		Bathing waters			
Industrial area (in ha)							

Table 4.8(ii). Documented historical flood Events in the area of the small basin of the river Ćehotina[17]

No.	Sub-Basin	River/Tributary	Affected Regions / Municip alities	Affected Settlements/ Villages	Affected Area (km²)	No. of persons Affected	No. of Deaths	No of Affected Dwellings	No. of Affected Small business
2.	Ćehotina	Ćehotina	Pljevlja	Zenica	0.08	32	0	10	NR
	Source (S), Mechanism (M) and Characterization (C) of flood according to EU guidelines[18]: S - A11, A12; M - A21; C - A34								
	Description of Damage No information is available								
	Possibility of future significant damage[19]		**Urbanization[20]:** No		**Declaring the area protected**: No		**Other Reasons**: No		
	Risk Assessment / Significance of Potential Risks (see footnotes 21, 22 above)								
	A) Human health, economic values		**B1) Water polluting substances / sites**		**B2) Protected areas**		**C) Risk for cultural heritage sites**		
	No. of houses		Contaminated sites		Nature Protected areas		UNESCO heritage sites		
	Settlement area (in ha)		Locations of substances		Drinking Water supply areas		Other cultural heritage sites		
	Industrial objects		IED / PRTR-location		Bathing waters				
	Industrial area (in ha)								

Tables 4.5 to 4.8 include an assessment of the areas in the Danube River Basin where future urban development may have a negative impact. Urbanization will have almost no impact on future floods in the basin except for one area (shown in Table 4.6 (x) for the Lim-Berane) due to the fact that the historic floods have occurred in mainly a rural or non-urban area. With respect to the Protected Areas, any possible future protection of certain areas (e.g. Lake Plav) will not have a negative impact on future floods.

High waters registered after 2010

Hydrological data clearly indicates that following the 2010 flooding events, further high-water events occurred in the Danube River Basin during 2012, 2016, 2017 and 2019 (Table 4.9). Despite the recorded high waters, data for recorded floods is not available. However, the hydrological data have been considered for the identification of areas of potential significant flood risk (Section 6).

Table 4.9. High waters registered at hydrological stations in the Danube River Basin after 2010

Year	Calculated Return Period (Years)
Watercourse/HS[24] : Grlja, "Vusanje"	
2012	10
Watercourse/HS: Lim, "Plav"	
2016	10
Watercourse/HS: Lim, "Bijelo Polje"	
2016	10-20
Watercourse/HS: Lim, "Dobrakovo"	
2016	10
Watercourse/HS: Tara, "Crna poljana"	
2016	20-30
Watercourse/HS: Tara, "Trebaljevo"	
2016	10-20
2018	10
Watercourse/HS: Ibar, "Rožaje"	
2016	20
2017	10
2019	10

[24] HS: Hydrological station

5 CLIMATE CHANGE IMPACTS

5.1 Considerations for the effect of climate change

Global warming policy has always been based on complex computer modelling. And the limitations of modelling in relation to the unknowns of all physical factors have been strengthened when it comes to predicting how the climate will change in the coming decades. However, even though diverse studies of climate change have been conducted, a mutual understanding regarding the standardization of methodologies is not sufficiently consolidated.

The typical global atmospheric-ocean models of general circulation used today to study climate and climate change range from 100 to 200 km. The models show a satisfactory degree of success in simulating the observed climatic conditions on a planetary and continental scale as well as the increase in mean global temperature, observed during the last decades, conditioned by anthropogenic greenhouse gas emissions.

Conversely, many local climatic characteristics of certain regions are very dependent on their local physical characteristics, such as complex topography, type of land and vegetation and their distribution, which is typical for Montenegro. Most of these local characteristics cannot be correctly represented in global models, since the scale of the local characteristics of an area is often several times smaller in area than the minimum resolution of global models.

As the assessment of future changes in extreme events in modified climate conditions is a particular challenge, in the first place due to the high degree of vulnerability of the sector to changes in these events but also due to the specificities of adaptation measures to these phenomena, the World Weather Organization made a recommendation in 2009 to monitor and identify changes in extreme weather and climate events. The changes in frequency and characteristics of extreme weather and climate events have been observed since the second half of the 20th century. These extreme events cannot be attributed to long-term climate change, but they can provide valuable predictions of future scenarios through climate models. According to these models, the frequency and intensity of extreme events are likely to increase as a result of climate change and are likely to change rapidly in this century.

Based on the monitoring and assessment of the climate in Montenegro, and the analysis of extremes, 5 measurements for the air temperature and 3 for precipitation were selected from the set of climate indices. These are: number of frost days, number of last day with frost (in the first half of the year) and number of first day with frost (in the second half of the year), number of very warm days, heat wavelength and vegetation period, number of consecutive days without rain, number of consecutive days with rain and number of days with heavy or very rainfall (greater than 20 mm and 60 mm, respectively).

These indices were analysed in the conditions of normal climate, which is considered the period 1961-1990 and in the conditions of projected climate in the periods 2001–2030 and 2071-2100 (marked as A1B scenario simulation). In addition to the 8 indexes mentioned above, a change in the total annual volume of snow and the change of average daily maximum wind speed was analysed. These changes were calculated from the direct output

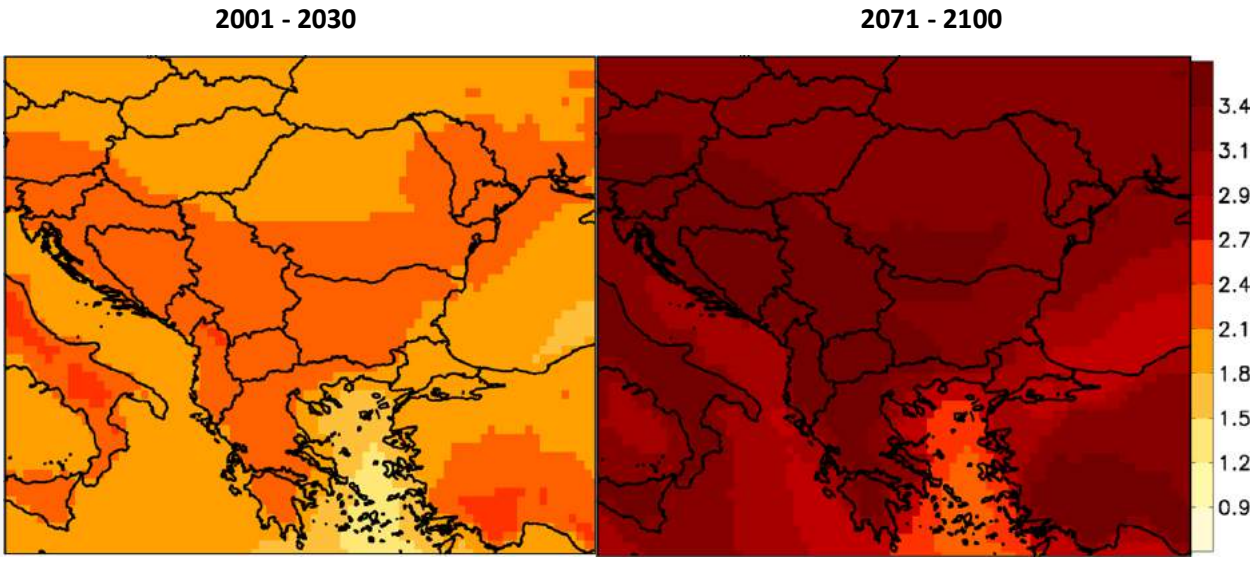
of the EBU-POM model and were expressed in percentage terms compared to the base period (1961-1990) and are presented below.

For the needs of the EBU-POM model, 4 meteorological stations were selected in the Danube basin at which measurements and observations are performed continuously, namely: Bijelo Polje, Kolašin, Pljevlja and Žabljak.

Temperature Projections

Figure 5.1 above, shows that the projected temperature for the period 2001-2030 is over 2 degrees in relation to the normal climate, which is considered for the period 1961-1990; for the period 2071-2100 the increase is calculated to be over 3 degrees.

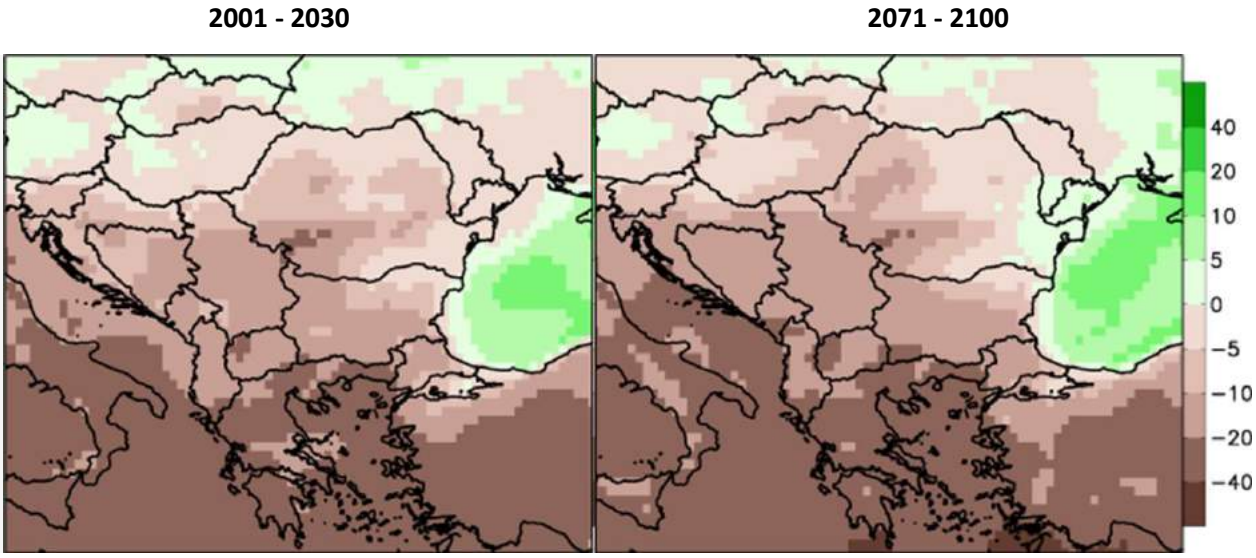
Figure 5.1. Change of average annual temperature (°C)



Precipitation Projections

Precipitation in the period 2001-2030 is calculated to decrease by 5% in the eastern part of the observed area (Ibar river valley) and by 10% in the rest of the Danube basin in relation to the normal climate, which is considered for the period 1961-1990. For the period 2071-2100 precipitation is calculated to decrease by 10 % in comparison to the present climate profile of the entire Danube River Basin (Figure 5.2).

Figure 5.2. Change in precipitation (%)



For the purpose of the PFRA of the particular importance is the current and projected Continuous Wet Days (CWD) Index and the relative intensity of rainfall, i.e., R20mm and R60mm Indexes. Extreme rainfall indicators used for the projections are shown in Table 5.1.

Table 5.1. Rainfall indicators used in the analysis

Index	Descriptor	Definition
CWD	Maximum length of wet spell	Maximum number of consecutive days with precipitation ≥ 1mm
R60mm	Number of days with very heavy rainfall	Annual number of days with daily precipitation ≥ 60 mm.
R20mm	Number of days with heavy rainfall	Annual number of days with daily precipitation ≥ 20 mm.
RX5day	Max 5-day rainfall	Maximum amount of precipitation in 5 consecutive rainy days
SDII	Daily precipitation intensity	Annual precipitation divided by the number of rainy days (defined as days with precipitation ≥ 1mm) in the year
CDD	Consecutive dry days	Maximum number of consecutive days when the daily rainfall is <1mm

The mean annual values of the CWD index were calculated for the period 1961–1990 for scenario A1B for the periods (2001-2030 and 2071-2100), with the change of this index in relation to the value from the period 1961–1990. The analysis reveals that the rainy period for both periods of time is decreasing, which is in line of all long dry seasons, which will

result in possible arid climate conditions in the future. Days with heavy rains (RR20mm) decrease slightly (Table 5.2).

Table 5.2. Mean annual values of the CWD and RR20mm indexes

Locations	CWD Index (change relative to 1961-1990)			RR20mm index (change relative to 1961-1990)		
	1961-1990	2001-2030	2071-2100	1961-1990	2001-2030	2071-2100
Bijelo Polje	8	8 (0)	7 (-1)	12	12 (0)	11 (-1)
Kolašin	10	10 (0)	9 (-1)	33	30 (-3)	27 (-6)
Pljevlja	7	8 (+1)	7 (0)	9	8 (-1)	7 (-2)
Žabljak	9	9 (0)	8 (-1)	21	19 (-2)	17 (-4)

In addition to model analyses of climate change scenarios, further analysis was conducted by the Department of Hydrometeorology and Seismology for the northern region of Montenegro for measured precipitation in the period from 1970 to 2017. For future climate projections, the RCP8.5 scenario was used, for which the future impacts of climate change on the climate regions of Montenegro were estimated.

There is a statistically significant change in the daily intensity of precipitation in all three cities of the northern region (Žabljak, Pljevlja and Kolašin). In Pljevlja, the number of days with very heavy precipitation has also changed significantly.

Analysis of the amount of precipitation by the main meteorological stations of all three regions shows variability both in space and time. The distribution of precipitation varies from one year to another. Deviations of the average amount of precipitation (in %) in relation to the climatic period 1971-2000 for north region is shown in the table on an annual level and by seasons June, July, August and December, January, February.

Table 5.3. Deviation of precipitation in % in relation to the period 1971-2000

	Annual	June-August	December - February
Žabljak	3	2	14
Pljevlja	0	-4	9
Kolašin	-2	-5	6

The climate projections revealed that changes in the total annual snowfall are negative for both time periods (2001-2030 and 2071-2100). This reduction in the annual amount of snow is greater than the reduction in the total amount of precipitation, which is expected considering that due to the increase in air temperature, snowfall will be deposited in the

form of rain. For the period 2001–2030 these changes will be less by about 10% in the northern parts of Montenegro. For the period 2071–2100 the changes are more significant. In the northern parts of Montenegro, the amount of snow projected to be lower by 30-50%, and lower by 30% in the easternmost areas.

Having in mind the situation with snow and increasing rainfall, in case of realization of the foreseen climate scenarios by the end of this century, an increased number of flood waves is expected, as well as changes in the flood regime: volume, duration, energy of flood wave.

In general, it can be concluded that flood events will be both more frequent and more intense, as a consequence of climate change.

During the preparation of the relevant flood risk assessments, the expected impacts of climate change were considered within one extreme flood scenario (500-year return period). The analysis included all proven or known, or estimated future impacts, including the effects of climate change.

5.2 Climate change impacts

The scenarios of climate change in the Danube basin and the consequences for hydrology, both in terms of increasing floods and longer low water periods and lack of water during the dry season are generally accepted.

In relation to hydrology, data obtained from the climate models described above were input to the hydrological models in order to calculate the effective change in water quantities in watercourses. Data indicating an increase in flows in the Danube basin were obtained, However, climate scenarios are only approximations of reality and cannot consider all of the influencing factors, i.e., they do not offer definitive predictions about specifics future events, rather than showing a wide range of possible future developments.

During this flood risk assessment, the expected impacts of climate change were considered by applying one extreme flood scenario (extreme flood recovery period ≥500 years). It includes all proven or known, or estimated future impacts, including climate change impacts. The impacts of climate change on the identification of areas with potentially significant flood risk are fully covered by working on scenarios of extreme flood events.

For considerations on climate change in the Preliminary Flood Risk Assessment, we can conclude the following:

- Having in mind all available data in Montenegro, as well as the experiences of other countries that we analyzed and an objective judgment on the data on the impact of climate change in this part of Europe, we can conclude that we do not have enough reliable data to quantify hydrological parameters (water level and flow) on the basis of the indicated changes in meteorological parameters in the foreseen scenarios. Preliminary flood risk assessment is by its nature based on existing data and is performed without “advanced hydrometeorological modeling” (if such information does not exist).

- Any hydrological model should consider not only the obtained data formats from climate models (primarily precipitation) related to the analysis of predicted climate change scenarios, but the whole set of data. This includes precipitation and snow cover, the duration of rain series over the entire catchment area, previous hydrological conditions in the field, changes that will occur in the basin due to natural and anthropogenic factors, etc.

- At this point we can only state the following: In general, it can be concluded that flood events will be both more frequent and more intense, as a consequence of climate change. Thus, although the reduction of total annual precipitation in most parts of Montenegro is expected, in the future short heavy rainfall, often combined with snowmelt and soil saturation, is expected to cause a higher risk of torrential floods caused by an increase in surface runoff.

6 IDENTIFICATION OF AREAS OF POTENTIALLY SIGNIFICANT FLOOD RISK (APSFR)

6.1 Methodology

The PFRA provides a high-level summary of significant flood risk for the RBD, based on available and readily derivable information. The PFRA is the first step in delivering a FRMP. The PFRA should cover historical flood events and the potential for future flood events that may have a significant adverse consequence on either, human health, the environment, cultural heritage, or economic activity. Flood-specific data such as historical flood information, geographic data, urban planning information, population statistics, economic activities, digital terrain models (DTM), hydrological and meteorological information, civil protection information and other national data was used to prepare the PFRA. This information is then used to identify the Areas of Potential Significant Flood Risk (APSFR), which are the areas that will be the priority for more detailed flood risk management assessment in the flood maps and FRMP stages.

