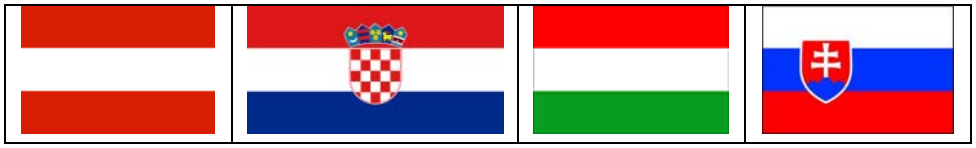
icpdr iksd
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

Flood Protection Expert Group

Sub-Basin Level Flood Action Plan
- Pannonian Central Danube



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December, 2009

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1. INTRODUCTION

In response to the danger of flooding and in line with its Joint Action Programme, the ICPDR decided in 2000 to establish the long-term Action Programme for Sustainable Flood Prevention in the Danube River Basin. The whole process was accelerated after disastrous floods in 2002 and resulted in adoption of the Action Programme at the ICPDR Ministerial Meeting on 13 December 2004.

The overall goal of the ICPDR Action Programme is to achieve a long term and sustainable approach for managing the risks of floods to protect human life and property, while encouraging conservation and improvement of water related ecosystems. Given the area, the complexity and the internal differences in the Danube River Basin, the Action Programme represents an overall framework, which needs to be specified in further detail for sub-basins. Therefore, the targets of the ICPDR Action Programme include preparation of flood action plans for all sub-basins in the Danube catchment area.

In September 2007 a Directive of the European parliament and of the Council on the assessment and management of flood risks (EFD) was adopted by the European Council. The aim of the Directive is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. The Directive requires Member States to first carry out a preliminary flood risk assessment by 2011 to identify areas at risk of flooding. For such areas they would then need to draw up flood risk maps by 2013 and establish flood risk management plans focused on prevention, protection and preparedness by 2015.

As the ICPDR Action Programme was designed in full coherence with EFD the flood action plans for sub-basins are an important part of implementation of the EFD and they summarize the key actions towards preparation of the flood risk management plans. Therefore, the preparation of the flood action plans for sub-basins can be considered as an interim step in implementation of EFD.

This action plan for the Pannonian Central Danube sub-basin reviews the current situation in flood protection and sets the targets and the respective measures aiming among others to reduction of damage risks and flood levels, increasing the awareness of flooding and to improvement of flood forecasting. The targets and measures are based on the regulation of land use and spatial planning, increase of retention and detention capacities, technical flood defences, preventive actions, capacity building, awareness and preparedness raising and prevention and mitigation of water pollution due to floods.

It is foreseen that this planning document will be further refined as appropriate and necessary by the bilateral river commissions.

2. CHARACTERISATION OF CURRENT SITUATION

2.1. Review and assessment of current situation

2.1.1. Natural conditions

The origin of the Danube is commonly accepted as beginning at the confluence of the two rivulets, the Breg and Brigach near Donaueschingen in the eastern part of the Black Forest (Germany). The distance from the source of the Danube to its issue (more accurately, its central distributary near Sulina/Romania) into the Black Sea is 2,780 km. Taken together with the length of the longer of the two headwater streams, the Breg (46 km), this gives an overall geographical flow distance of 2,826 km. This places the Danube as the second longest river in Europe; the Volga being the longest.

The course of the Danube is commonly subdivided into three main sections, these are:

- the upper Danube from its source to the mouth of Morava ("Porta Hungarica"), the breakthrough of the Danube between the - here relatively low - elevations of the Alpine and Carpathian ranges at the eastern edge of the Vienna Basin,
- the middle Danube, that reaches down to the " Iron Gate ", the deeply incised narrow valley reach of the river between the Carpathians and the Stara Planina, and
- the lower Danube to its delta emptying into the Black Sea.

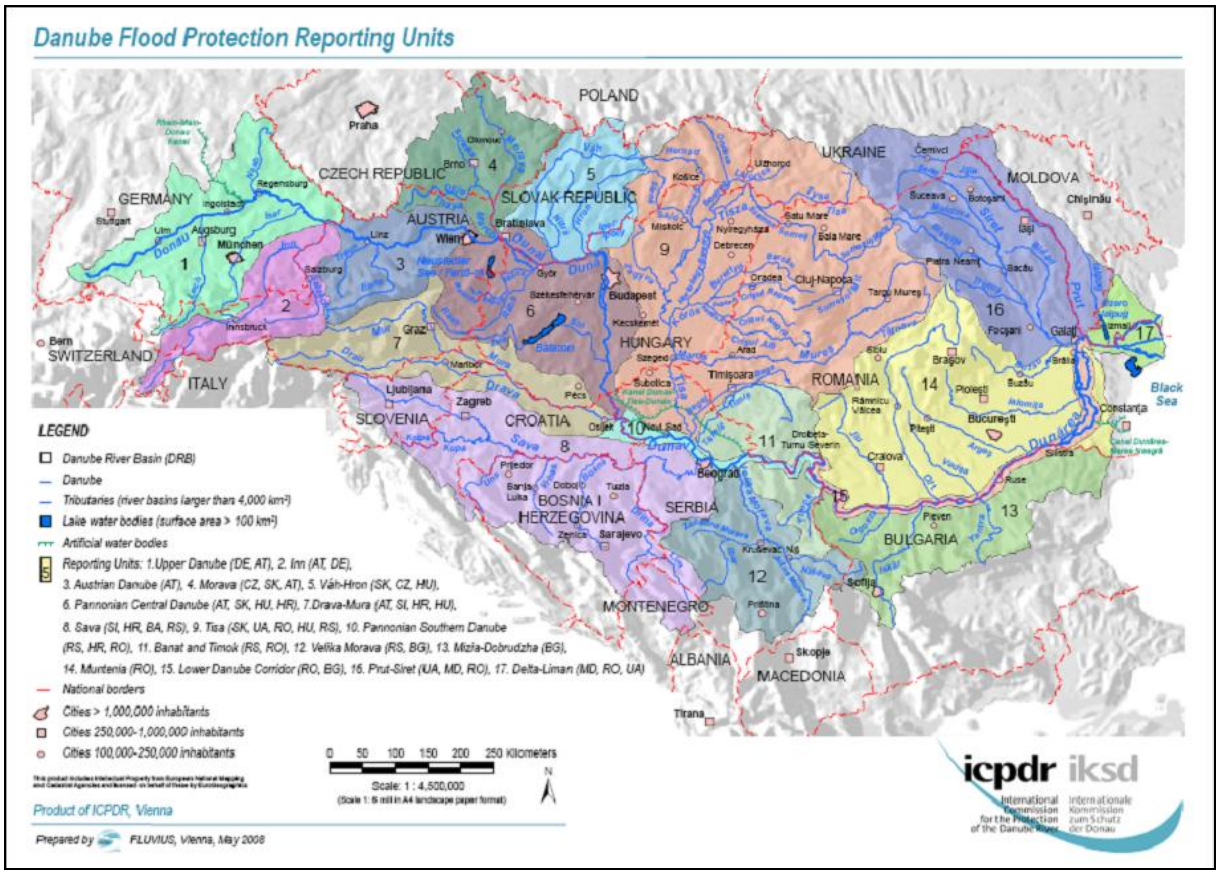
Characteristic features of the entire river reach of the Danube are the alternating flat basins and passages through mountain regions. This generally goes along with changes in the river gradient ratios: In the mountainous reaches and breakthrough valleys of the river, there is typically a relatively large gradient of over 0.4‰ . When entering the basins and lowlands the river often builds up extended alluvial fans, on which the gradient gradually decreases. In the lowland areas, the gradient ranges between 0.08 and 0.03‰. The lowest gradient and consequently the lowest flow velocity are to be found in the last 250 km of the Danube to the Black Sea, where the gradient falls to 0.004 ‰.