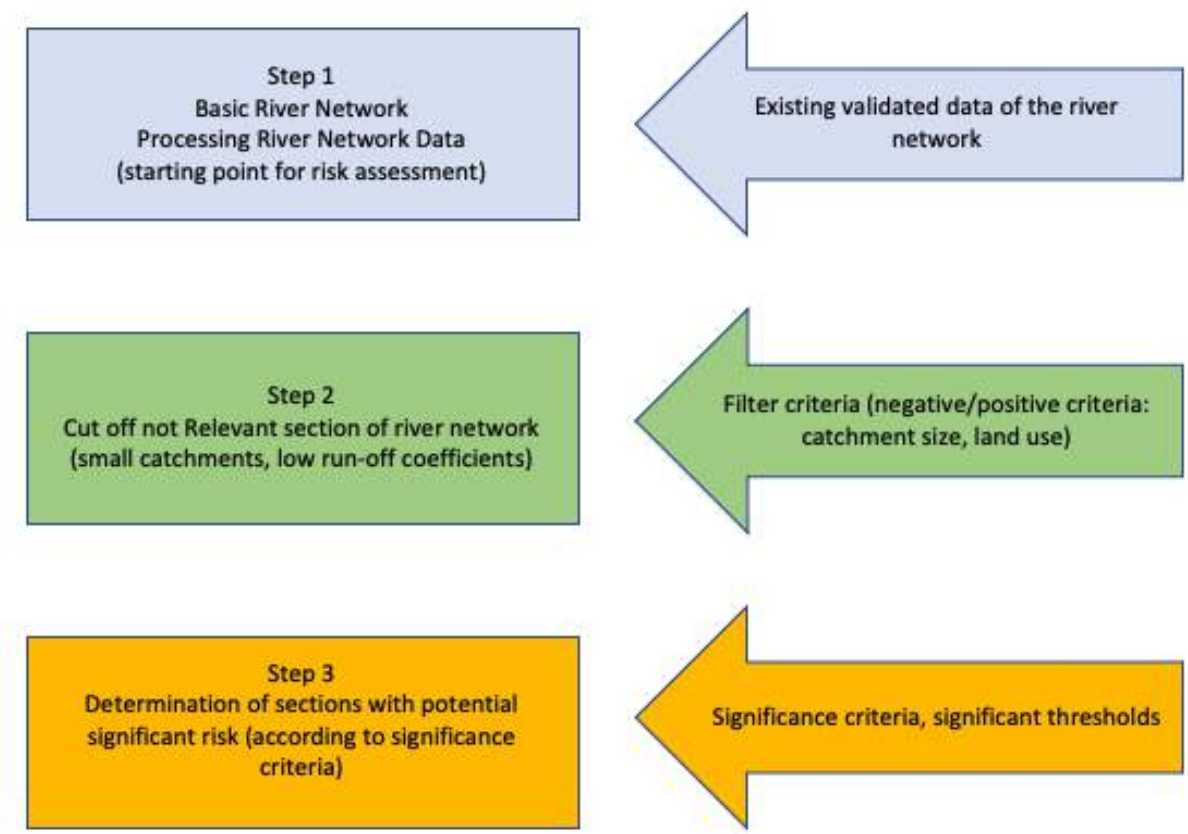
Generally, the identification of areas at potential significant flood risk follows three main working steps (Figure 6.1):

1. Determination of the initial river network: the river network is taken from the Danube Basin Management Plan. In addition, a validation with Open Street Map (OSM) data and with satellite images ensured the correctness. The whole relevant river network is processed in one GIS project and validated to be used for the further filtering process.

2. Determination of the river network that might have flood risk (filtering out not relevant river stretches according to negative criteria like size of the catchment, length of the stretch or characteristics of the riverbanks or flood plains (very steep or canyons, only 100% rural land uses). Here the threshold for the relevant catchment area was determined in an iteration using 50 km², 30 km², 20 km² and 10 km². The threshold of 10 km² results in a river network including many stretches which are dry for most of the year. So, 20 km² was determined as an adequate threshold for relevant river stretches. Nevertheless, smaller river sections were evaluated. All flooding along river stretches with catchments <20 km² the flood event can be defined as flash flooding or heavy rain event, while >20 km² is defined as river floods.

3. Assessment of the remaining river network in terms of potentially affected assets at risk, land uses or risk of pollution in case of floods and comparison with agreed significance criteria. The results are river stretches at potential risk, named: “Areas of Potential Significant Flood Risk” (APSFR).

Figure 6.1. Work steps of the preliminary flood risk assessment for the identification of areas with potential significant flood risk



The determination of the areas of potential significant flood risk is based on the analyses of the river sections, for which, from recent events, damage potential has to be expected and added by those stretches of the river network in which floods may have adverse consequences on human life, economy, ecology, or cultural heritage. For the single assets at risk, the significance of the risk is checked stepwise.

For the assessment steps the significance criteria are used, which cover all considerable assets at risk. Each step is linked to one criterion. Thus, the potential significant risk in each area is systematically checked and documented with the respective criteria in fact sheets[25].

According to the specifications of the Floods Directive, four groups of assets at risk shall be considered in flood risk management and in the preliminary flood risk assessment. The risk assessment and consequent risk reduction measures shall aim at all four groups of receptors and according to indicators, as shown in Table 6.1.

[25] In November 2018, the document Preliminary Flood Risk Assessment for the Drin / Drim - Buna / Bojana River Basin was adopted. This document was prepared by GIZ within the project Climate Change Adaptation in Transboundary Flood Risk Management for the Western Balkans. At the meeting of the project Working Group on 4th June 2020, it was adopted that the same criteria will be used in the preparation of the PFRA as used by the GIZ in the preparation of its document.

Assets at risk were determined to identify potential significant risks for all risk receptors. Significance criteria and the threshold define what is identified as potential significant (Table 6.2).

Table 6.1. Risk receptors and risk indicators

Risks	Example for flood risk indicators
Human Health	• Number of residential properties. • Critical services (Hospitals, Police/Fire/Ambulance Stations, Schools, Nursing Homes, etc.).
Economic Activity	• Number of non-residential properties. • Length of road or rail. • Area of agricultural land.
Environment	Designated sites (water protection areas, areas with water pollutant substances) and flora / fauna according to the EU-habitat directive
Cultural Heritage	Cultural heritage sites (e.g., World Heritage Sites).

Table 6.2. Significance criteria for the PFRA

Assets at Risk and Significance Criteria	Receptors				Significance Criteria	Threshold of Significance
	Human Health	Economic Activity	Environment	Cultural Heritage		
A) Human Health, economic values						
No. of houses	x	x			Existing area or area in the flood area of the extreme event	≥ 10
Settlement area	x	x				≥ 0.5 ha
Industrial objects		x				≥ 1
Industrial area		x				≥ 0.5 ha
Critical/valuable agricultural assets		x				Case to case
B) Environmental Risks						
B1 - Water Polluting Substances / Sites						
Contaminated sites			x		Existing object at risk (extreme event scenario)	≥ 1
Locations dealing with specific substances			x			≥ 1
B2 – Protected Areas						
Nature protected areas (e.g. Natura 200 etc.)			x		Existing assets at risk (extreme event scenario)	≥ 1
Drinking water supply	x		x			≥ 1
Bathing waters	x					≥ 1
C) Risk for Cultural Heritage Sites						
UNESCO heritage sites				x	Existing assets at risk (extreme event scenario)	≥ 1
Other relevant cultural heritage sites				x		≥ 1

For all areas in which floods have ever been observed and in which flood risk can be expected, evaluations are done to assess if the risk for one of the receptors exceeds the threshold (= significant, coloured in red) on not (= not significant, coloured in green).

Significance criteria for human health and economic values

An essential factor for the assessment of adverse consequences of flood events and their significance according to the Directive is the extent of risks for settlements, trade, and industry areas. This also reflects the respective damage potential in the areas.

To determine the significance threshold for human health and economic values the economic damage potential – if assessments are existing – may be used. Alternatively, here a threshold of ca. 0.25 Million€ is used with the assumption that this damage can be reached by flooding 10 or more houses (leaving water depth and damage functions out of the estimations). If only housing area size can be assessed the approximate of 0.05 ha per house, consequently 0.5 ha of housing area is considered to be the threshold for a potential significant risk.

In addition, risk for agricultural areas or agricultural assets is determined significant when in local or regional context substantial economic damage is possible that can ruin the basis for the existence of farmers. This includes vulnerable special crops, animals, and machinery. The assessment of these criteria was done by expert judgement (significant agricultural risk areas or objects).

A fixed threshold or limit for the flood agricultural area or economic risk for agriculture is not used in the PFRA because:

- Economic data are not available (especially not for the whole River Basin).
- Damage values in agriculture depend, like for all other land uses, but here much more, on the induvial situation: grassland, cropping or special cultures or even structures cannot be assessed by the size of the inundated area.
- The individual agricultural land use can change from year to year and can consequently not be used as criteria for a flood risk management process that is determined to take 6 years.
- If agricultural land use would be used as a significance criterion almost all inundated areas in a River Basin would have to be determined as significant. This would result in the need of a very large hazard and risk mapping plan area and flood risk management plans accordingly.

Retrospectively, based on different risk area assessments, it can be stated that no APSFR would have added or reduced due to the aspect agricultural values at risk, according to the expert assessments.

Specific damage potentials result from different factors like population density, specific real estate values and added value and differ from location to location. These aspects need to be considered when preparing detailed risk maps. For the preliminary flood risk assessment, the use of the named indicators is sufficient to determine areas of potential significant flood risk.

Significance criteria for environmental risk

Adverse consequences of flooding for a River Basin mainly occur if water polluting substances are mobilised by flood water entering rivers or lakes. Thus, the most important assets at risk in this respect are contaminated sites (soil) and locations for storing or using water pollutant substances. The highest environmental risk can be found if water pollutions meet most vulnerable natural areas, like nature conservation areas or protected natural sites. Thus, the assessment of significant risks includes the steps B1 “River sections with locations or facilities to store water polluting substances” and B2 “River sections with significant risk for protected areas”.

Significance criteria for cultural heritage

In the course of the verification step C “River sections with important or UNESCO cultural heritage” the significance of the risk of flood events is assessed by:

- UNESCO world heritage sites are classified as significant if damage as consequence of flooding is possible.
- River sections with at least one cultural heritage site or object with special regional or national importance if damage as consequence of flooding is possible.

Collection and documentation of risk information for the APSFR

Based on the evaluation of recorded and documented past flood events and including local knowledge and expert judgement areas or stretches of rivers with damages in flood events or potential (observed) risk were identified. For these areas all available information and data on flooding, land use, objects at risk and urban or infrastructure planning were collected and analysed. The data were assessed and compared with the significance criteria. The results are documented in Table 6.3.

For the whole River Basin, the river network is analysed (based on the available digital terrain models – DTMs), to identify all river sections with a catchment area >20 km². For the remaining parts the potential flood corridor was constructed. Land use and assets at risk according to the significance criteria were evaluated for the inundation areas. Thus, a second set of data was created for all potential risk areas to prove or validate the data and results collected for the fact sheets.

Based on the comprehensive documentation of hazard information, risk information and assessment steps, the determination of each single APSFR is made transparent.

6.2 Identification of APSFR

The results of the preliminary flood risk assessment are the starting point for determining the area of potentially significant flood risks. Determining the APSFR is the last step in the planning cycle when flood risks are observed in the same way on the entire state territory.

Based on the analysis described above, 19 APSFR in the Danube Basin area have been defined. All data provided in Figures 6.2 to 6.20 indicate the APSFR zones, which incorporate, where possible, the calculated extent of the HQ10, HQ100 and HQ500 year return periods.

The APSFR are located in each Sub-Basin as follows: the area of the small basin of the river Ibar (4), the area of the small basin of the river Lim (11), the area of the small basin of the river Tara (2), the area of the small basin of the river Ćehotina (1) and the area of the small basin of the river Piva (1). A summary overview of the location of each APSFR in the Danube River Basin is presented in Figure 6.2. Individual APSFR are shown in Figures 6.3 to 6.21.

On the river Ibar in Rožaje, the historical floods from 2010 identified one location that was flooded and was confirmed by hydrological data. However, three locations are identified on the tributaries (Ibarac, Lovnička, Župnička reka) although these are not covered by hydrological data. However, they were identified as APFSR based on the HQ10 HQ100 and HQ500 calculations from data available for the Ibar River.

The situation is different on the Lim River in the municipality of Plav where three locations are defined by historical floods as flood areas. Namely, for the Djuricka river, which is a tributary of the Lim. However, since there are no relevant or related hydrological data these areas cannot yet be determined as APFSR. It is therefore necessary to install measuring instruments in the upcoming period to determine the hydrological characteristics of these areas. The section in the centre of Plav which was flooded by the Plav River in 2010 has meanwhile been protected by an embankment. The area flooded by the river Ljuca and Lake Plav in 2010 is outside the boundaries of large waters.

For the locations of Ribarevina and Vinicka on the river Lim, no historical floods have been identified, but hydrological data confirm that floods in this area are probable. Therefore, the drafting of the APFSR was proposed. The situation is the same for the lowest part of Lim in Montenegro at the confluence with a large tributary of the river Bistrica.

In the Piva catchment, the last floods were identified in 1987 on the rivers Bijela and Bukovica in Savnik. However, a check of hydrological data found that most of the city could be affected by floods. Therefore, the drafting of the APFSR was proposed.

Table 6.3 provides a summary of each APSFR according to the coding schema for EU guidelines for reporting APSFR for the preliminary flood risk assessment[26]. The schema includes specific coding to characterise the following: the cause of floods, flood mechanisms, and the impact of flood events on risk receptors of human health, environment, cultural heritage, and economic activity. A description of each code is presented in Table 6.4.

[26] Technical Support in Relation to the Implementation of the Floods Directive (2007/60/EC) June 2013.

Table 6.3. APSFR for Danube River Basin according to the EU Schema[27]

APSFR Code	Catchment area	River / Tributary	Year	Period	Flood Sources	Flood Mechanism	Flood Characteristics	Affected Regions / locations	Settlement/ village	Human Health	Environment	Cultural Heritage	Economic Activity
APSFR01_DRB_Ibar01	Ibar	Ibar	2010	December	A11,A12	A21	A31, A34	Municipality Rozaje	Suho Polje, Zeleni	B11	B25	B31 2 religious objects	B41, B42, B44
APSFR02_DRB_Ibarac01	Ibar	Ibarac	2010	December	A11,A12	A21	A31, A34	Municipality Rozaje	Ibarac	B11	B25	B34	B41, B42, B44
APSFR03_ DRB _Lovnicka rijeka01	Ibar	Lovnicka	2010	December	A11,A12	A21	A31, A34	Municipality Rozaje	Hurije,Donja Lovnica	B11	B25	B34	B41, B42, B43, B44
APSFR04_DRB _Zupanica01	Ibar	Zupnica	2010	December	A11,A12	A21	A31, A34	Municipality Rozaje	Kalače, Skarepača, Koljeno, Rasadnik	B11, B12	B25	B34	B41, B42, B43, B44
APSFR05_DRB _Grncar01	Lim	Grncar	2010	December	A11, A12	A21	A34	Municipality Gusinje	Grncar, Dosusje	B14	B25	B34	B41

[27] Technical Support in Relation to the Implementation of the Floods Directive (2007/60/EC) June 2013.

APSFR Code	Catchment area	River / Tributary	Year	Period	Flood Sources	Flood Mechanism	Flood Characteristics	Affected Regions / locations	Settlement/ village	Human Health	Environment	Cultural Heritage	Economic Activity
APSFR06_DRB _Vruja01	Lim	Vruja	2010	December	A11, A12	A21	A34	Municipality of Gusinje	urban area	B14	B25	B34	B41, B44
APSFR07_DRB _Lim01	Lim	Lim	2010	December	A11, A12	A21	A34	Municipality of Plav	Brezojevica, Rambalovi lugovi	B14	B25	B34	B41
APSFR08_DRB _Lim02	Lim	Lim	2010	December	A11, A12	A21	A34	Municipality of Andrijevica	Prljnije	B14	B25	B34	B41
APSFR09_DRB_Lim03	Lim	Lim	-	-	A11, A12	A21	A34	Municipality of Berane	Vinicka	B14	B25	B34	B41, B44
APSFR10_DRB_Lim04	Lim	Lim	2010	December	A11, A12	A21	A34	Municipality of Berane	Talum, Riversajd, Hareme	B14	B25	B34	B41
APSFR11_DRB_Lim05	Lim	Lim	-	-	A11, A12	A21	A40	Municipality of Bijelo Polje	Ribarevina	B14	B25	B34	B46
APSFR12_DRBLim06	Lim	Lim	2010	December	A11, A12	A21	A40	Municipality of Bijelo Polje	Rakonje	B14	B25	B34	B46
APSFR13_DRB_Lim07	Lim	Lim	2010	December	A11, A12	A21	A40	Municipality of Bijelo Polje	Ljesnica, Rijeka	B14	B25	B34	B41, B44
APFSR14_DRB_Lim08	Lim	Lim	2010	December	A11, A12	A21	A40	Municipality of Bijelo Polje	Lipnica	B14	B25	B34	B41

APSFR Code	Catchment area	River / Tributary	Year	Period	Flood Sources	Flood Mechanism	Flood Characteristics	Affected Regions / locations	Settlement/ village	Human Health	Environment	Cultural Heritage	Economic Activity
APFSR15_DRB_Lim09	Lim	Lim	-	-	A11, A12	A21	A40	Municipality of Bijelo Polje	Oljue, Sutivan, Gubaac, Konatari	B14	B25	B34	B46
APSFR16_DRB_Tara01	Tara	Tara	2010	December	A11, A12	A21	A31	Municipality of Kolasin	Donji Razanj	B12	B25	B34	B41, B44
APSFR17_DRB_Tara02	Tara	Tara	2010	December	A11, A12	A21	A31	Municipality of Mojkovac	Podbisce, Ambarine	B14	B25	B34	B41, B43
APSFR18_DRB_Breznica01	Cehotina	Breznica	2010	December	A11, A12	A21	A34	Municipalty of Pljevlja	Sevari	B14	B25	B34	B41, B43
APSFR19_DRB_Bukovica and Bijela01	Piva	Bukovica i Bijela	-	-	A11, A12	A21	A40	Municipality of Savnik	urban area	B14	B25	B34	B46

Table 6.4. Description of APSFR codes

Flood Sources	• A11 - Fluvial • A12 - Pluvial • A13 - Groundwater • A14 - Sea water • A15 - Artificial Water
Flood Mechanism	• A21 - Natural Exceedance: Flooding of land by waters exceeding the capacity of their carrying channel or the level of adjacent lands. • A22 - Defence Exceedance: Flooding of land due to floodwaters overtopping flood defences. • A23 - Defence or Infrastructural Failure: Flooding of land due to the failure of natural or artificial defences or infrastructure. This mechanism of flooding could include the breaching or collapse of a flood defence or retention structure, or the failure in operation of pumping equipment or gates. • A24 - Blockage / Restriction: Flooding of land due to a natural or artificial blockage or restriction of a conveyance channel or system. This mechanism of flooding could include the blockage of sewerage systems or due to restrictive channel structures such as bridges or culverts or arising from ice jams or landslides. • A25 - Other: Flooding of land by water due to other mechanisms, for instance wind setup floods. • A26 - No data available on the mechanism of flooding.
Flood Characteristics	• A31 - Torrential flood: A flood that appears and disappears fairly quickly, with little or no warning, usually as a result of intense rainfall over a relatively small area. • A32 - Spring flood due to melting snow: Flooding due to rapid melting of snow, possible in combination with precipitation or ice plug. • A33 - Second flash flood: A flood that occurs rapidly and does not fall into the category of torrential floods. • A34 - Medium-Rapid Flood: The onset of flooding that occurs more slowly than a sudden flood. • A35 - Slow-on Flood: A flood that takes a long time to form. • A36 - Sediment flow: A flood that transports large amounts of sediment. • A37 - Rapid flow: A flood in which flood waters flow at high speed.

	• A38 - Deep flood: A flood in which flood waters are of significant depth. • A39 - Other characteristics. • A40 - Flood characteristics data not available.
Human Health	• B11 - Human Health: Adverse consequences to human health, either as immediate or consequential impacts, such as might arise from pollution or interruption of services related to water supply and treatment and would include fatalities. • B12 - Community: Adverse consequences to the community, such as detrimental impacts on local governance and public administration, emergency response, education, health and social work facilities (such as hospitals). • B13 - Other • B14 - Not applicable
Environment	• B21- Waterbody Status: Adverse consequences ecological or chemical status of surface water bodies or chemical status of ground water bodies affected, as of concern under the WFD. Such consequences may arise from pollution from various sources (point and diffuse) or due to hydromorphological impacts of flooding. • B22 - Protected Areas: Adverse consequences to protected areas or waterbodies such as those designated under the Birds and Habitats Directives, bathing waters or drinking water abstraction points. • B23 - Pollution Sources: Sources of potential pollution in the event of a flood, such as IPPC and Seveso installations, or point or diffuse sources. • B24 - Other potential adverse environmental impacts, such as those on soil, biodiversity, flora and fauna, etc. • B25 - Not applicable
Cultural Heritage	• B31 - Cultural Assets: Adverse consequences to cultural heritage, which could include archaeological sites / monuments, architectural sites, museums, spiritual sites and buildings. • B32 - Landscape: Adverse permanent or long-term consequences on cultural landscapes, that is cultural properties which represents the combined works of nature and man, such as relics of traditional landscapes, anchor locations or zones. • B33- Other • B34 - Not applicable
Economic Activity	• B41 - Property: Adverse consequences to property, which could include homes. • B42 - Infrastructure: Adverse consequences to infrastructural assets such as utilities, power generation, transport,

	storage and communication. • B43 - Rural Land Use: Adverse consequences to uses of the land, such as agricultural activity (livestock, arable and horticulture), forestry, mineral extraction and fishing. • B44 - Economic Activity: Adverse consequences to sectors of economic activity, such as manufacturing, construction, retail, services and other sources of employment. • B45 - Other • B46 - Not applicable

Figure 6.2. A summary overview of all APSFR in the Danube River Basin

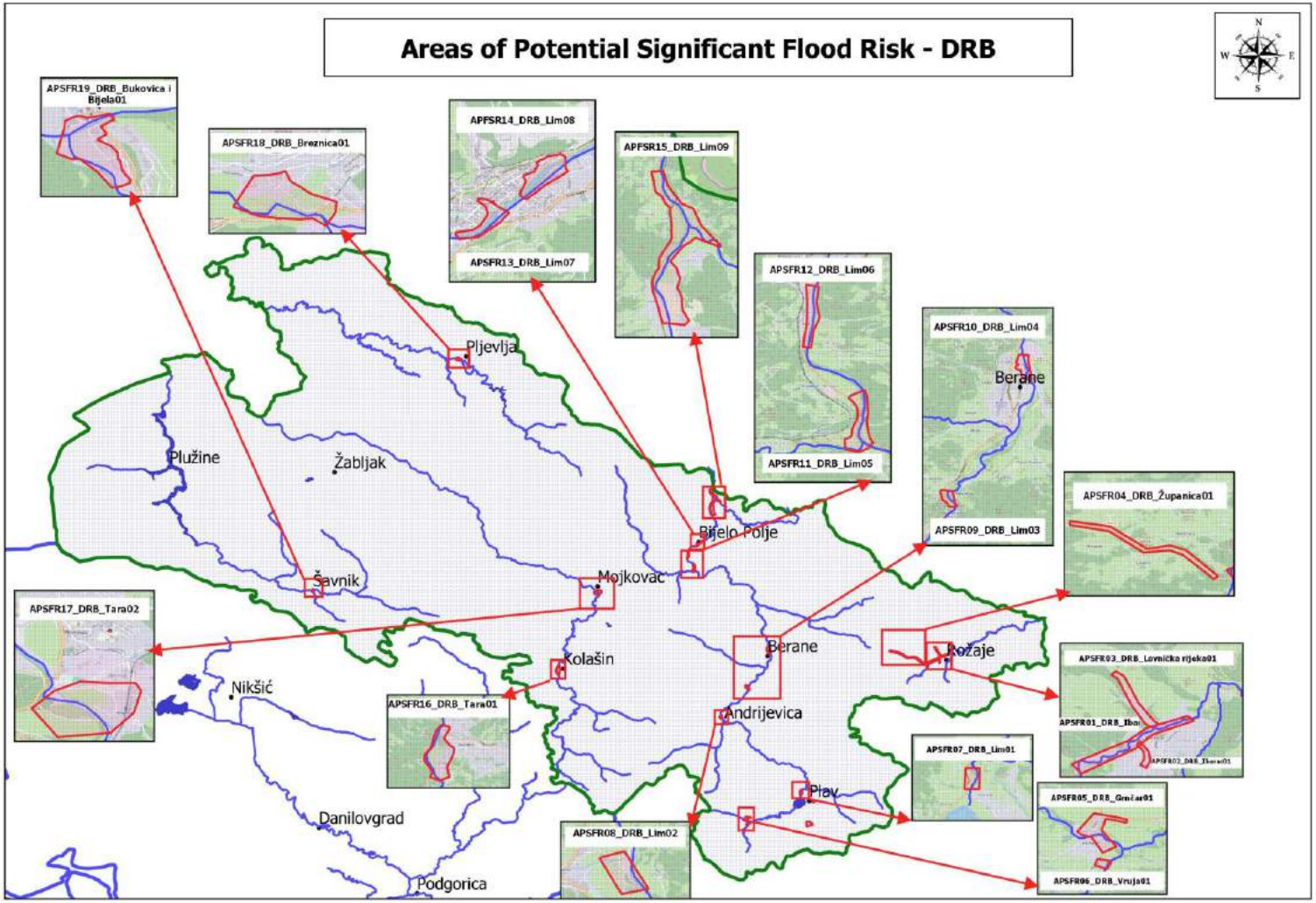


Figure 6.3. APSFR01_ DRB_Ibar01

Catchment Area: Ibar; **River/Tributary**: Ibar; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Torrential flood (A31), Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality Rozaje; **Settlements/Villages**: Rozaje-Suho Polje -Zeleni.

Comments: Wider zone around the watercourse bearing in mind the calculations for 500-year-return waters and the dense population along the riverbed in the relatively narrow river valley. The zones covered by the historical flood and the hydrological data coincide.

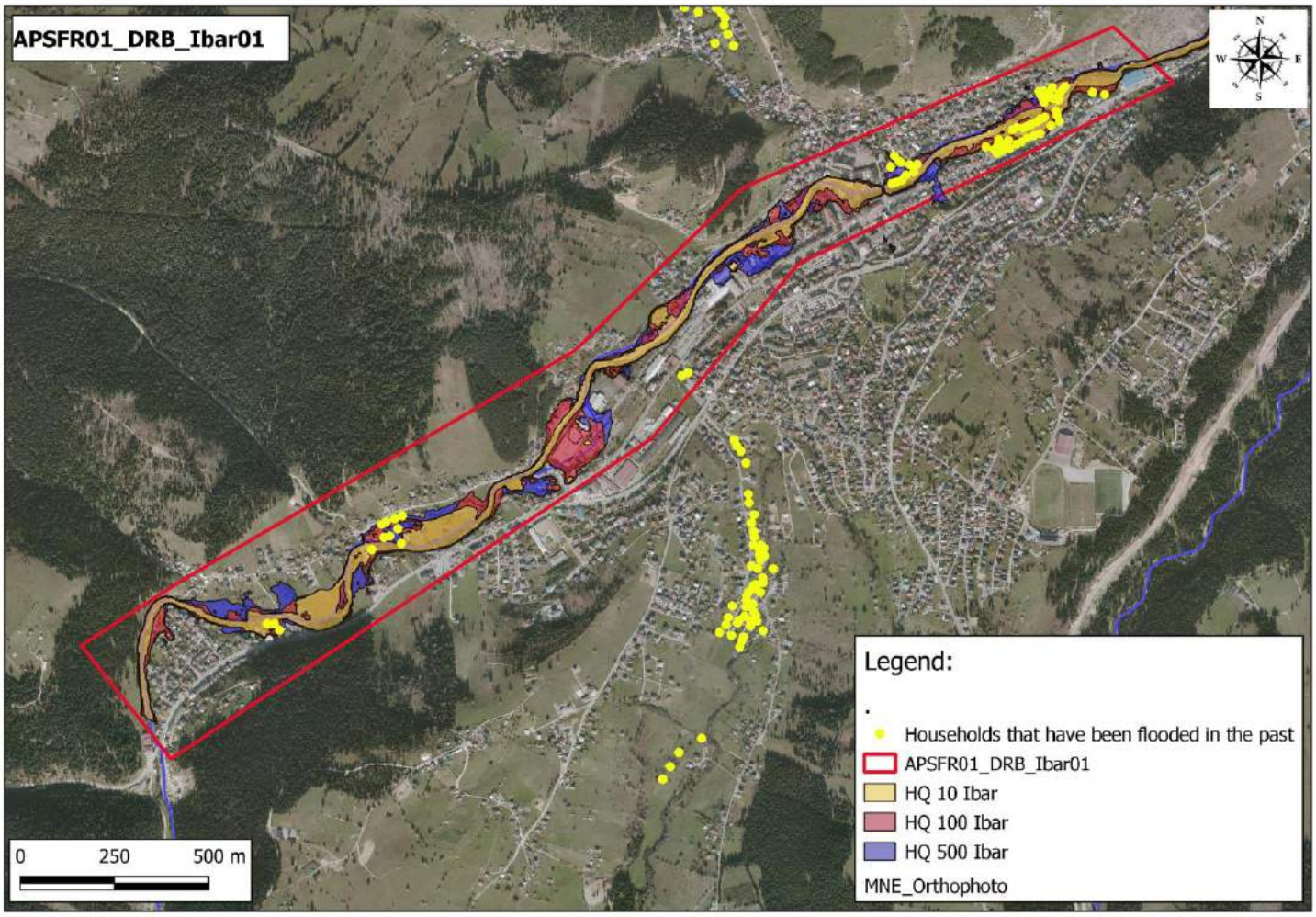


Figure 6.4. APSFR02_DRB_Ibarac01

Catchment Area: Ibar; **River/Tributary**: Ibarac; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Torrential flood (A31), Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality Rozaje; **Settlements/Villages**: Rozaje-Ibarac.

Comments: This area is determined by the historical floods. Hydrological data are not available for this zone. The river Ibarac is a right tributary of the river Ibar, into which it flows in the town of Rožaje. Due to the narrow and shallow riverbed, pronounced slope of the terrain, as well as torrential character, and with unplanned buildings in the settlement of Ibarac, the watercourse Ibarac in its lower course, in the length of about 1500 meters, spills great damage to buildings and local infrastructure.

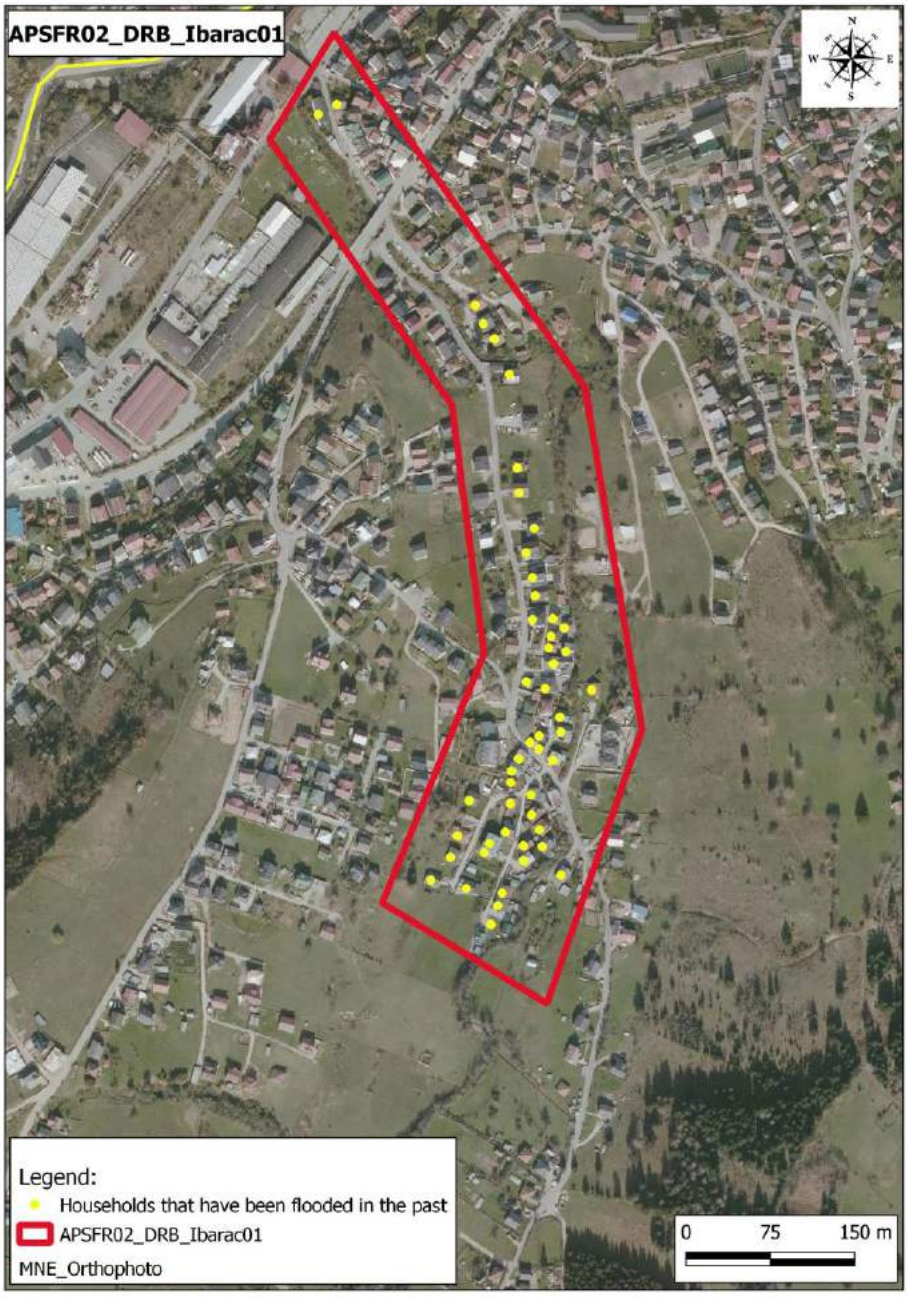


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Figure 6.5. APSFR03 DRB_Lovnicka rijeka01

Catchment Area: Ibar; **River/Tributary**: Lovnicka**; Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Torrential flood (A31), Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality Rozaje; **Settlements/Villages**: Hurije, Donja Lovnica.

Comments: This area is determined by the historical floods. Hydrological data are not available for this zone. The Lovnička river causes damage in its middle and lower course, up to its confluence with the Ibar. A special problem is urbanization and dense population, as a result of which the riverbed is narrowed to 1-2 meters. With large waters, which mainly correspond to the large waters of the Ibar, it is difficult for it to outflow, which further complicates the situation during floods.