The Pannonian Central Danube is located in the “middle Danube” reach spreading from the mouth of the Morava to the mouth of Dráva (See *Figure 1.* Figure).

The Danube sub-basin of the Pannonian Central Danube in **Austria** extends over portions of the provinces of Styria and Lower Austria as well as over the whole of Burgenland. The following section aims to briefly characterise the Danube sub-basin of the Pannonian Central Danube, based on the most important waters. *Figure 2.* Figure shows an overview of the sub-basin of the Pannonian Central Danube in Austria. The sub-basin extends over a part of the province of Lower Austria.

The section of the Danube in the Danube sub-basin of the Pannonian Central Danube begins at the confluence of the Donaugraben with the Danube at Langenzersdorf, north of Vienna. A short distance afterwards, the Danube flows through the Austrian capital, Vienna. Here, the Danube splits up into the main river, the Neue Donau and the Donaukanal. However, the Neue Donau and the Donaukanal are reunited with the main river a few kilometres

downstream. From Vienna to the border between Austria and Slovakia (confluence with the March), the Danube flows through the Donau-Auen National Park for about 38 river kilometres. This section of the river is characterised by the already partially accomplished dismantling of the heavy flood control constructions. The completed dismantling, as well as further planned measures, is intended to contribute to revitalising the water meadow, while at the same time also mitigating the flood wave and stabilising the river bed.



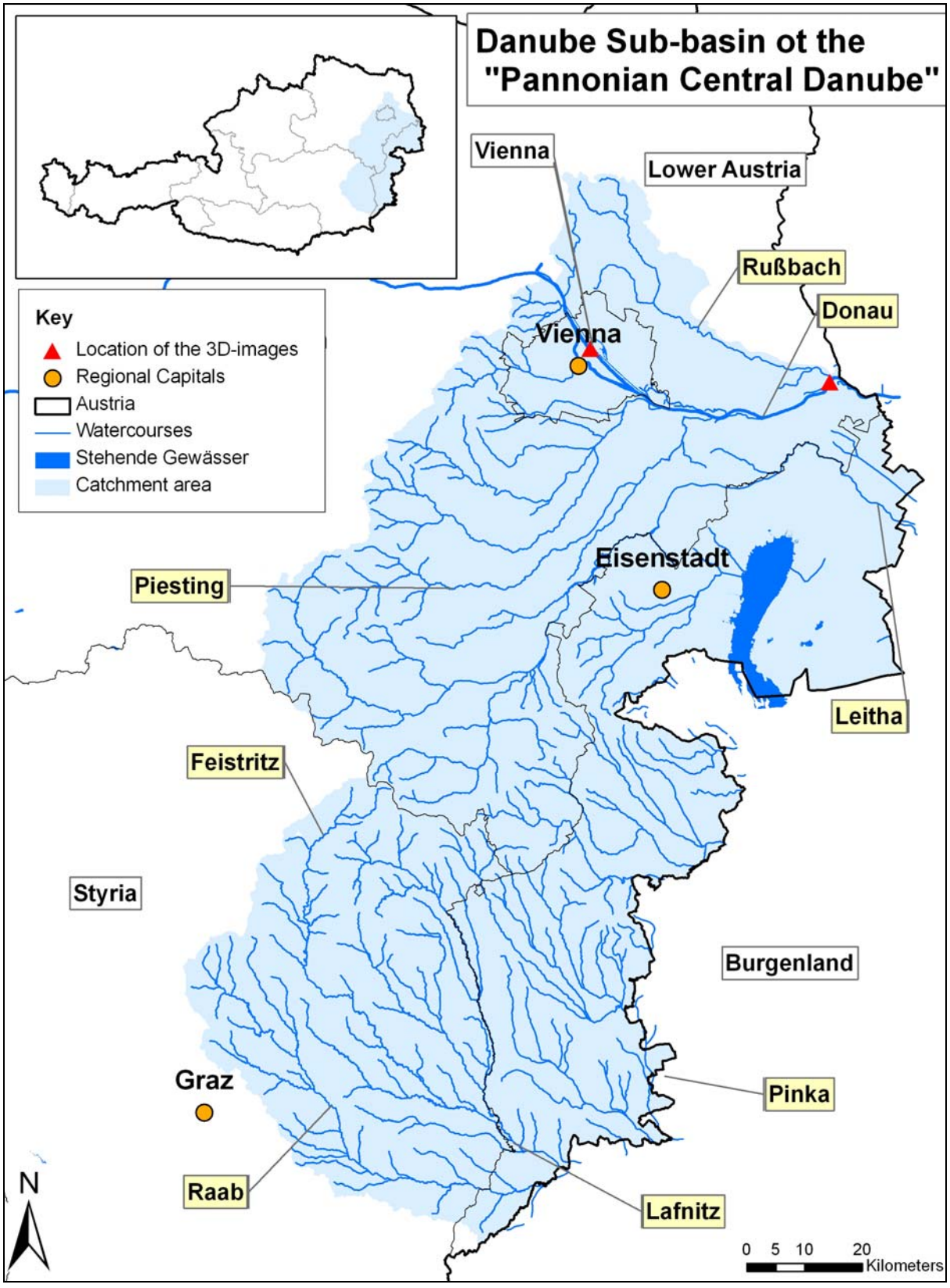
1. Figure Flood protection reporting units of the Danube Basin (ICPDR)