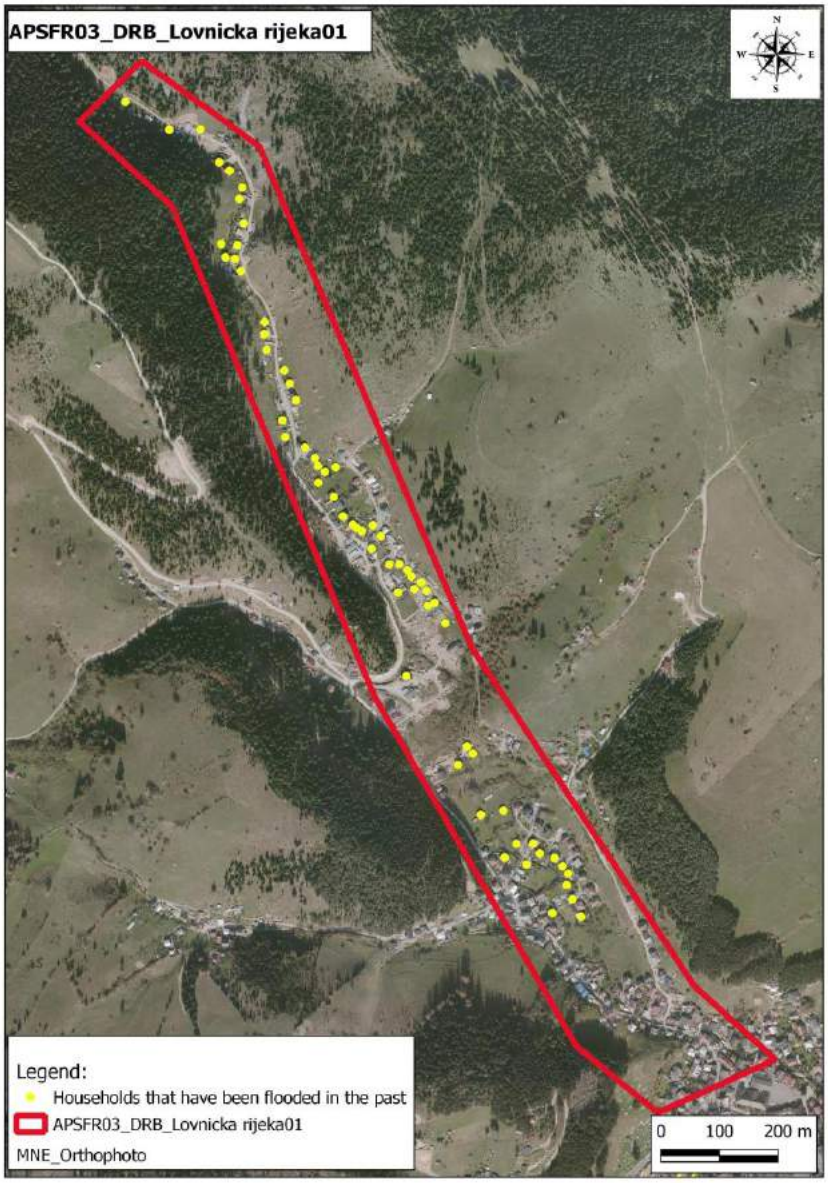


Figure 6.6. APSFR04_DRB_Županica01

Catchment Area: Ibar; **River/Tributary**: Zupnica; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Torrential flood (A31), Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality Rozaje; **Settlements/Villages**: Kalače, Skarepača, Koljeno, Rasadnik.

Comments: This area is determined by the historical floods. Hydrological data are not available for this zone. The river Zupanice is a torrent with flooding is especially pronounced in periods of coincidence of heavy rainfall and snow melting.

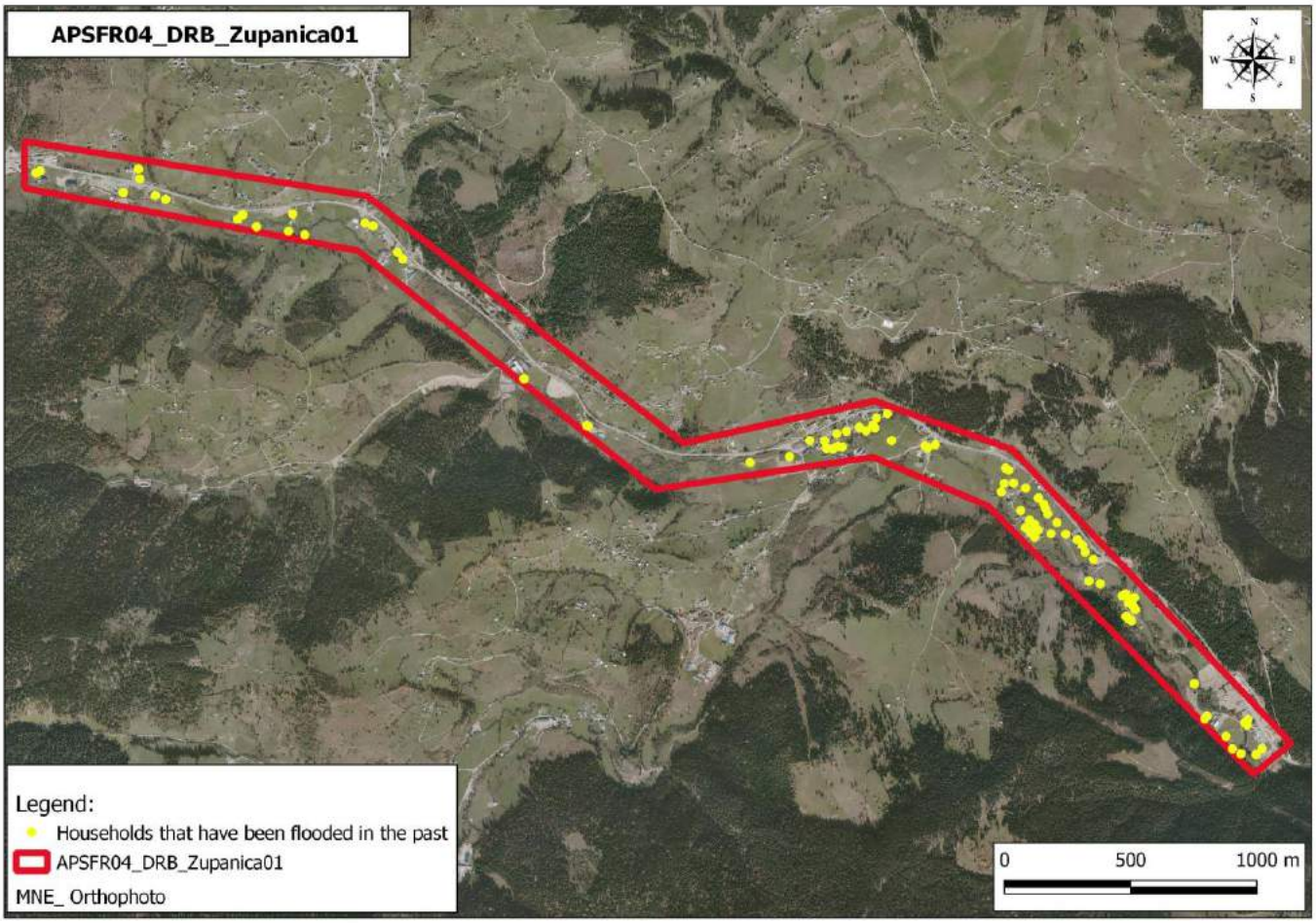


Figure 6.7. APSFR05_DRB_Grncar01

Catchment Area: Lim; **River/Tributary**: Grncar; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality Gusinje; **Settlements/Villages**: Gusinje, Grncar, Dosusje.

Comments: The zones covered by the historical flood and the hydrological data coincide. From 1968 to 2003, 7 flood episodes were recorded (based on hydrological data), practically every five years.

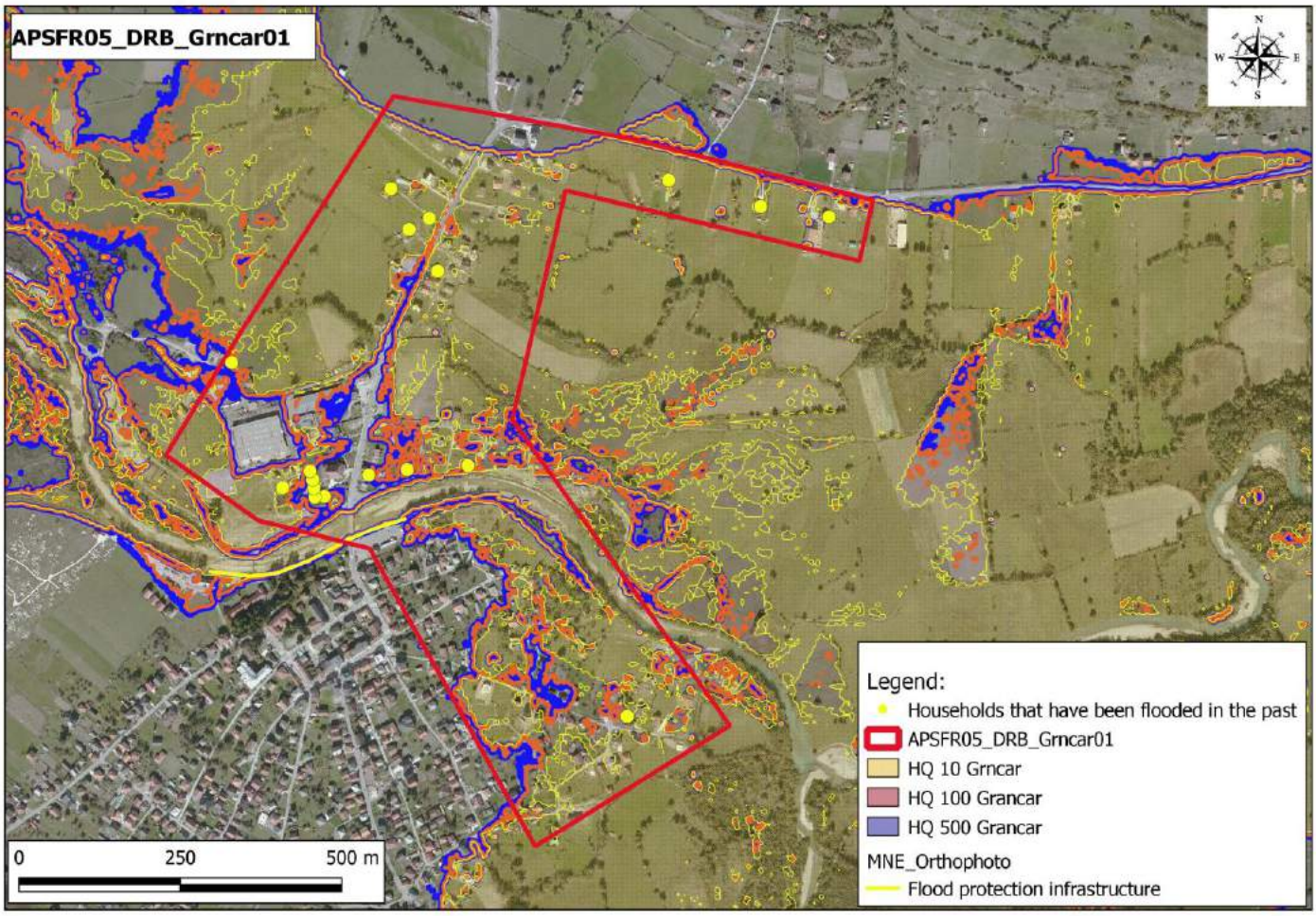


Figure 6.8. APSFR06_DRB_Vruja01

Catchment Area: Lim; **River/Tributary**: Vruja; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality Gusinje; **Settlements/Villages**: Gusinje.

Comments: The zones covered by the historical flood and the hydrological data coincide. From 1968 to 2003, 7 flood episodes were recorded (based on hydrological data), practically every five years.

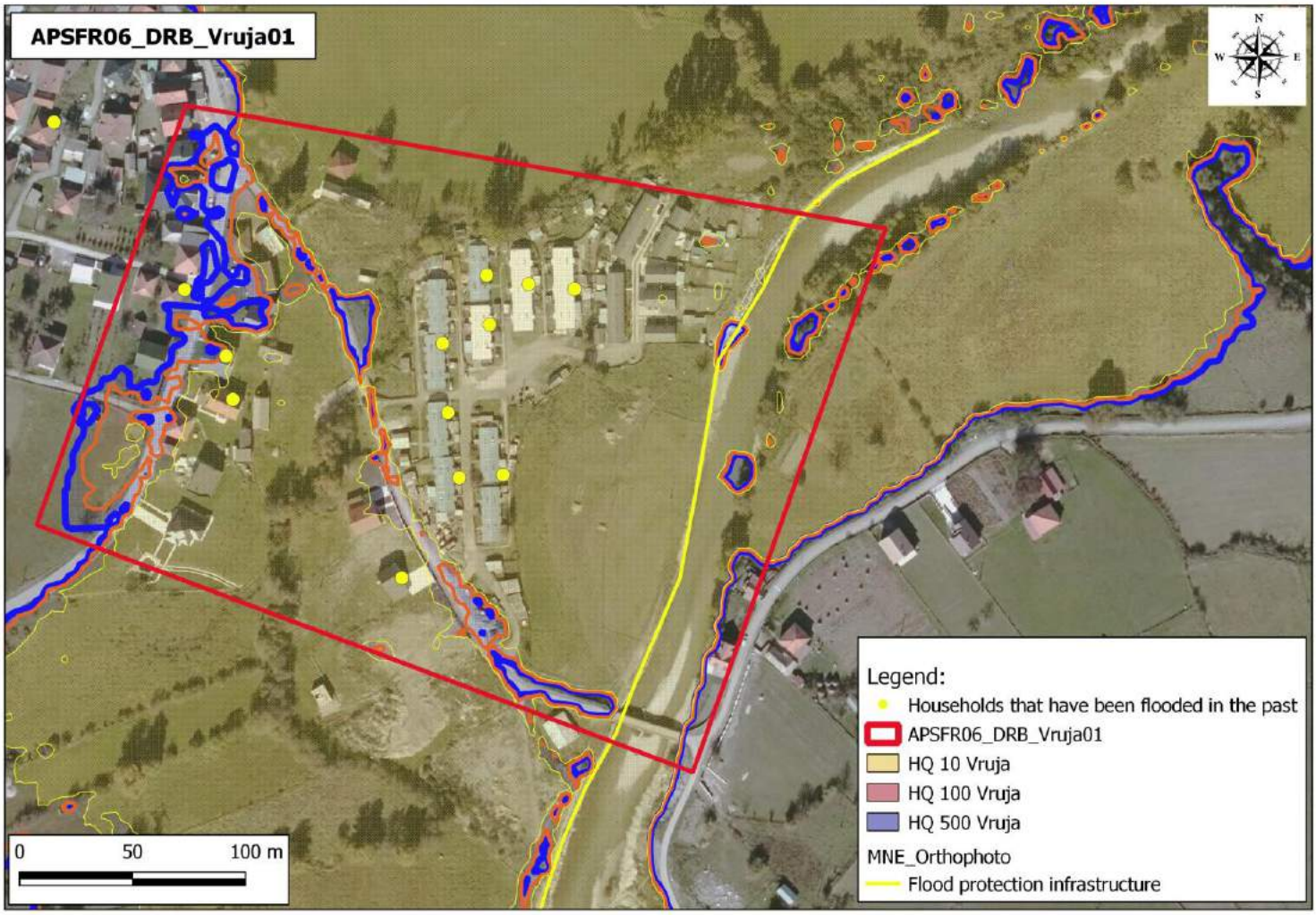


Figure 6.9. APSFR07_DRB_ Lim01

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality of Plav; **Settlements/Villages**: Plav, Brezojevica, Rambalovi lugovi.

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

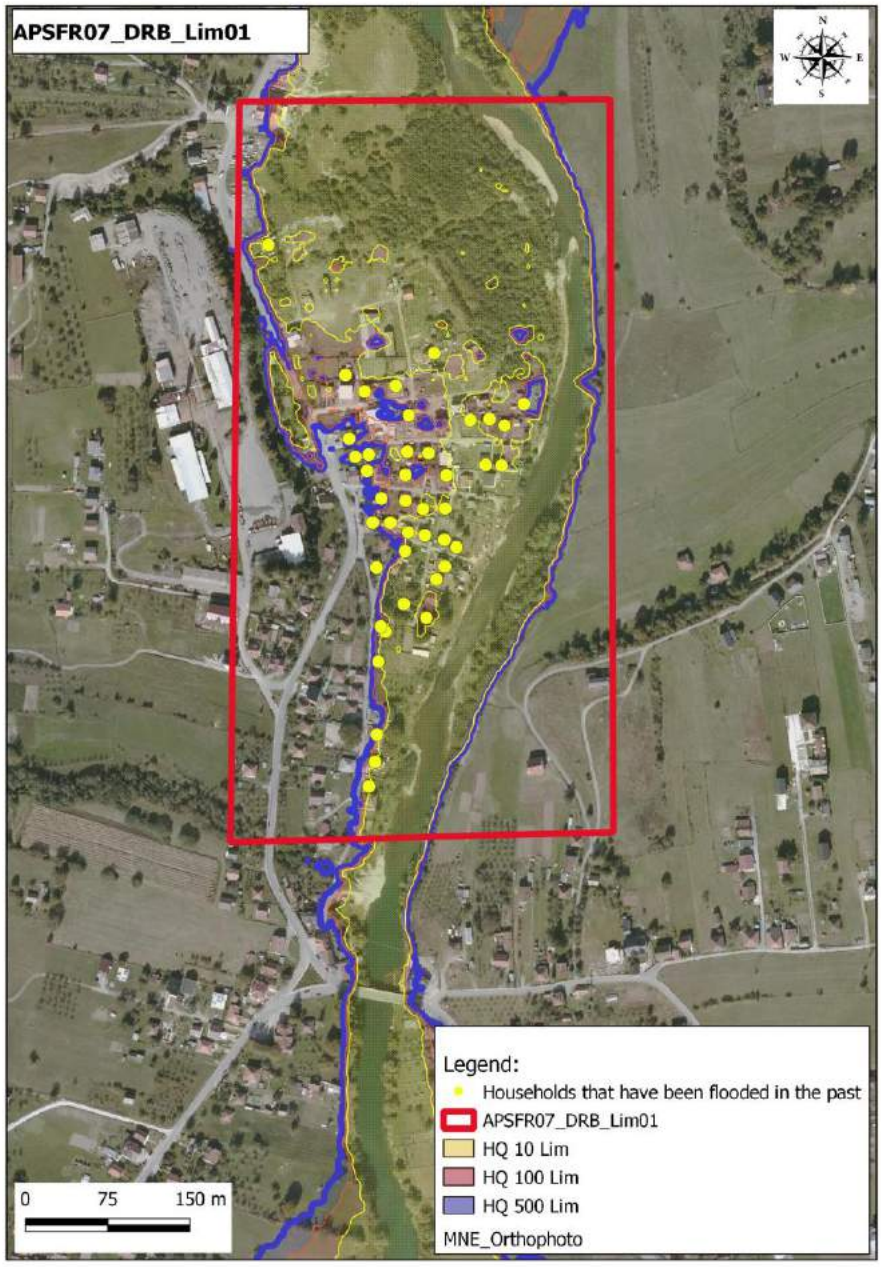


Figure 6.10. APSFR08_DRB_ Lim02

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality of Andrijevica; **Settlements/Villages**: Andrijevica, Prljnije

Comments: The proposed zone covers the incidents of known historical flooding.

Figure 6.11. APSFR09_DRB_Lim03

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality of Berane; **Settlements/Villages**: Vinicka

Comments: Hydrological data cover the zone. Previous data on flooding of these terrains at high waters of Lim and its tributary Vinicka river, identify several rural households with agricultural production in the vilages Vinicka and Navotina. This location is designated as an area of significant flood risk.

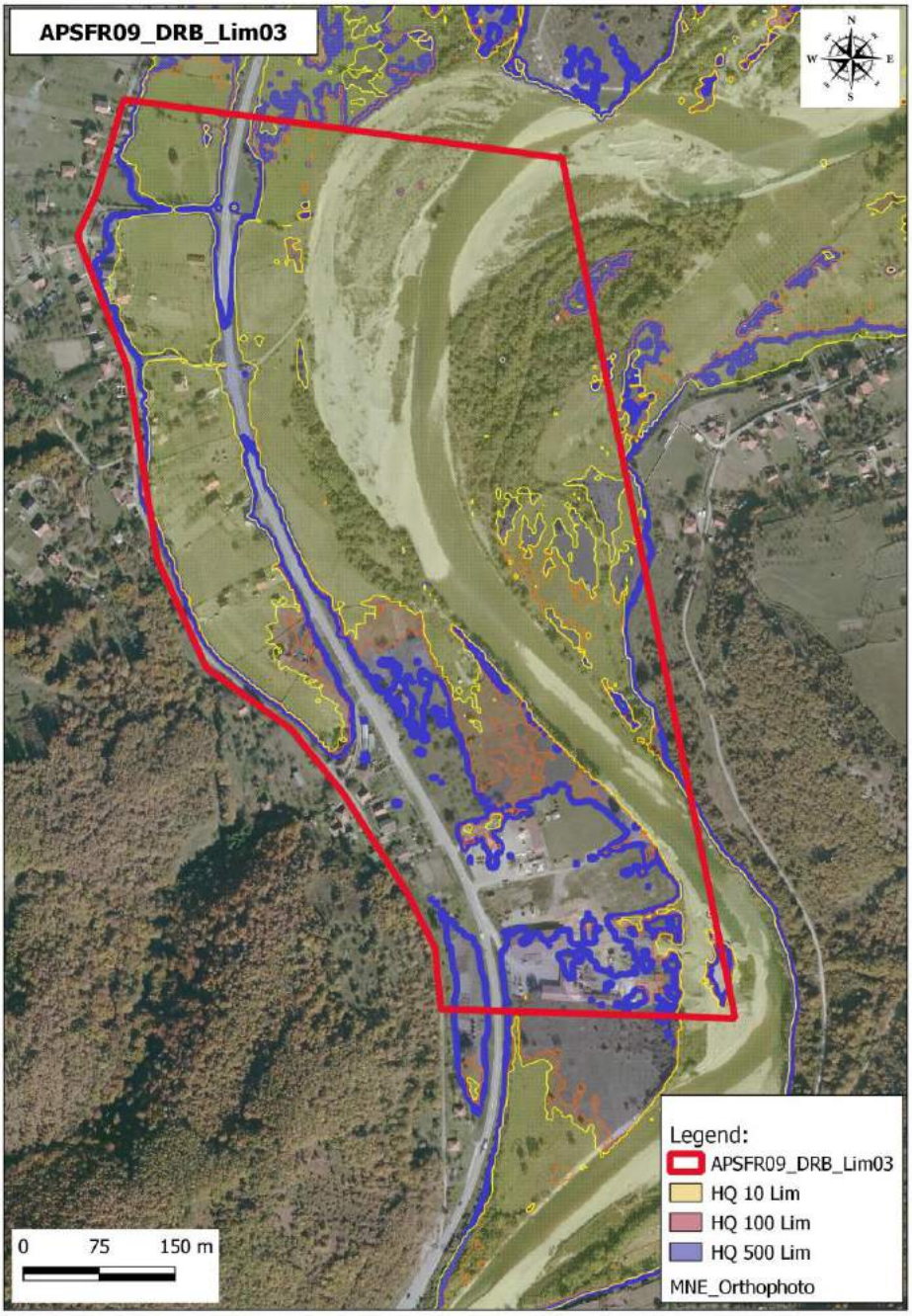


Figure 6.12. APSFR10_DRB _Lim04

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipality of Berane; **Settlements/Villages**: Berane, Talum, Riversajd, Hareme

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

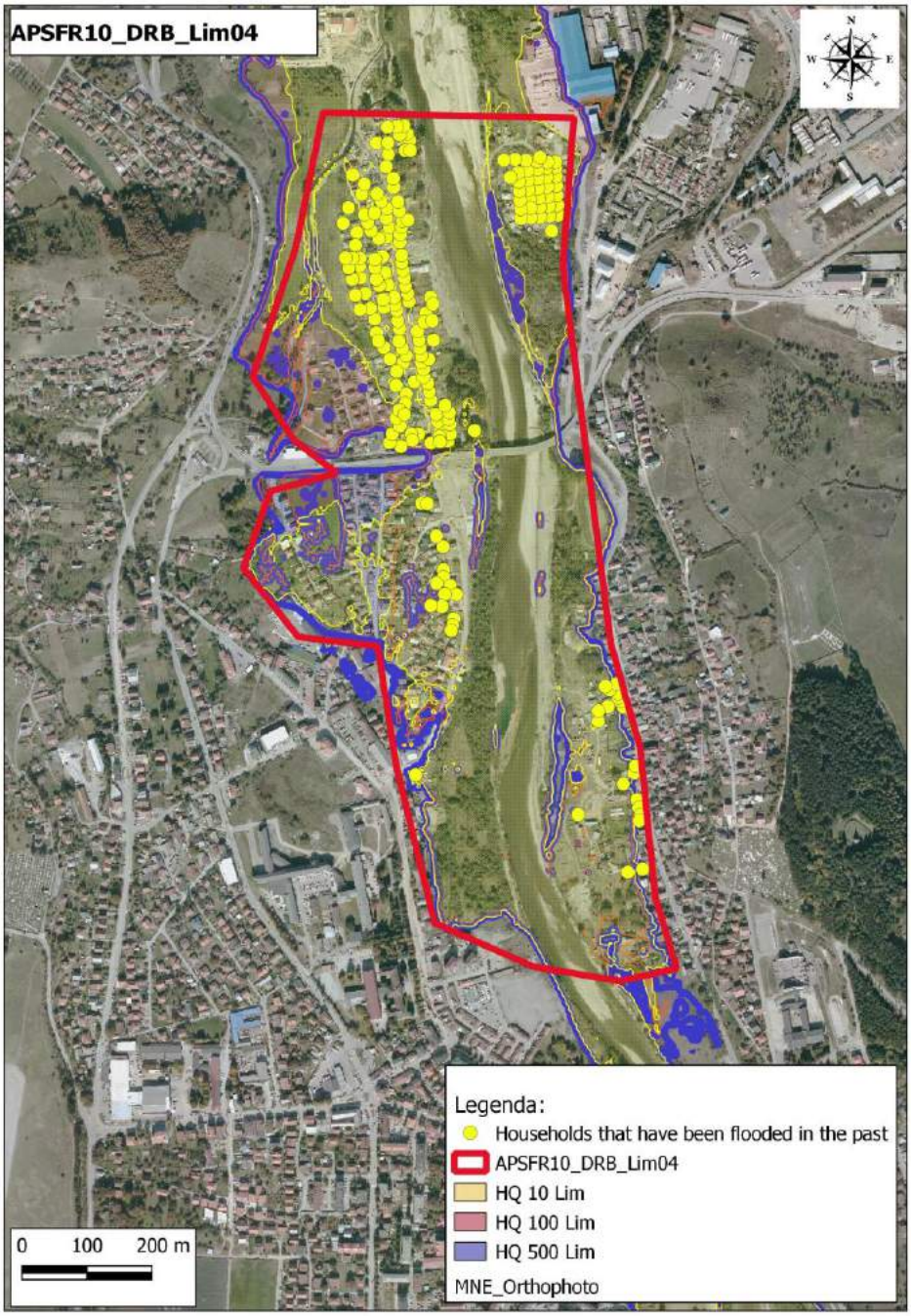


Figure 6.13. APSFR11_DRB_ Lim05

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: No Data (A40); **Affected Regions/Locations**: Municipality of Bijelo Polje; **Settlements/Villages**: Ribarevina.

Comments: Hydrological data cover the proposed zone. Having in mind the previous data on flooding of these terrains at high waters of Lima and its tributaries, with several rural households with agricultural production, catering and business facilities, endangerment of even the main road infrastructure, this location is defined as an area of significant flood risk. Extreme waters, according to the conducted calculations, reach the fences of a large electric transformer plant of exceptional importance for the supply of electricity in this part of Montenegro.

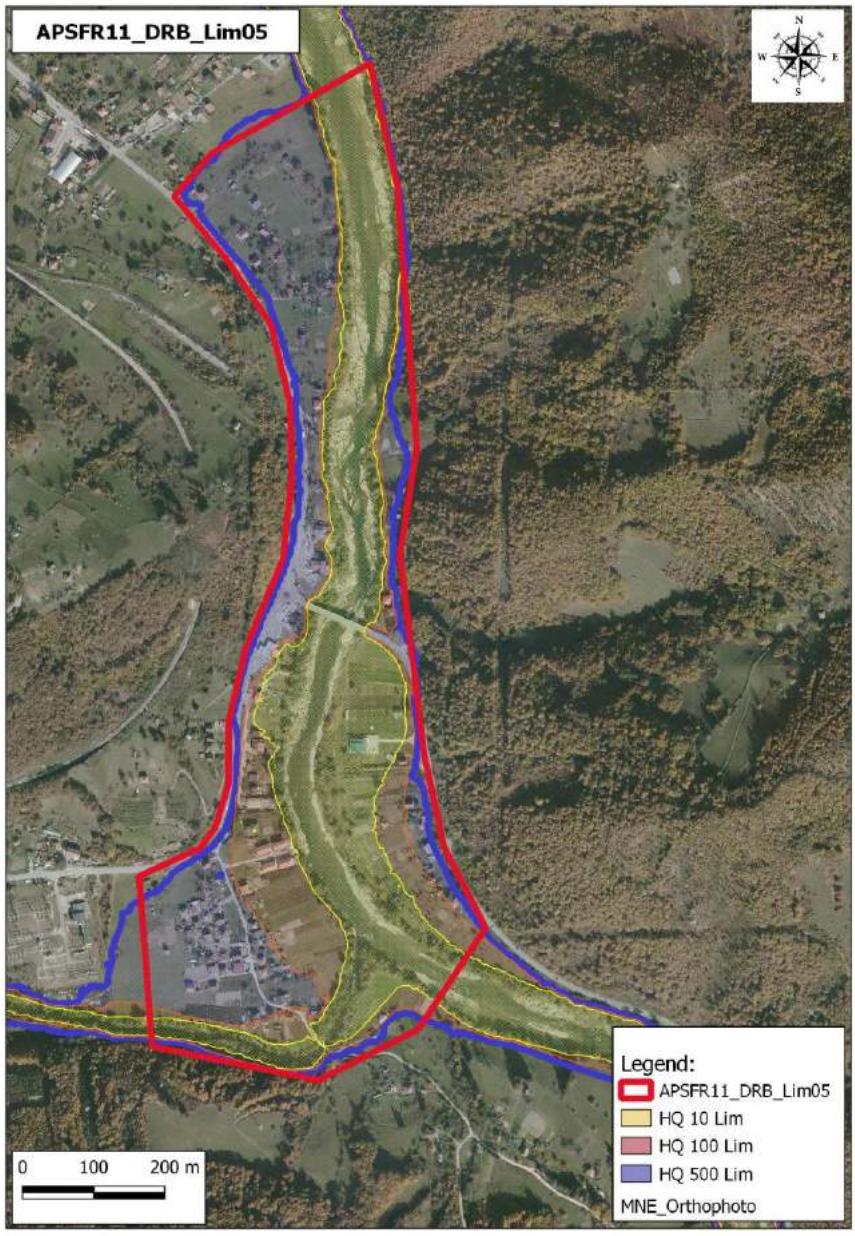


Figure 6.14. APSFR12_DRB_Lim06

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: No Data (A40); **Affected Regions/Locations**: Municipality of Bijelo Polje; **Settlements/Villages**: Rakonje

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

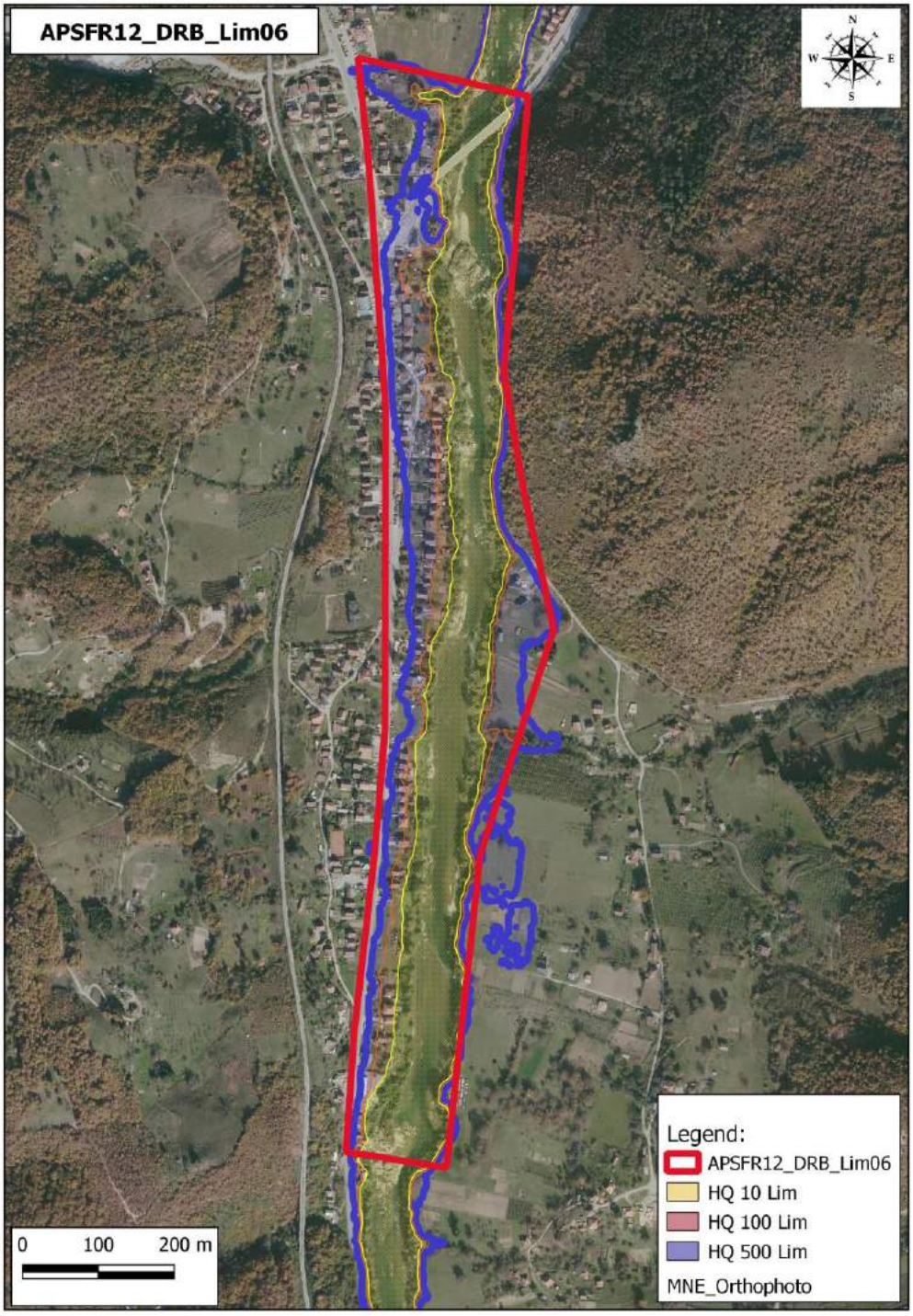


Figure 6.15. . APSFR13_DRB_Lim07

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: No Data (A40); **Affected Regions/Locations**: Municipality of Bijelo Polje; **Settlements/Villages**: Ljesnica, Rijeka