The Russbach stream to the north of the Danube, the Schwechat, the Triesting, the Fischa including the Piesting, as well as the Leitha, together with the Schwarza and Pitten, to the south of the Danube, represent the major watercourses of the Danube sub-basin in Lower Austria. With the exception of the Leitha, these waters still flow into the Danube in Austria. The Leitha, formed through a confluence of the Schwarza and Pitten, flows through Lower Austria and Burgenland for about 100 river kilometres and, after about 180 river kilometres, flows into the Danube. Its course is extremely varied in character, ranging from a heavily meandering river in dense alluvial forest, and extensively braided stretches, to a heavily regulated river.

Besides the Strem, Pinka and Leitha, the Rabnitz represents one of the most important watercourses in Burgenland. It flows through central Burgenland and, a short distance above the confluence of the Raab, flows into a side-arm on the right bank of the Danube in Hungary near Győr.

The discharge volume in Eastern Styria is determined by the main rivers, the Raab, Feistritz and Lafnitz. The Raab has its source in the region of the Passail Alps, and drains a catchment area of about 1 020 km² along about 250 river kilometres (of which 95 river kilometres or 890

km² are found in Styria) until its confluence with a side-arm of the Danube near Győr. Along its course in Hungary, it absorbs into itself further important Austrian watercourses (for example, the Strem and Pinka).

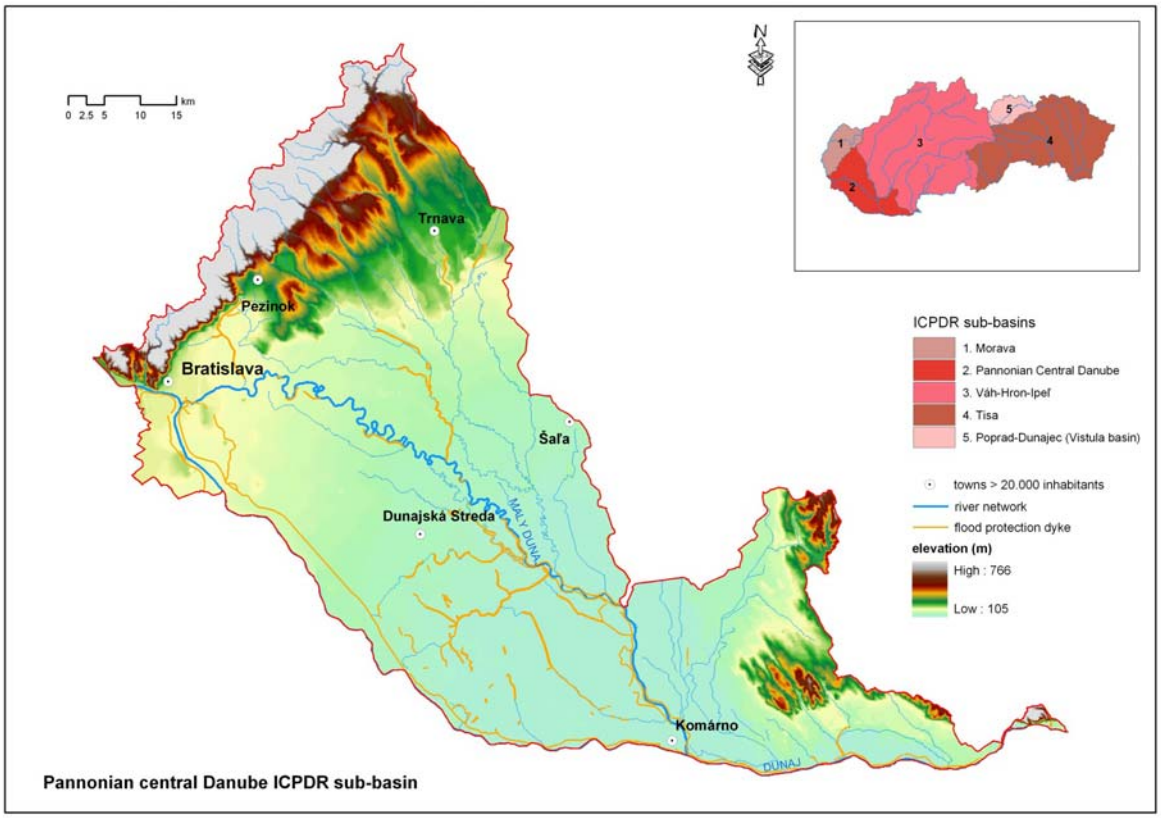


2. Figure The Danube sub-basin of the Pannonian Central Danube in Austria (Image: Revital ZT)

The Pannonian Central Danube basin at the territory of **Slovakia** consists from the following main parts (sub-basins):

- Danube river from the mouth of the Morava River to the mouth of the Ipeľ River
- Rivers and creeks the springs of which are located on the south-eastern slopes of the Malé Karpaty mountain range (the Little Carpathian Mountains),
- Closing stretches of the Váh River, the Hron River and the Ipeľ River within the influence of the Danube flood backwater effect.

Figure 3. Figure shows the topographical map of the Pannonian Central Danube Basin on the territory of Slovakia. Large watercourses, as well as numerous smaller watercourses are under administration of the Slovak Water Management Enterprise, state enterprise (important watercourses). The other watercourses are administered by the municipalities, forestry, agriculture, army, etc. Overview of the watercourses in the territory of interest is given in the Table 1. Table.



3. Figure Topography of the Slovak part of the Pannonian Central Danube River Basin

1. Table Number and length of watercourses in the Pannonian Central Danube River Basin – Slovak part

River Sub-Basin	Total number of water courses	Number of important water courses	Total length of water courses [km]	Length of important water courses [km]
Danube	502	319	1 107.33	874.01

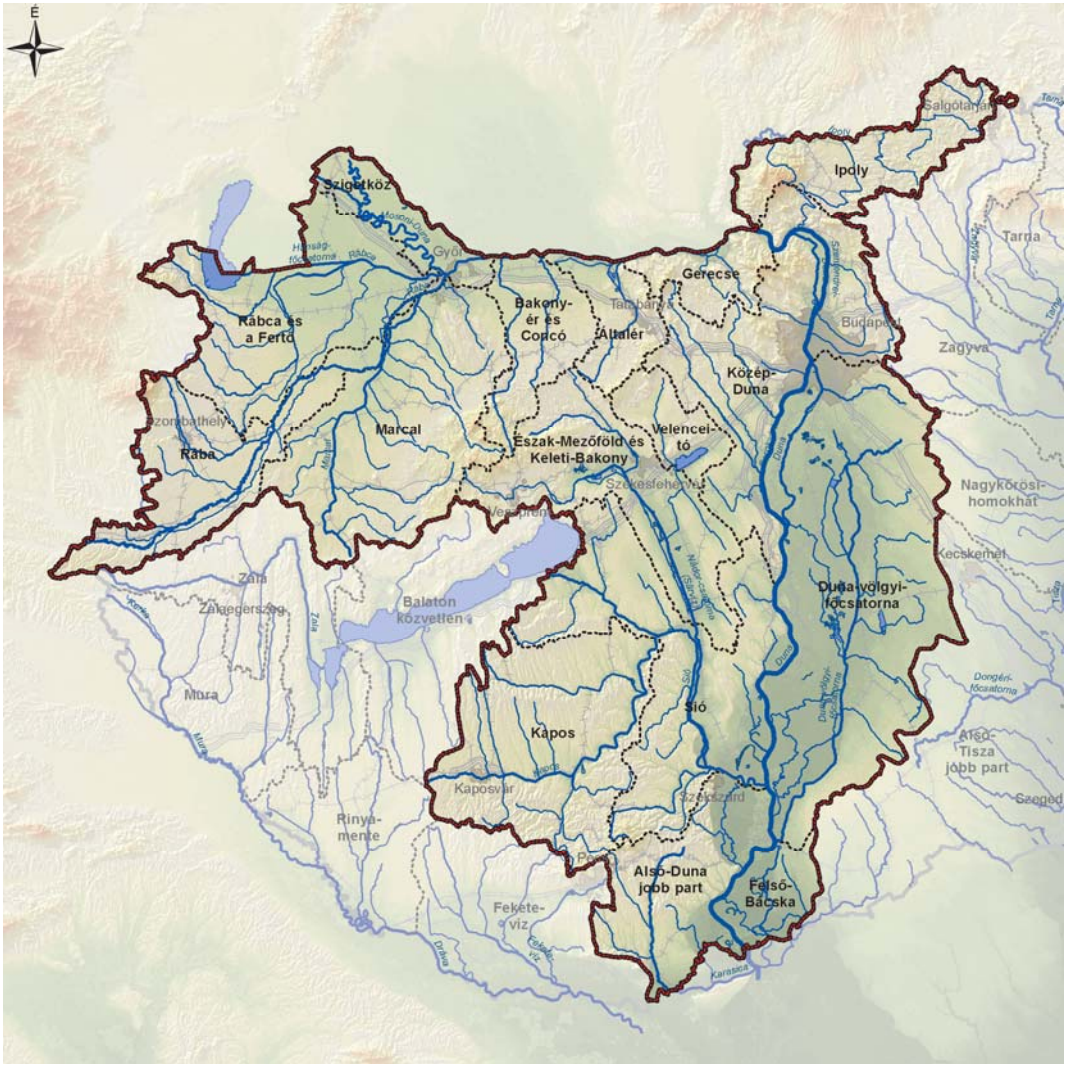
Basic hydrological characteristics of the Pannonian Central Danube at the territory of Slovakia can be found in the Table 2. Table.

2. Table Basic characteristics of the Pannonian Central Danube Basin at the Slovak territory

River Sub-Basin	Watershed Area	Share	Long-term Mean Discharge	Average Annual Precipitation	Annual Precipitation	
					Runoff	Evaporation
	[km^2]	[%]	[m^3·s^{-1}]	[mm]	[%]	[%]
Danube	1 138	2.32	2 348.0	550	6	94

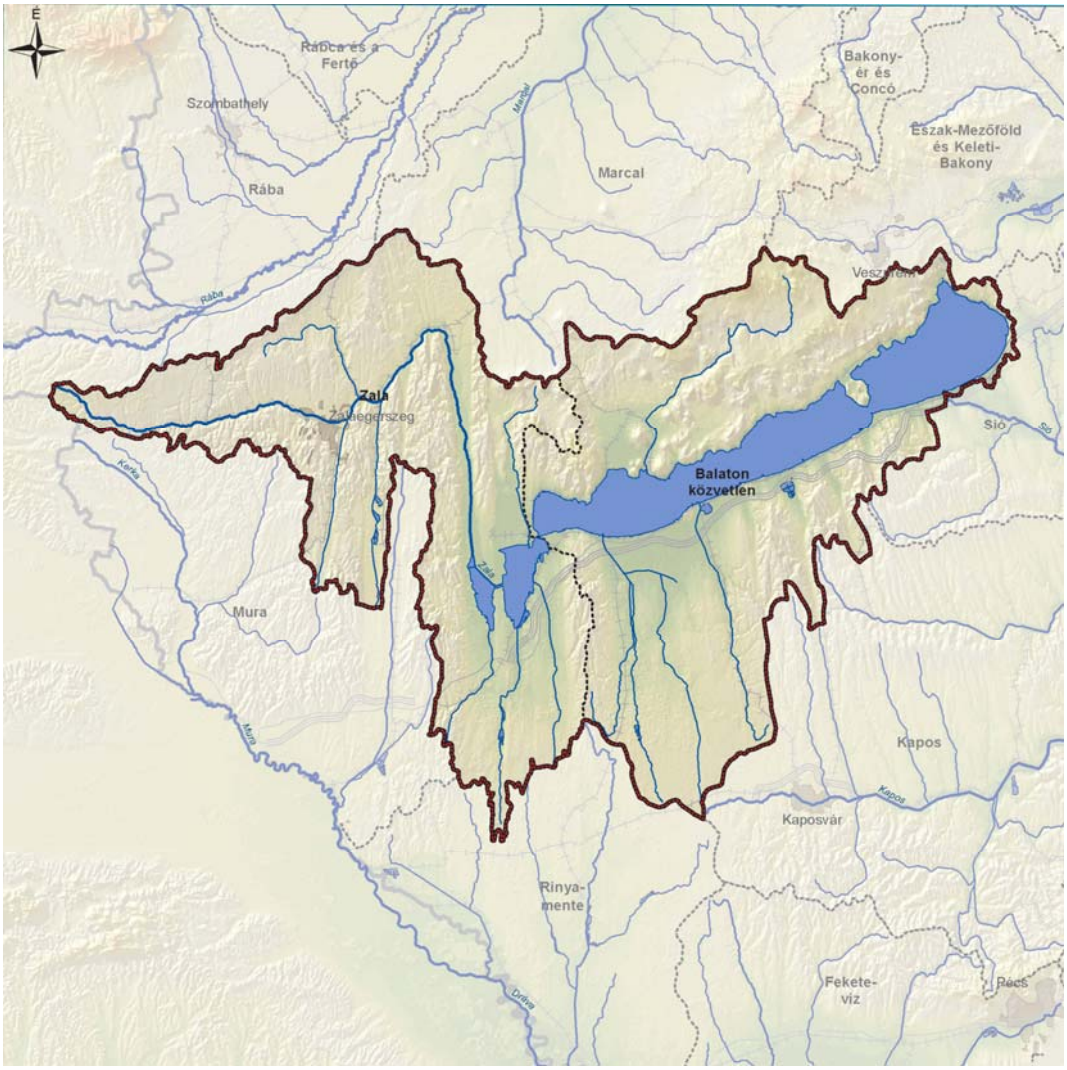
The rivers and creeks, the springs of which are located on the south-eastern slopes of the Malé Karpaty mountain range (the Little Carpathian Mountains), have the natural character in the mountainous parts only. They are trained in the inhabited areas and either downstream to their mouths. Some stretches of the creeks are closed from top in the villages, which creates potential for hazardous situations during floods, because of insufficient flow capacity.