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

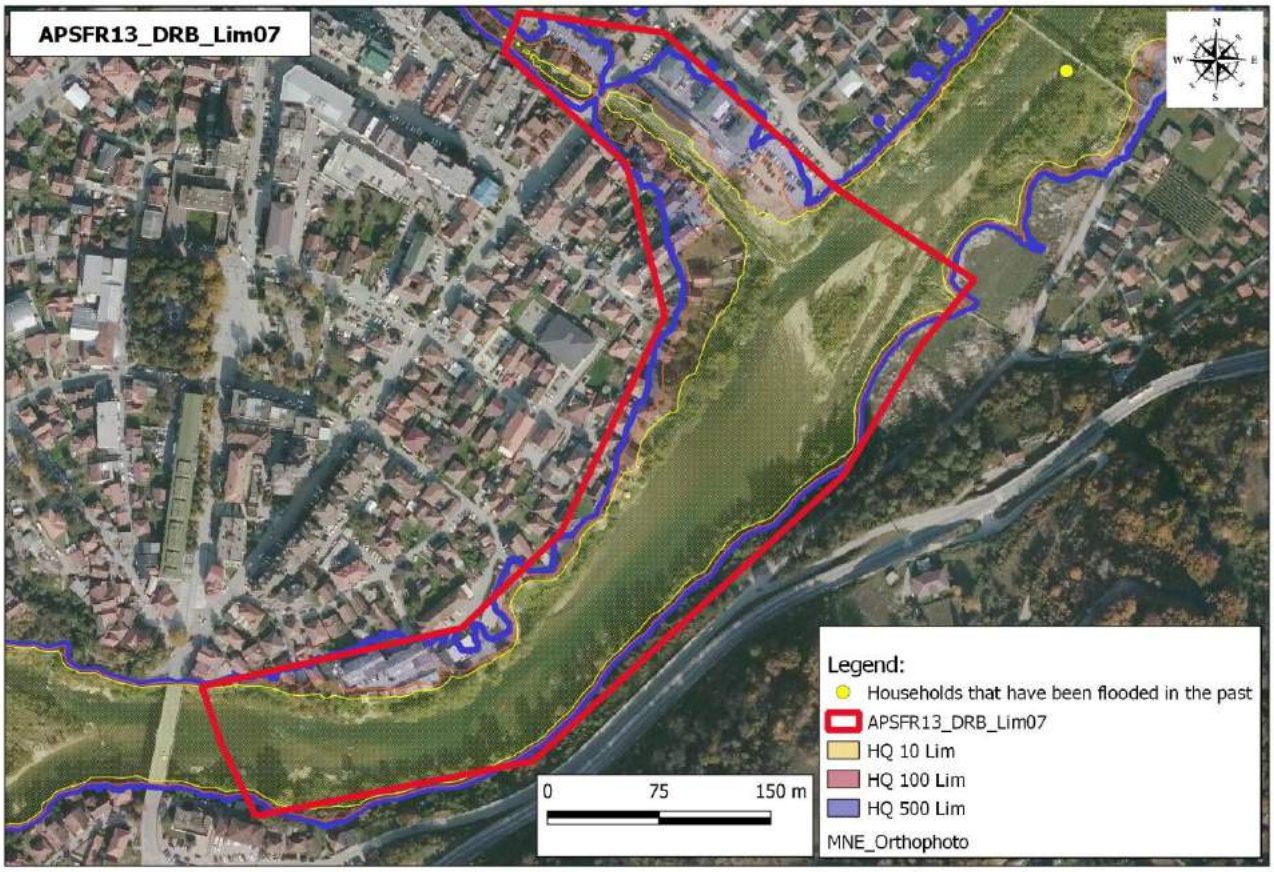


Figure 6.16. APFSR14_DRB_Lim08

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: No Data (A40); **Affected Regions/Locations**: Municipality of Bijelo Polje; **Settlements/Villages**: Lipnica

Comments: Hydrological data cover the proposed zone. This was partially confirmed by the historical floods. Settlements at the mouth of the river Lipnica are endangered.

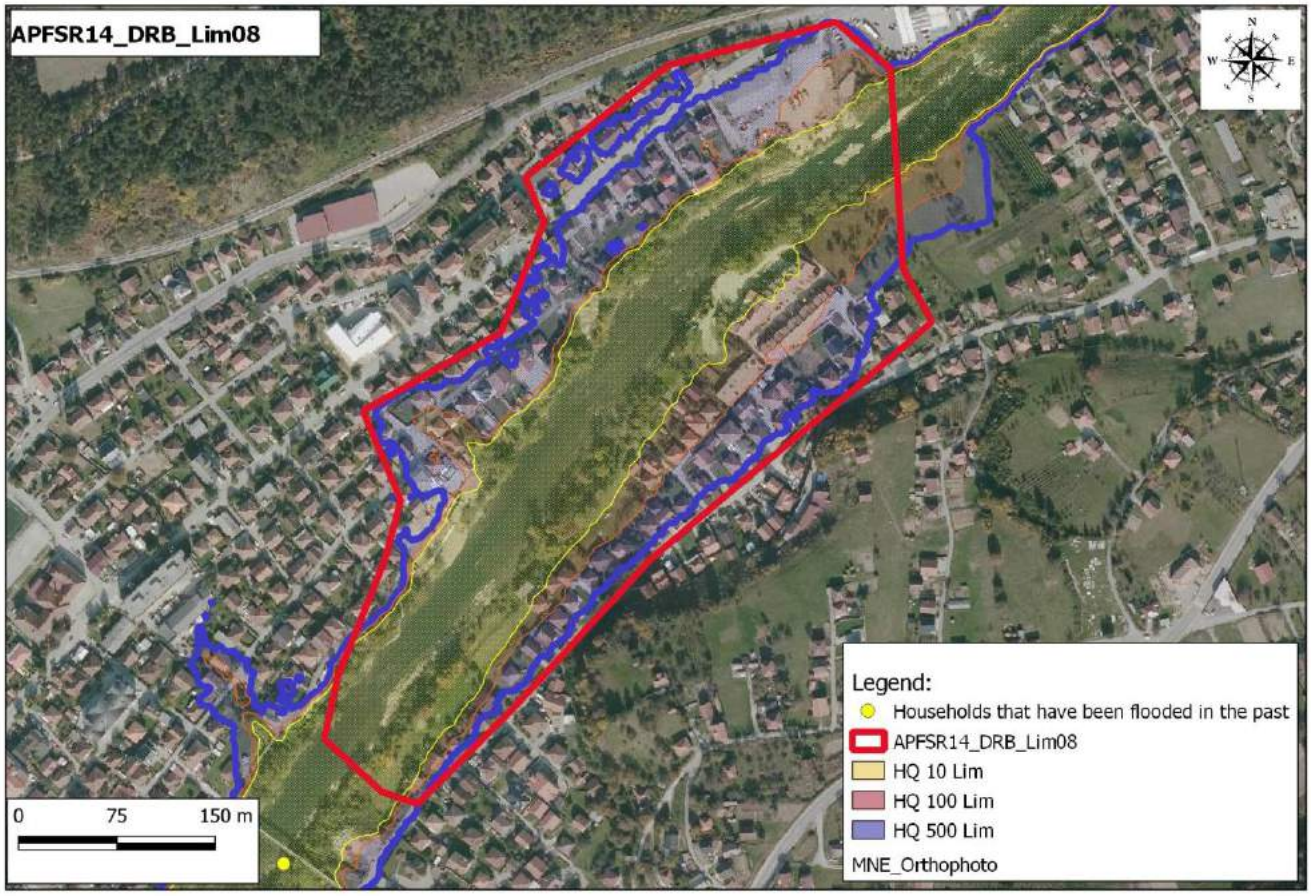


Figure 6.17. APFSR15_DRB_Lim09

Catchment Area: Lim; **River/Tributary**: Lim; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: No Data (A40); **Affected Regions/Locations**: Municipality of Bijelo Polje; **Settlements/Villages**: Oljue, Sutivan, Gubaac, Konatari

Comments: Hydrological data cover the proposed zone, which is the lowest part of Lim in Montenegro at the confluence with a large tributary of the river Bistrica. Hydrological data indicates the potential for flooding events.

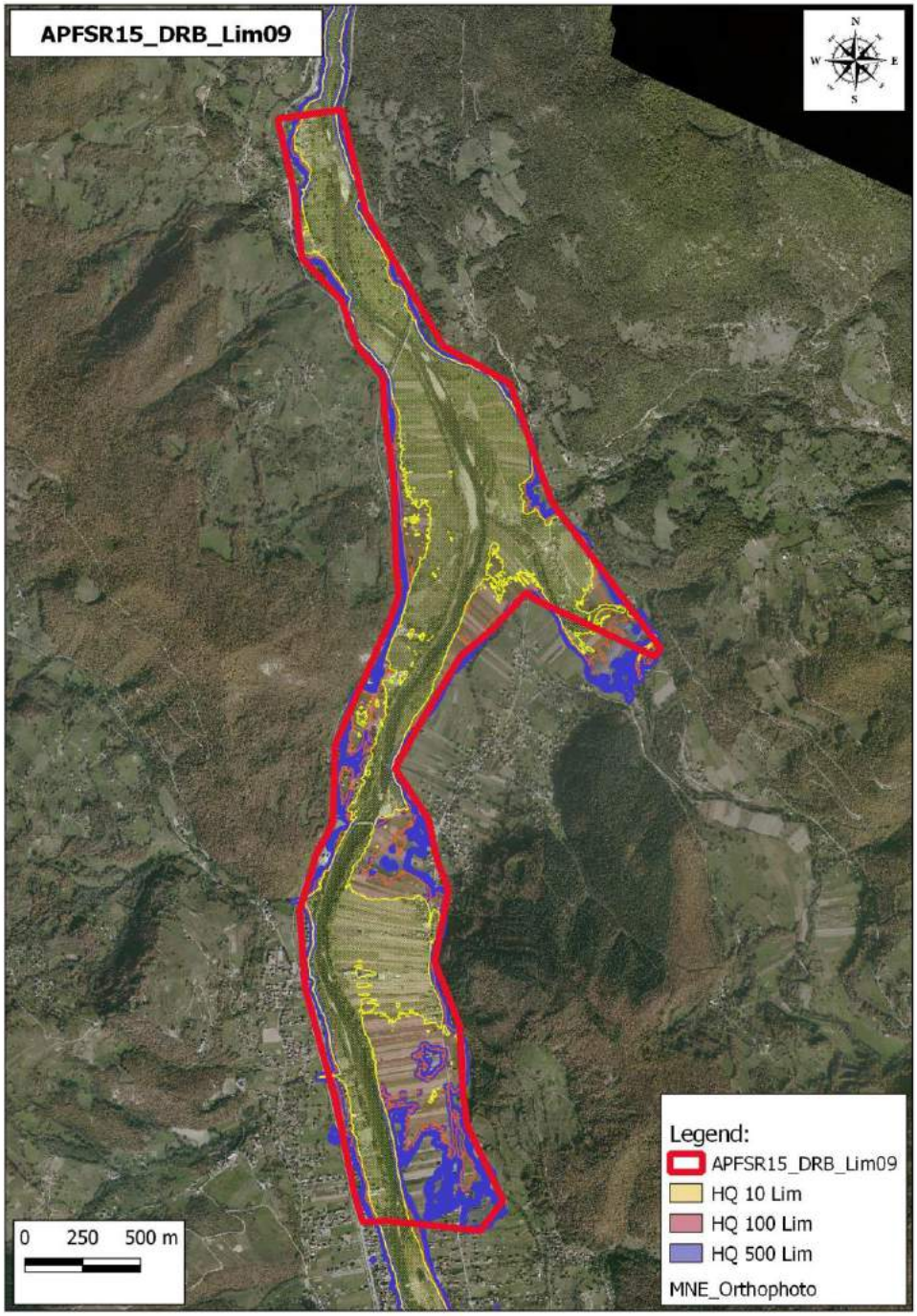


Figure 6.18. APSFR16_DRB_Tara01

Catchment Area: Tara; **River/Tributary**: Tara; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Torrential flood (A31); **Affected Regions/Locations**: Municipality of Kolasin; **Settlements/Villages**: Kolasin – Donji Razanj

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

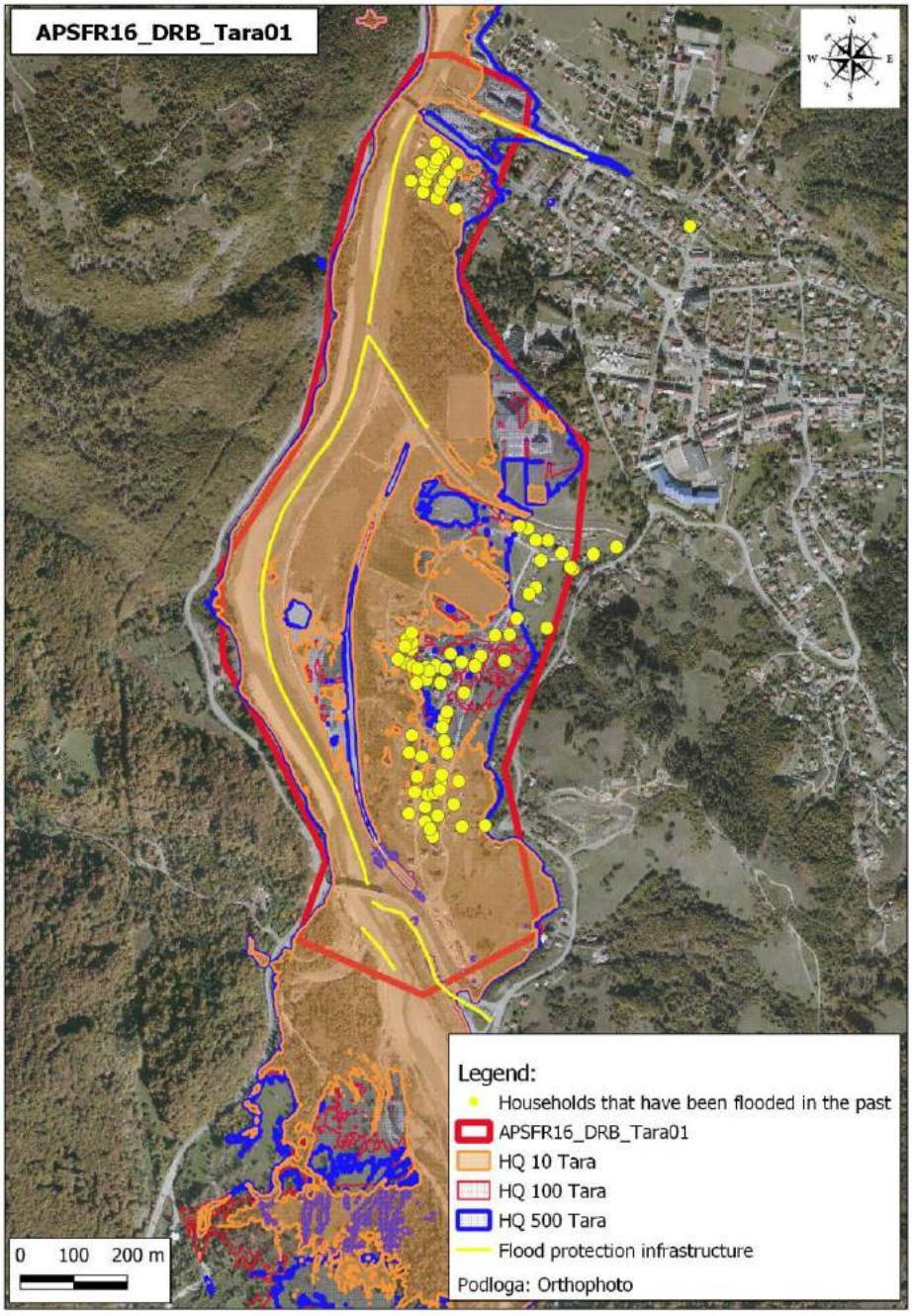


Figure 6.19. APSFR17_DRB_Tara02

Catchment Area: Tara; **River/Tributary**: Tara; **Flood Types**: **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Torrential flood (A31); **Affected Regions/Locations**: Municipality of Mojkovac; **Settlements/Villages**: Podbisce, Ambarine

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

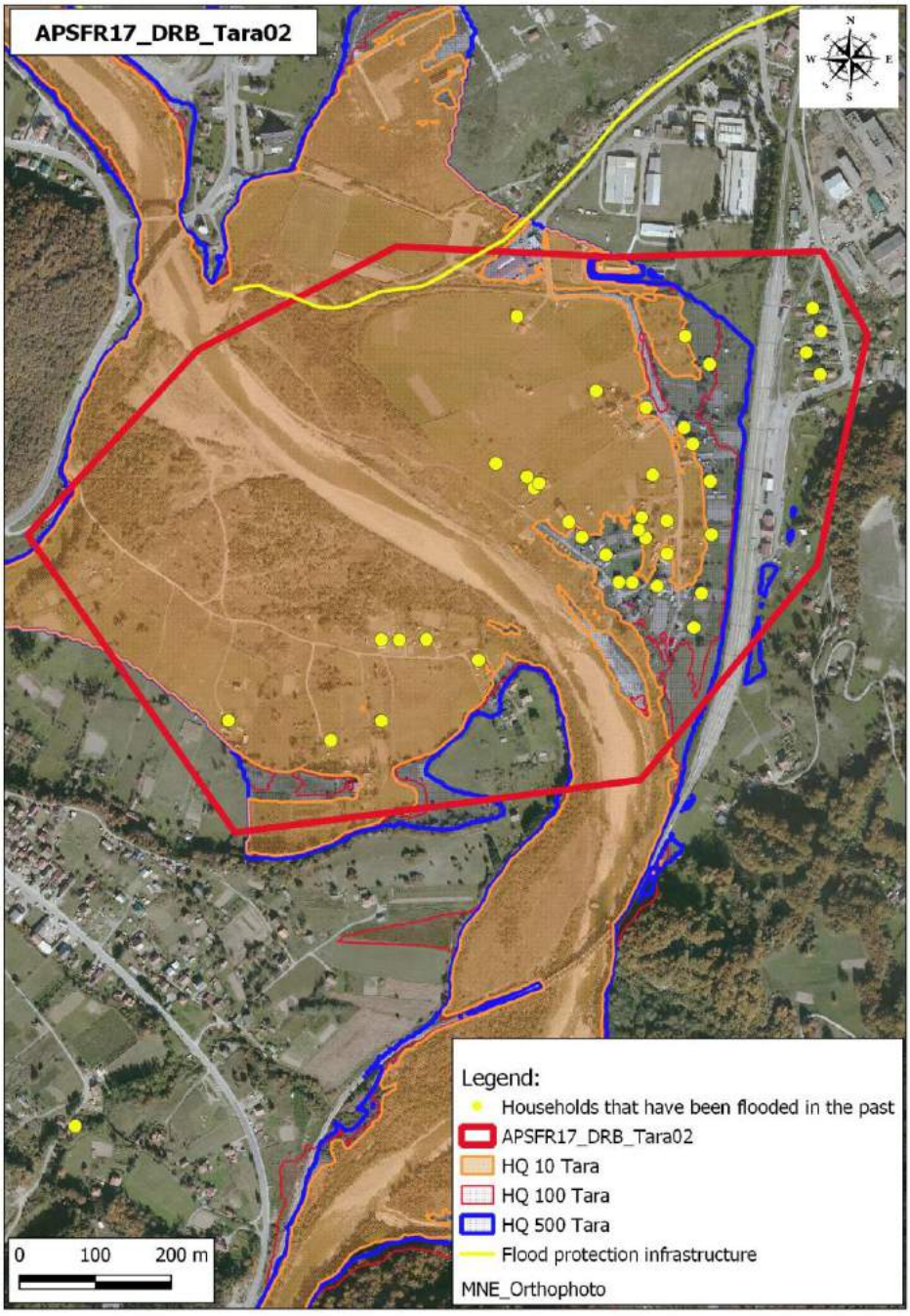


Figure 6.20. APSFR18_DRB_Breznica01

Catchment Area: Ćehotina; **River/Tributary**: Breznica; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: Medium-Rapid Flood (A34); **Affected Regions/Locations**: Municipalty of Pljevlja; **Settlements/Villages**: Sevari

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.