The Pannonian Central Danube Basin in **Hungary** is 40 495 km^2 with 523 rivers, channels, lakes, oxbow lakes, karstic regions etc. on it including the watershed of Lake Balaton as well. The following two figures show the delineation of the two watersheds.



4. Figure The Pannonian Central Danube Basin

The immediate watershed of the Danube in Hungary can be characterised as hilly with the maximum height of 756 m A.s.l. in the Pilis Mountain. The lowest point of this region is at the southern border. In spite of the hilly character in the northern part most of the area is flatland. In contrast to that the watershed of Lake Balaton is mostly hilly with the highest point (437 m A.s.l.) in Badacsony.

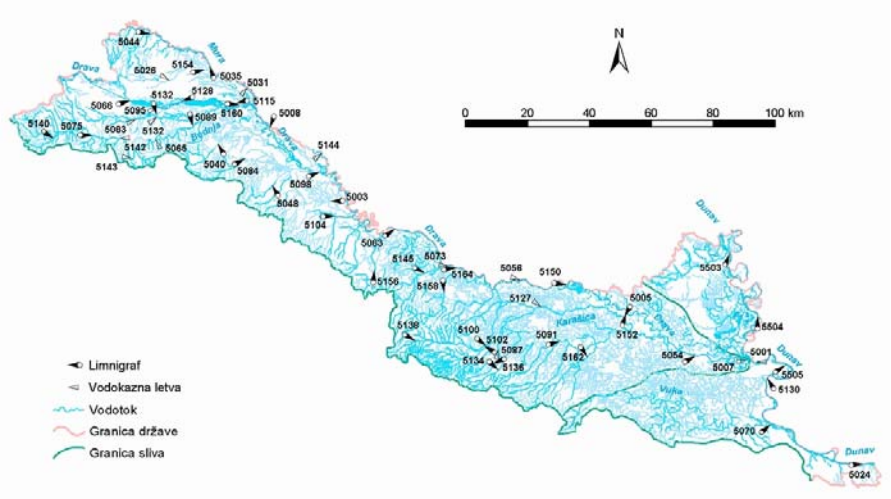


5. Figure The Lake Balaton Basin

The Pannonian Central Danube sub-basin in **Croatia** spreads about 710 km^2. The length of the Danube River upstream of the Drava mouth in Croatia is approximately 51 km (See *Figure 6.* Figure). Its whole length in Croatia is an international waterway and for the most part also constitutes the state border with Serbia. The largest tributary of the Danube upstream of the Drava river mouth in Croatia is Baranjska Karašica (201.5 km^2).

The Danube river basin is located in the Pannonian plain and along its rims. The relief is characterized by wide alluvial valleys and hilly/mountainous regions. This is mostly flatlands area (80 - 135 m altitude), with some relatively low mountains (Fruška gora and Krndija). The lowest part is Eastern Slavonia and Baranja, with damp flood prone lowlands.

The marshy and swampy area in the wide Danube inundation area upstream of the Drava river mouth has been declared as nature park - the "Nature Park of Kopački rit" (http://www.kopacki-rit.com/) and also is listed as Ramsar sites. This area is characterized by high level of biodiversity.



6. Figure Gauging stations in Drava and Danube River Basins

2.1.1.1. Hydrology[1]

Immediately downstream of the mouth of Morava River, the Danube enters the Pannonian basin, to be more precise it enters the most western region of the Upper Hungarian lowland. Here, the course of the middle Danube is initially characterized by a bifurcations at an alluvial fan a few kilometres south-east of the Slovak capital, Bratislava. Apart from a few insignificant branches, two larger arms of the river split from the main bed of the Danube: the so-called "Maly Dunaj", running north, and the so-called "Mosoni Duna", running south. The river reunites again at Komárno.

On this reach, one finds also one of the major anthropogenic interventions into the river: Near the Slovak village of Cunovo (Hungarian: Dunacsún, Danube-km 1852) the headrace canal of the Gabcikovo hydropower plant branches off. This canal serves a hydropower plant that became operational in 1992. The water abstraction here – on an average – leaves about 20% of the available water volume in the original riverbed, with a seasonal variation between 250 and 600 m^3/s. Near the village Sap (SK), at Danube-km 1811, the diversion canal from the power station joins the old bed of the Danube again.

On its route through the Upper Hungarian lowlands and the Hungarian hill country that continues in the east, the river receives only moderately water-abundant tributaries. From the northern Carpathians arc it receives the Vah, the Hron, and the Ipel, from the south, the Raab. All these tributaries show nivo-pluvial mid-mountain characteristics in their discharge patterns. Here, the discharge maxima are coupled with the time of the snowmelt in the Carpathians, which normally takes place in spring. The climatic conditions of this river section, which - in contrast to the upper Danube - are greatly influenced by continental

[1] The text of this Chapter is based on: IHP UNESCO: Flow Regime of River Danube and its Catchment int he Series „The Danube and its Catchment – A Hydrological Monograph" Koblenz & Baja 2004

conditions result in summer periods of low precipitation, what is reflected in the discharge pattern with a striking early-autumn minimum.

With its cutting through the Hungarian mid-mountain region, the Danube, which so far took a more or less steady west-to-east course, abruptly bends at Visegrád, approximately 45 km north of Budapest, at a right angle to the south and enters the great Hungarian lowlands, and from there follows its western edge. In this southward course, the Danube receives only one tributary worth mentioning, the water-poor Sió, the canalised outlet of Lake Balaton.

The runoff regime of the middle Danube from the mouth of Morava to the mouth of the Drava gradually changes from an alpidic river to a lowland river. This happens on a relatively long stretch of about 500 km with reaches of low gradients only a few moderately water-abundant tributaries feed into the river. All their discharge patterns, however, demonstrate - as mentioned before - a pronounced middle-mountain character.

Mean annual precipitation amounts to 656 mm in the Pannonian Central Danube sub-basin.

The water regime of the Danube River in **Croatia** is glacial, characterized by two distinct seasons: the high water season during May and June and the low water season during winter months. Water temperatures were the highest in August, and lowest in January.

The basic characteristics of small rivers in the river basin is that they have features of highland mountain and lowland flows, they are short and have relatively small catchment area, which is driven by relief areas. For the formation of larger water courses natural conditions are not favourable. The flow regime of the tributaries of the Danube in the river basin is significantly different from that of the main river. At tributaries high flow seasons usually last from November to April, and are not identical with flood periods of Danube. On the Danube high flow seasons occur in February, March and April in the first half of the year and in November and December in the second half, while the low water seasons occur in August and September.

2.1.2. Floodplains and flood defences

2.1.2.1. Levees

In **Slovakia** the Danube River channel is trained in the whole section from the mouth of the Morava River (the state border with the Austria) to the mouth of the Ipeľ River (the state border with the Hungary). The flood protection dykes are built on the river bank/banks. Other types of flood protection structures are applied on the short stretches in the Bratislava city centre and in the town Komárno. The dykes in stretches between the villages Marcelová and Radvaň nad Dunajom and also the villages Kamenica nad Hronom and Chľaba are not needed, because of favourable terrain configuration. The total length of the dykes on the left bank of the Danube River channel in Slovakia is 160.341 km, and on the right bank 22.707 km.

The Danube Lowland is the largest area endangered by flooding in the Slovakian part of the Pannonian Central Danube River basin. The morphology of the territory is formed by the sediments of the Danube River. There is a decrease of the terrain surface in the direction from

the main river channel. The left bank line is the higher part of the terrain surface, if the dykes are not taken into account. Therefore, the floodwater or inundated water cannot flow back into the channel. This area is potentially endangered in the case of the dykes' failure or overflow during the large floods. The technical conditions of the dykes are monitored and evaluated regularly.

Large hydraulic structure was constructed at the Slovak section of the Danube river. It consists from the complex of structures in Cunovo (weirs, power plant, navigation lock, intake structures), Hrusov (Cunovo) reservoir (total volume approximately 110 mil. m^3), headrace navigation canal, complex of structures in Gabcikovo (power plant, navigation locks), tailrace navigation canal, structure which ensure feeding of extensive system of river branches with water in Dobrohost and other auxiliary structures. Besides other purposes, hydraulic structures contribute to the flood protection of surrounding territory.

The Hungarian stretch of the Danube is protected by dykes. The design level corresponds to $Q_{1\%}$ in general and $Q_{1‰}$ in case of Budapest. The freeboard being between 1-1.5 m respectively. The stretch between Esztergom and the southern Hungarian border is particularly dangerous for ice jamming. For this reason on this stretch of the Danube the 1956 historical icy flood levels were used as design standard. This is at certain locations 2-3 m higher than the normal $Q_{1\%}$ flood level.

There is one three km long section of the Danube –ironically in Óbuda, Budapest – where no flood protection is provided. Discussion on how to protect this short stretch has been going on for years now.

Recently a large programme has been launched to bring the protection up to the present design standard. This programme envisages strengthening of the existing dykes without dyke relocation or increasing their height above the standard.

In **Croatia** flood protection and amelioration drainage works in the wide lowland areas of Slavonia and Baranja made urban, rural and traffic development as well as agricultural production possible.

The concept for flood protection on Danube Basin area is mainly based on flood protection by dikes along the major watercourses. The dykes with a less or more sufficient altitude (freeboard from 0.5 to 1.20 m) protect related areas against flood of 100 years return period.

The beginning of dyke building along the Danube River started in 18th century with the aim of protecting lowland part of the Baranya from Mohács (Hungary) to Draž. (Croatia). The Zmajevac-Kopačevo dyke was built in the length of 33.5 km in 1874. Dyke building continued throughout 19th century. After a disastrous flood in mid-sixties and early seventies, during 1970's the flood protection system was build and all dykes are still in use today.

Construction and subsequent reconstructions of defense embankments Drava-Danube and Zmajevac-Kopačevo enabled the effective protection of Baranja from high water levels of Drava and Danube and the preservation of broad flood prone areas along the Drava mouth.

Such a solution has beneficial effect on the natural water regime in the Nature Park Kopački rit, as well as to protection from flooding in downstream areas along the Danube.

A significant problem for flood protection to the Danube area is occurrence of ice jams that could cause ice floods. Icebreakers are used to remove the ice jams, which impede the smooth flow of water.

For the full completion of flood protection system, in the Pannonian Central Danube in Croatia is necessary to build lateral channel (Kneževi Vinogradi-Zmajevac) and/or 4 small reservoirs (Kamenac, Kotlina, Suza, Div Dolina).