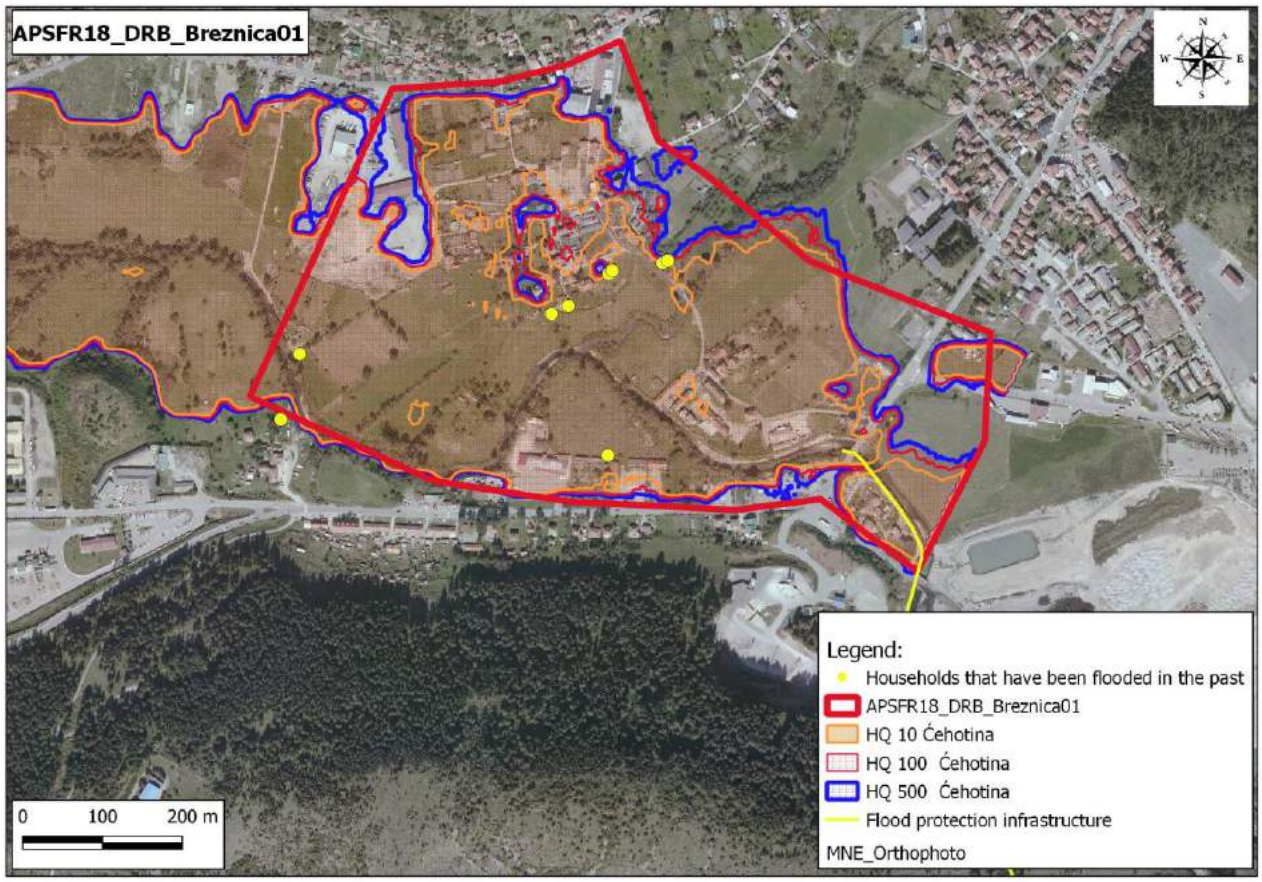
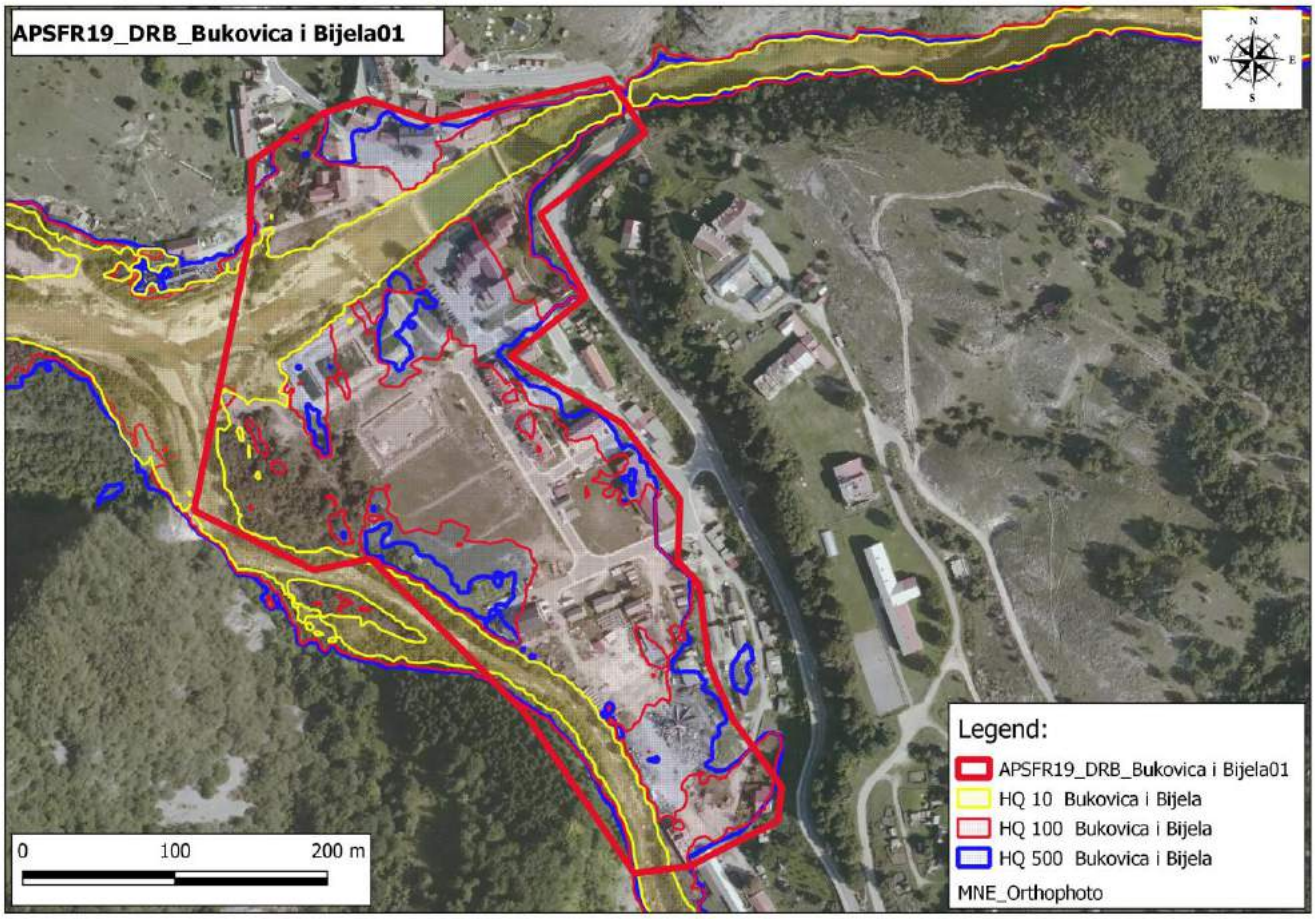


Figure 6.21. APSFR19_DRB_Bukovica i Bijela01

Catchment Area: Piva; **River/Tributary**: Bukovica i Bijela; **Flood Source**: Fluvial (A11), Pluvial (A12); **Flood Mechanism**: Natural Exceedance (A21); **Flood Characteristics**: No data (A40); **Affected Regions/Locations**: Municipality of Savnik; **Settlements/Villages**: Savnik

Comments: Hydrological data cover the proposed zone, which indicates the potential for flooding events.



7 CONCLUSIONS

The following conclusion can be drawn from the Preliminary Flood Risk Assessment of the Danube River Basin:

1. The legal Basis for undertaking the Preliminary Flood Risk Assessment

Based on a legal review It can be concluded that the transposition of requirements from the EU Floods Directive into national legislative framework for the Preliminary Flood Risk Assessment in Montenegro has been achieved in all relevant areas.

Apart from strictly legislative framework, with respect to the overall strategy of flood management there is a clear need for streamlining the objectives and recommendations by identifying one umbrella strategy, most likely the National Plan of Protection and Rescue from Flooding. All other strategy documents should be aligned with the objectives set by the chosen overarching policy and update regularly in accordance with latest amendments of such policy.

2. The adequacy of data required to conduct the PFRA

The PFRA should cover historical flood events and the potential for future flood events that may have a significant adverse consequence on either, human health, the environment, cultural heritage, or economic activity. Flood-specific data such as historical flood information, geographic data, urban planning information, population statistics, economic activities, digital terrain models (DTM), meteorological information, civil protection information and other national data is required to prepare the PFRA. This information is then used to identify the Areas of Potential Significant Flood Risk (APSFR), which are the areas that will be the priority for subsequent detailed flood risk management assessment in the flood maps and FRMP stages.

Historical hydrological data related to the recorded high (potential) flood waters on the network of hydrological stations in the Danube River Basin were analysed from 1952 when water level measurements began on rivers. Since the early 1950s, six events have been registered with flows of a calculated return period of 100 years. However, the most common high-water flows in the Danube basin were calculated with a 10-year return period, occurring 146 times to date.

Despite the fact that the historical hydrological data assessment indicates that flooding in the Danube basin would have occurred on multiple occasions in the past, there are no official data before 2010 detailing the extent of the inundated areas of flood waters or damage to property.

The only information available that can be included for the PFRA relates to the historical flooding event that occurred in late 2010/early 2011 where flood events were recorded within 8 municipalities encompassing 23 distinctly individual affected areas. 4 areas were located in the Ibar Sub-Basin, 13 in the Lim Sub-Basin, 4 in the Tara Sub-Basin and 2 in the Ćehotina Sub-Basin.

The recorded data of late 2010/early 2011 include the areas of inundation caused by flood waters, the number of persons affected, a description of the damage to residential and

business properties together with a record of the damage to cultural assets in the area. The recorded data thereby allow for the determination of the significance of the potential risks in relation to human health, environmental and cultural criteria at each location of recorded flooding.

Notwithstanding the lack of detailed data to document historical flood events, the data from late 2010/early 2011 is invaluable for the Preliminary Flood Risk Assessment.

For the purpose of producing the PFRA, 21 existing and historical hydrological stations (HS) the Danube Basin relating to the major rivers were chosen as relevant for analysis. A statistical analysis was performed using the method of annual extremes to calculate the probability that 10%, 1% and 0.2%, i.e., return periods of 10, 100 and 500 years. The HEC-RAS model was used to calculate the flood lines. Data on the geometry of the riverbed (topography of the main riverbed and inundation) were obtained from a digital terrain model (resolution 5m). Calibration of the model was performed based on 2010 flood data. Using a cross-section of the water mirror plane with a digital terrain model, spatial data for the display of flooded areas was obtained, in the form of polygons, and the display of depths, in raster form. This data was used (as shape files) for further processing in the Quantum GIS program.

Of the other existing data, historical data were emphasized, i.e., locations of houses that were flooded during the highest recorded floods during 2010-2011. Data obtained during the earlier phase of this project related to flood protection infrastructure were also used. An Orthophoto image of Montenegro, obtained from the Real Estate Administration of Montenegro, was used as a basis for presenting and comparing data.

A topographic map of Montenegro with a scale of 1:25,000, as well as available data available on the Internet (Open Street Map (OSM), Google Maps) were used for analysis, but the Orthophoto image of Montenegro was presented as the most useful as a background. Data relating to Corine Land Cover were also considered during the data analysis.

Based on the analysis of all the above data, 19 APSFR in the Danube Basin area were defined and represented in GIS format.

3. Forecasting of future flood Events

Based on climate precipitation projections, in general, it can be concluded that flood events will be both more frequent and more intense, as a consequence of climate change. Thus, although the reduction of total annual precipitation in most parts of the Danube River Basin is expected, in the future, short heavy rainfall, often combined with snowmelt and soil saturation, is expected to cause a higher risk of torrential floods caused by an increase in surface runoff.

During the flood risk assessment, the expected impacts of climate change were considered by applying one extreme flood scenario (extreme flood recovery period ≥ 500 years), which included all proven or known, or estimated future impacts, including climate change impacts. The impacts of climate change on the identification of areas with potentially significant flood risk are fully covered by working on scenarios of extreme flood events.

8 ANNEX 1 DATA AND INFORMATION ANALYSIS

Starting with the fact that the Preliminary Assessment of Flood Risk is practically the first step in the process of preparing the Flood Risk Management Plan and that its development was defined by the available information, it was necessary to analyse the data obtained and determine the shortcomings and challenges for the realization of the preliminary assessment.

Based on the available data and information, the preparation of the PFRA included the following analysis:

- Inventory of existing flood defence infrastructure.
- A study on high water hydrology (results of calculation of the probable of high waters by method of annual maximums for hydrological stations of the Danube River Basin).
- Modelling and outputs.
- APSFR Spatial Display Process Method.

8.1 Inventory of existing flood defence infrastructure

As a source of information in the preparation of this material, the documents adopted by the state and local authorities, as well as the prepared project documentation were used, as follows:

- National Flood Protection and Rescue Plan, 2019.
- Flood protection and rescue plans for the municipalities of Rozaje, Pljevlja, Plav, Kolasin, Mojkovac, Andrijevica, Bijelo Polje and Berane.
- Report on the implementation of the project "Emergency measures for flood prevention and rehabilitation", 2014.
- Main design of the riverbed for Plavska Rijeka.
- Main design of the embankment and regulation works of the Grnčar riverbed upstream and downstream from the bridge at the entrance to Gusinje.
- Main design of the embankment and regulation works of the Vruje riverbed upstream and downstream from the bridge over the Vruje river near the refugee settlement in Gusinje.
- Main project of intervention regulation works on the river Lim near Andrijevica from the mouth of Zlorečica to Slatina.
- Main project of regulation of the river Zlorečica through Andrijevica.
- Main project for regulation of the Lim riverbed in the municipality of Berane.
- Regulation works of the Tara riverbed at the Ambarina location and downstream of the bridge to protect the Jalovište embankment, Municipality of Mojkovac.
- Regulation works of the tributary Rudnica 1,000 m Mojkovac.
- Main project of regulation of the Tara, Pčinja, Svinjača and Pažanj riverbeds - Municipality of Kolašin.

All available information on facilities built in the middle of the last century were used. In the document prepared under this current project 'Inventory of the existing flood protection infrastructure', all locations where works on flood protection infrastructure were performed are provided descriptively and provided in GIS maps.

8.2 Analysis of high waters

The task of hydrological analysis of high waters was to determine the probable occurrence of critical events. High water analyses and calculations depend on the statistical analysis of available data. On insufficiently studied basins it is necessary for high waters to be accounted for based on precipitation data, i.e., based on the rainfall.

Statistical analysis of high waters is a tool for linking the size of high waters to the probability of appearance. In practice, this is most commonly conducted on a series of maximum annual flows/water levels. The probable occurrence of high waters is most often expressed as the annual probable to overcome p(x) i.e., the average of the annual maximum exceeds x. The return period (in years) T(x) is the reciprocal value of this probable and represents the expected number of years for which flow/water level x will be exceeded at least once. The underlying problem in the statistical analysis of high waters is the short historical sequences and processing period, on which the values of the high waters depend. Another significant problem is the incurability in the low- probable high-water ratings, the occurrence of the extraction of the high water scattered beyond the range of observed values.

For the purpose of producing the PFRA 21 hydrological stations (HS) from the Danube Basin have been selected. Data from existing[28] and historical hydrological stations[29] were used for the analysis of high-water levels (Figure 8.1 and Table 8.1). The data for the selected HS has been provided by the Institute of Hydrometeorology and Seismology of Montenegro. In the preparation of this analysis, it was necessary to consult experts from the Hydrological Analysis Department, as the information relating to the history of the HS work, the method of measurement and observation were of crucial importance for the preparation of this Study. For certain HS input sequences are shorter than the actual available. The reason for this was to take account of the change in the location of the certain stations, as well as the evident disturbed natural flow regime on certain profiles.

After the final adoption of the data for the calculation, a statistical analysis was performed using the method of annual extremes and calculated the probability that 10%, 1% and 0.2%, i.e., return periods of 10, 100 and 500 years. To describe the law of distributing maximum annual data, multiple theoretical distribution functions (Log Pearson III, Pearson III, In, Gumbel and GEV) were used. Statistical analysis of hydrological extremes yielded models (probability distributions) that describe the X-P relationship well enough in the observed data set. The adopted values of the water level and flow for all 21 hydrological stations which were obtained by statistical analysis are shown In Table 8.1.