As a result of intensive flood protection works nowadays we have totally 132 km of dikes along the Danube river (111 km upstream of the Drava mouth and 21 km downstream the Drava mouth), which protect around 145,000 hectares of urban, forestry and agricultural areas (approximately 16% of Drava and Danube river basin area) mostly with protection from flood of 100 years return period of occurrence.

2.1.2.2. Ice control

Ice and ice jamming is a major threat to the Pannonian Central Danube. Until the large river training works started in the middle of XIXth century ice jamming caused exceptionally devastating floods on the Danube.

Without going into details the March 1938 flood has to be mentioned that destroyed Pest and part of Buda (Buda and Pest was separate by that time). Also the 1940, 1941 and 1956 icy floods caused huge damages. The river training works executed under uniform principles improved the situation but still further measures had to be taken.

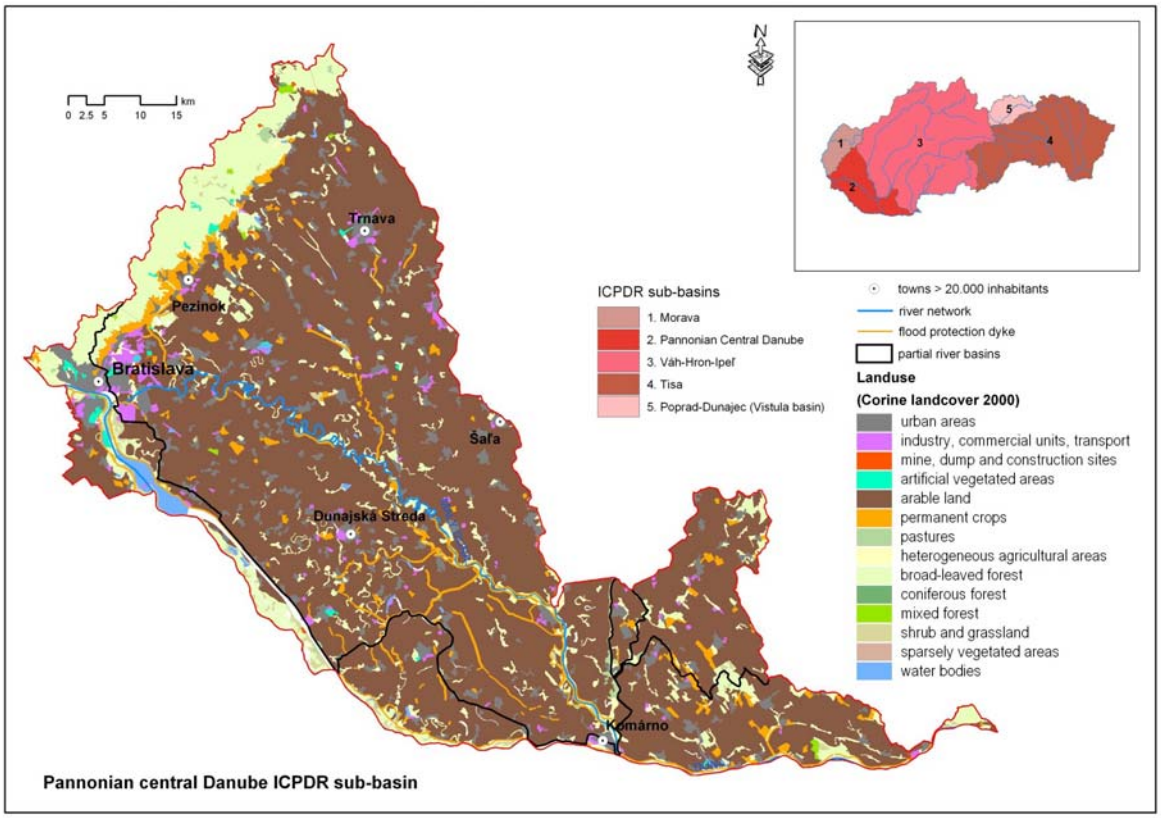
In 1955 a 227 km long section of the Danube between Dunaföldvár and Vukovár was declared of common interest by both Hungary and Yugoslavia. A 16 ship ice-breaker fleet was set up and operated jointly. The aim of it was to keep the ice moving as long as it was possible. When break-up time arrived the ice-breaker fleet started working from downstream to upstream to clear the river from ice. This ice breaking operation proved to be successful and no major problems have been recorded. Nowadays the joint operation of the ice-breaker fleet is under negotiation.

The climate change, the increased concentration of dissolved material in the Danube water, the heat pollution and the construction of new hydropower plants on the Danube decreased the pressure of ice jamming on this stretch of the Danube.

2.1.3. Characterisation of land uses and known risks

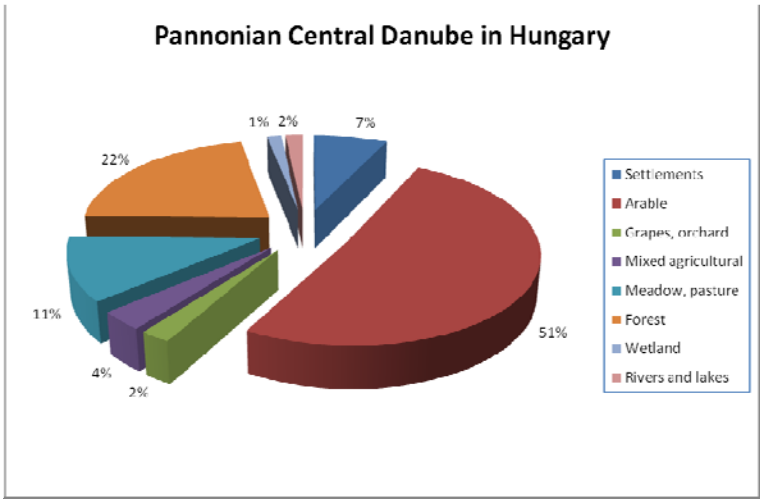
The Danube River flows in **Slovakia** through the regions, which have different socio-economic character. The capital city of Bratislava is the most important stretch of the Danube River in the Slovakia from the socio-economic point of view. The towns Komárno and Štúrovo are important centres as well. Rapidly developing recreation and trading areas can be found in the surrounding of the hydraulic structures in Čunovo and Gabčíkovo. Agriculture dominates in other zones along the Danube River. The most fertile soils are situated along or close to the river. Population density is lower in the agricultural areas, comparing with the

average. The land use map of the Pannonian Central Danube river basin at the territory of Slovakia (according to Corine landcover 2000) is given below.