[28] The current operational (existing) hydrological stations on the Danube River Basin are shown in Annex 1.

[29] Historical hydrological stations refers to stations that are currently not operating.

Further analysis yielded the required computational flows HQ10, HQ100 and HQ500 for all listed measurement profiles. The correlation of the calculated values of HQ10, HQ100 and HQ500 on the measuring profile with the characteristic upstream downstream profiles was performed by a rational method.

The hydraulic model HEC-RAS was used to calculate the flood lines. Data on the geometry of the riverbed (topography of the main riverbed and inundation) were obtained from a digital terrain model (resolution 5m) (source: Real Estate Administration of Montenegro). The model does not include river regulations, or any other work performed after the development of the subject DEM. Calibration of the model was performed based on 2010 flood data. Using a cross-section of the water mirror plane with a digital terrain model we obtained spatial data for the display of flooded areas, in the form of polygons, and the display of depths, in raster form. This data was used (as shape files) for further processing in the Quantum GIS program. It is important to note that the accuracy of the hydraulic watercourse model largely depends on the resolution of the digital terrain model (DMT).

Figure 8.1 Overview of analyses hydrological stations on watercourses Montenegro

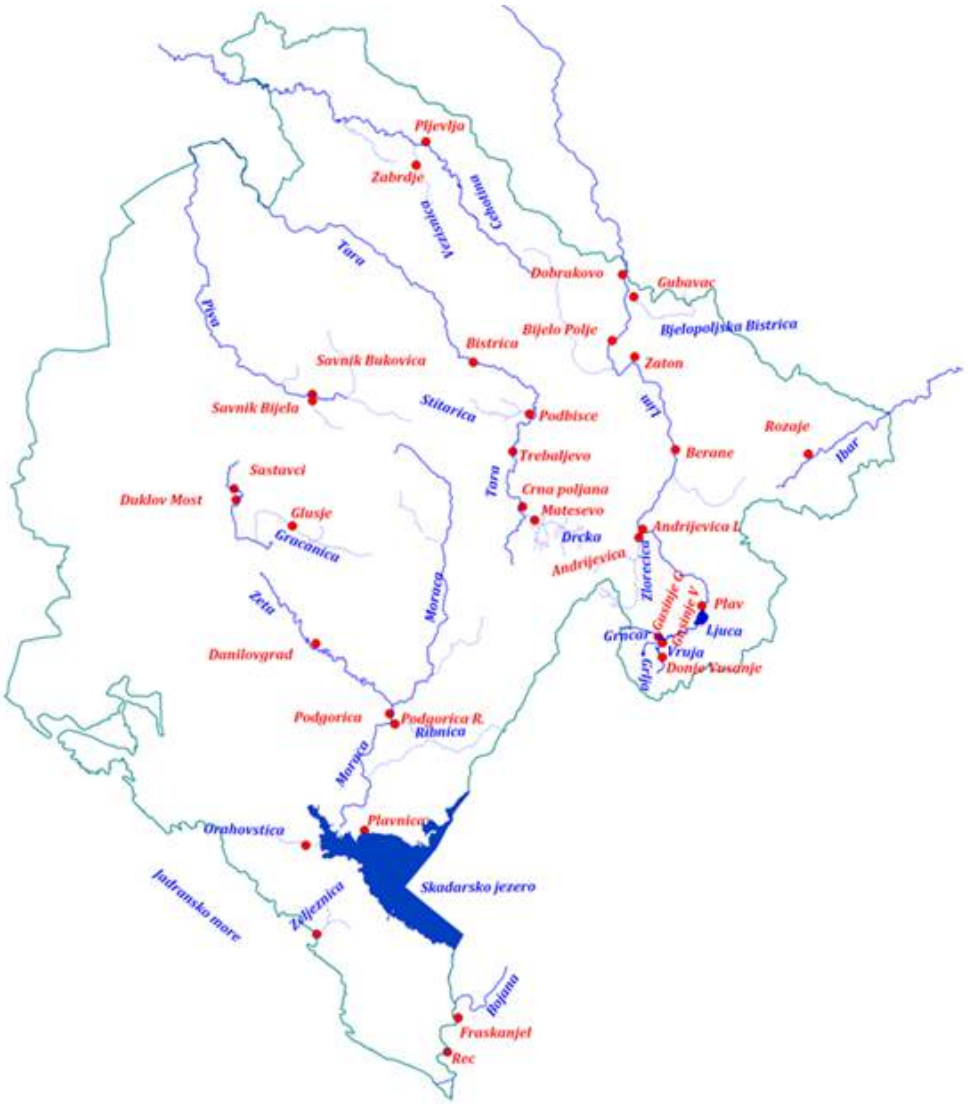


Table 8.1. Hydrological stations in the Danube River Basin used for computational flow analysis. Adopted values of water level (H) / flow (Q) obtained by statistical analysis for the annual probability of occurrence of 10, 1 and 0.2% (T = 10 years; T = 100 years; T = 500 years).

Station	Watercourse	River Basin	Longitude	Latitude	m.a.s.l[30]	H(cm)			Q(m³/s)		
						10%	1%	0,2%	10%	1%	0,2%
Plav	Lim	Drina	42° 36' 28"	19° 55' 58"	906.58	242	309	352	231	363	461
Andrijevica	Zlorečica	Lim	42° 43' 24"	19° 47' 55"	742	225	268	289	142	223	275
Andrijevica	Lim	Drina	42° 43' 49"	19° 48' 24"	744.39	280	364	421	341	470	555
Berane	Lim	Drina	42° 52' 03"	19° 52' 49"	658.05	423	524	580	492	620	690
Zaton	Lim	Drina	42° 58' 57"	19° 46' 16"	583.9	302	366	403	629	894	1079
Bijelo Polje	Lim	Drina	43° 01' 52"	19° 45' 05"	559.67	336	434	496	758	1099	1338
Gubavač	Bjelopoljska Bistrica	Drina	43° 06' 09"	19° 47' 54"	545	209	277	322	47.4	65.0	77.4
Dobrakovo	Lim	Drina	43° 08' 13"	19° 46' 55"	531.61	419	574	687	950	1356	1631
Crna Poljana	Tara	Drina	42° 46' 32"	19° 33' 01"	965.8	291	370	418	302	496	636
Mateševo	Drcka	Tara	42° 45' 14"	19° 34' 33"	1015	188	225	247	100	132	147
Trebaljevo	Tara	Drina	42° 51' 44"	19° 31' 54"	894.08	388	529	617	503	746	901
Podbišće	Štitarica	Tara	42° 55' 15"	19° 34' 09"	839.73	154	213	251	63.9	143	202
Bistrica	Tara	Drina	43° 00' 16"	19° 27' 00"	736	528	688	788	655	956	1149
Pljevlja	Ćehotina	Drina	43° 20' 29"	19° 21' 47"	754.99	210	276	316	99.7	161	211
Zabrđe	Vezišnica	Ćehotina	43° 08' 46"	19° 18' 30"	770	239	297	328	71	96.3	110
Rozaje	Ibar (pvr)	Zapadna Morava	42° 45' 55"	20° 08' 59"	1035.14	147	204	250	54.7	107	155
Vusanje	Grlja	Vruja	42° 30' 30"	19° 50' 00"	960	151	204	243	57.4	89.2	113
Gusinje	Vruja	Ljuča	42° 33' 25"	19° 50' 34"	920	178	227	260	118	176	217
Gusinje	Grnčar	Ljuča	43° 33' 53"	19° 50' 13"	918	179	213	230	ND[31]	ND	ND
Šavnik	Bijela	Pridvorica	42° 56' 59"	19° 5' 58"	832.01	198	291	356	70	166	240
Šavnik	Bukovica	Pridvorica	42° 57' 27"	19° 6' 11"	819.08	226	283	318	115	179	225

[30] Height in metres above sea level

[31] ND: Not Determined. Water Flow measurements were not recorded at Gusinje HS.

8.3 APSFR Spatial Display Process Method

After obtaining data from the hydrological model in the form of polygons (file type: shape files) related to HQ10, HQ100 and HQ 500 for all major rivers in the Danube basin, they were compared in the Quantum GIS program with other existing data. Of the other existing data, historical data were emphasized, i.e., locations of houses that were flooded during the highest recorded floods in Montenegro (during 2010-2011). Data obtained during the earlier phase of this project related to Flood protection infrastructure were also used. An Orthophoto image of Montenegro, obtained from the Real Estate Administration of Montenegro, was used as a basis for presenting and comparing data.

A topographic map of Montenegro with a scale of 1:25,000, as well as available data available on the Internet (Open Street Map (OSM), Google Maps) were used for analysis, but the Orthophoto image of Montenegro was presented as the most useful as a background. Data relating to Corine Land Cover were also considered during the data analysis.

Based on the analysis of all the above data, the APSFR in the Danube Basin area were defined and represented in GIS format (Section 6).

8.4 Recorded hydrological data

Year	Expected Flooding Mechanism[32]	Calculated Return Period (Years)
Watercourse Location: Grlja, "Vusanje"		
Related APSFR06_DRB_Vruja01		
1960	Large Scale Floods	30
1962	Outflow from the riverbed	10
1968	Outflow from the riverbed	10
1969	Outflow from the riverbed	10
1974	Large Scale Floods	30
1979	Outflow from the riverbed	10
2009	Outflow from the riverbed	10
2010	Large Scale Floods	50-60
2012	Outflow from the riverbed	10
Watercourse Location: Vruja, "Gusinje"		
Related APSFR06_DRB_Vruja01		
1960	Outflow from the riverbed	10
1963	Large Scale Floods	20
1968	Outflow from the riverbed	10
1969	Outflow from the riverbed	10
1974	Large Scale Floods	30-50
1979	Large Scale Floods	20-30

[32] The mechanism of flooding has been described based on the and the topography of the region.

Year	Expected Flooding Mechanism[32]	Calculated Return Period (Years)
1995	Outflow from the riverbed	10-20
1999	Outflow from the riverbed	10-20
Watercourse Location: Grnčar,"Gusinje"		
Related APSFR05_DRB_Grnčar01		
1968	Outflow from the riverbed	10
1969	Outflow from the riverbed	10
1986	Large Scale Floods	10
1990	Outflow from the riverbed	10
1991	Outflow from the riverbed	10
1999	Outflow from the riverbed	10
2003	Outflow from the riverbed	10
Watercourse Location: Lim, "Plav"		
Related APSFR07_DRBLim01		
1952	Outflow from the riverbed	10
1963	Outflow from the riverbed	10
1968	Outflow from the riverbed	10
1979	Large Scale Floods	40-50
1995	Outflow from the riverbed	10
1999	Outflow from the riverbed	10
2000	Large Scale Floods	10
2003	Large Scale Floods	10
2008	Outflow from the riverbed	10
2010	Large Scale Floods	10
2016	Outflow from the riverbed	10
Watercourse Location: Zlorečica, "Andrijevica"		
Related APSFR08DRB_ Lim02		
1995	Outflow from the riverbed	10
1998	Outflow from the riverbed	10
2000	Outflow from the riverbed	10
2003	Outflow from the riverbed	10
2010	Outflow from the riverbed	10
Watercourse Location: Lim, "Andrijevica"		
Related APSFR08_DRB_Lim02		
1952	Large Scale Floods	20-30
1955	Outflow from the riverbed	10-20
1962	Outflow from the riverbed	10
1963	Large Scale Floods	20-30
1968	Large Scale Floods	20-30
1970	Large Scale Floods	20
1974	Large Scale Floods	N/A
1977	Outflow from the riverbed	10
1979	Outflow from the riverbed	10
1980	Outflow from the riverbed	10

Year	Expected Flooding Mechanism[32]	Calculated Return Period (Years)
1981	Outflow from the riverbed	10
1985	Outflow from the riverbed	10
1994	Outflow from the riverbed	10
1995	Outflow from the riverbed	10
1998	Outflow from the riverbed	10
1999	Outflow from the riverbed	10
2000	Outflow from the riverbed	10
2003	Outflow from the riverbed	10
2010	Large Scale Floods	10
Watercourse Location: Lim, "Berane"		
Related APSFR09_DRB_Lim03; APFSR10_DRB_Lim04		
1968	Outflow from the riverbed	10
2000	Outflow from the riverbed	10
2010	Large Scale Floods	10
1968	Outflow from the riverbed	10
1970	Outflow from the riverbed	10
1974	Large Scale Floods	20-30
1979	Large Scale Floods	100
1985	Outflow from the riverbed	10
1995	Large Scale Floods	10
2000	Outflow from the riverbed	10
Watercourse Location: Lim, "Bijelo Polje"		
Related APSFR11_DRB_Lim05; APSFR12_DRB_Lim06; APSFR13_DRB_Lim07; APSFR14_DRB_Lim08		
1952	Large Scale Floods	100
1963	Outflow from the riverbed	10
1968	Outflow from the riverbed	10
1970	Outflow from the riverbed	10
1974	Outflow from the riverbed	20
1979	Large Scale Floods	40
1985	Outflow from the riverbed	10
1994	Outflow from the riverbed	10
1995	Outflow from the riverbed	10
2000	Outflow from the riverbed	10-20
2010	Large Scale Floods	20-30
2016	Outflow from the riverbed	10-20
Watercourse Location: Bistrica, "Gubavač"		
Related APSFR14_DRB_Lim08; APFSR15_DRB_Lim09		
1949	Outflow from the riverbed	10
1952	Outflow from the riverbed	10
1955	Outflow from the riverbed	10
1958	Outflow from the riverbed	10
1977	Outflow from the riverbed	10

Year	Expected Flooding Mechanism[32]	Calculated Return Period (Years)
1979	Large Scale Floods	100
1981	Outflow from the riverbed	10
1984	Large Scale Floods	30
1988	Outflow from the riverbed	10
Watercourse Location: Lim, "Dobrakovo"		
Related APSFR15_DRB_Lim09		
1963	Outflow from the riverbed	10
1970	Outflow from the riverbed	10
1974	Outflow from the riverbed	10
1979	Large Scale Floods	100
1985	Outflow from the riverbed	10
2016	Outflow from the riverbed	10
Watercourse Location: Tara, "Crna poljana"		
Related APSFR16_DRB_Tara01		
1970	Outflow from the riverbed	10
1974	Outflow from the riverbed	10
1979	Outflow from the riverbed	10
1992	Large Scale Floods	30
1995	Outflow from the riverbed	10
1999	Outflow from the riverbed	10
2000	Outflow from the riverbed	10
2003	Outflow from the riverbed	10
2004	Outflow from the riverbed	20
2007	Outflow from the riverbed	10
2010	Outflow from the riverbed	10
2016	Large Scale Floods	20-30
Watercourse Location: Tara, "Trebaljevo"		
Related APSFR16_DRB_Tara01; APFSR17_DRB_Tara02		
1963	Outflow from the riverbed	10
1970	Outflow from the riverbed	10
1974	Outflow from the riverbed	10-20
1979	Outflow from the riverbed	10
1992	Large Scale Floods	30
1999	Outflow from the riverbed	10
2000	Outflow from the riverbed	10-20
2004	Outflow from the riverbed	10
2010	Outflow from the riverbed	20
2016	Outflow from the riverbed	10-20
2018	Outflow from the riverbed	10
Watercourse Location: Štitarica, "Podbišće"		
Related APSFR17_DRB_Tara02		
1968	Outflow from the riverbed	10-20
1974	Outflow from the riverbed	10-20

Year	Expected Flooding Mechanism[32]	Calculated Return Period (Years)
1979	Outflow from the riverbed	10
1990	Outflow from the riverbed	10
1991	Large Scale Floods	100
1992	Outflow from the riverbed	10
Watercourse Location: Tara, "Bistrica"		
Related APSFR17_DRB_Tara02		
1963	Outflow from the riverbed	10-20
1968	Outflow from the riverbed	10
1974	Large Scale Floods	20-30
1979	Outflow from the riverbed	10-20
1992	Large Scale Floods	20-30
1999	Large Scale Floods	20-30
Watercourse Location: Ćehotina, "Pljevlja"		
Related APSFR18_DRB_Brezojevica01		
1968	Outflow from the riverbed	10
1969	Outflow from the riverbed	10
1974	Large Scale Floods	20-30
1979	Large Scale Floods	30
1985	Outflow from the riverbed	10
1989	Outflow from the riverbed	10
1994	Outflow from the riverbed	10-20
1997	Outflow from the riverbed	10-20
2000	Outflow from the riverbed	10-20
2006	Outflow from the riverbed	10
2010	Large Scale Floods	10
Watercourse Location: Ibar, "Rožaje"		
Related APSFR01_DRB_Ibar01; APFSR02_DRB_Ibarac01; APFSR03_DRB _Lovnička rijeka01; APFSR04_DRB_Županica01		
1972	Large Scale Floods	100
1973	Outflow from the riverbed	10
1979	Outflow from the riverbed	10
2010	Large Scale Floods	10
2016	Outflow from the riverbed	20
2017	Outflow from the riverbed	10
2019	Outflow from the riverbed	10
Watercourse Location: Bukovica, "Šavnik"		
Related APSFR19_DRB_Bukovica i Bijela01		
1952	Outflow from the riverbed	20
1964	Outflow from the riverbed	20
1968	Large Scale Floods	40
1974	Outflow from the riverbed	10
1979	Outflow from the riverbed	10
1985	Outflow from the riverbed	10

Year	Expected Flooding Mechanism[32]	Calculated Return Period (Years)
1987	Outflow from the riverbed	10
Watercourse Location: Bijela, "Šavnik"		
Related APSFR19_DRB_Bukovica i Bijela01		
1952	Outflow from the riverbed	10
1970	Outflow from the riverbed	10-20
1974	Outflow from the riverbed	10

8.5 Existing Hydrological measuring stations