7. Figure Land use in the Slovak part of the Pannonian Central Danube River Basin

The land use in Hungary is shown on the Figure below. It is based on CORINE CLC 50 data.



8. Figure Land use data of the Hungarian stretch of the Pannonian Central Danube

2.1.4. Conditions of flood forecasting and warning

In **Austria** a flood forecasting model is currently in trial operation on the Wienfluss. It covers the Wienfluss all the way to its confluence with the Donaukanal. The flood forecasting model of the province of Lower Austria is accessed on the Danube in Vienna.

The flood which occurred in August 2002 was the immediate reason for the consistent development of a flood information system aimed at geographically representing and covering the entire province. Starting with the Danube, a flood forecasting system for all larger main rivers and affluents is being developed step by step in Lower Austria.

A forecasting model for the Danube in Austria, covering the Danube catchment area from Passau (Bavaria) all the way to the national border, has been in trial operation since 2006. As the main river in the Danube sub-basin of the "Inn", the Inn is incorporated in the model from Schärding onwards. The Bavarian State Office for Water Management calculates hourly forecasts for the mutual intersection at Passau, which are likewise incorporated into the Austrian model. The forecasts are calculated at hourly intervals by means of physics-based models, for a forecasting period of up to 48 hours.

In addition, forecasting models for smaller tributary catchment areas (at present 15 in the whole of Lower Austria) are in operation in Lower Austria. The forecast is carried out by means of a simplified procedure (Unit Hydrograph Procedure).

The results (analyses and forecasts of precipitation and air temperature as raster data) of the meteorological models of the Central Institute for Meteorology and Geodynamics are incorporated in the discharge simulation as definitive input parameters.

In the event of a potential threat of flooding, the Hydrographic Service of Lower Austria passes a flood warning on to the neighbouring state of Slovakia.

There are currently still no forecasting models in operation in the Styrian sub-zone of the Danube sub-basin. A forecasting model for a jointly-operated flood notification service is to be made available in the catchment area of the Raab, within the framework of a cross-border EU flood project jointly run by Austria and Hungary, (Austrian-Hungarian Water Commission). The "Pro Raab(a)" early warning system enables an early assessment of regional or local occurrences of flooding based on hydrographic data, while also taking weather forecasts into account. The project for the model, which calculates flood forecasts for up to 48 hours in advance, is to be completed in 2010.

As well as the forecasting model on the Raab mentioned above, two further models on the Rabnitz and the Leitha (including the Schwarza and Pitten) are currently in process in Burgenland. The forecasting model for the Leitha is to be set up in cooperation with the Hydrographic Service of Lower Austria and covers the catchment area of the Leitha all the way to the national border. The forecasting model is to be put into operation by 2013.

The Hydrological Forecasts and Warning Department of the Slovak Hydrometeorological Institute is responsible for providing operational information on the hydrological situation on

the territory of **Slovakia**. The network consists of 80 hydrological forecasting stations. The hydrological information contains the following parameters: water stages, discharges, water temperatures, the appearance of ice effects and the relation of current water stages/discharges to their long-term means. Apart from these instantaneous values, the Department provides set of various types of forecasts – numerical forecasts for selected stations, trends in water stages, information on snow conditions (snow depth, water equivalent of snow cover, information on the water supply in the snow for selected profiles utilized for reservoirs operation).

In **Hungary** a progress achieved on the flood control project has generated a growing need for the establishment of a „central hydrographic institute" in the second half of the 19th century. After lengthy preparations, the integrated hydrologic (hydrographic) service was organised in 1886, when the Hydrographic Division was founded as the second after the first similar institution in France. The tasks of the new service included, among others, the improvement of flood forecasting. The National Water Reporting Service has issued forecasts on the height and time of flood peaks since 1892. The Daily Flow Regime Chart has been published continuously since 1895.

The National Meteorological Service generates meteorological warnings. These warnings reach Regional Environmental and Water Management Directorates (KÖVIZIGs) by means of Water management Information System via the Central Water and Environmental Directorate (VKKI) Preparedness Unit or the National Hydrological Forecasting Service (NHFS-VITUKI) or directly. Generation of hydrological warnings is the primary responsibility of district water authorities however any agency (NHFS etc.) receiving information indicating the necessity of flood warning or flood alert should act with no time delay.

Regular (daily) hydrological forecast for the Danube River and main tributaries are issued by NHFS-VITUKI. The conceptual modularly structured GAPI/TAPI modelling system is in use containing rainfall- runoff (with snow accumulation and ablation, soil frost sub-modules); channel routing; statistical updating; and simplified hydraulic - backwater modules. Forecasting of flood crests is the responsibility of the agency named by Rules of Hydrometeorological Activity during floods - VKKI Directive. As a principle the territorially competent water authority is named as responsible. Different versions of multiple (linear) regression models are in use. The practice of forecasting allows some overlaps between district water authorities of neighbouring river reaches and NHFS-VITUKI issued forecasts. Finalisation and publishing forecast products is subject to comparison and negotiations in-between different actors.

Results of EFAS are also incorporated into the daily operation of the NHFS-VITUKI.

For more efficient operative flood defence Hrvatske vode has established a system of on-line monitoring stations. Today, on line data system consists of 103 automatic stations in **Croatia**. 6 of them are in the Danube river basin (1 upstream the Drava mouth and 5 downstream). The real-time monitored water levels can be found on the website http://www.voda.hr or at the same address when using "wap" mobile phones as well as on the teletext of Croatian Television (HTV).

Data on water level obtained from field stations are used for the preparation of forecasts of arrival, propagation, and transformation of a flood wave.

Systematic forecasting of water levels and flows in the Drava and Danube River Basins basin is conducted by Hrvatske vode at the majority of water gauge profiles in the Danube River, which are relevant for the implementation of flood defence measures under the National Flood Defence Plan.

2.1.5. Institutional and legal framework

Waters in Austria lie within the competency of the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). However, the Danube and also the March and the Thaya are exceptions to this rule. These waters lie within the sphere of competency of the Federal Ministry of Transport, Innovation and Technology (BMVIT).

The protective hydraulic engineering within the catchment area can be subdivided into the spheres of competence of the Federal Hydraulic Engineering Administration (BMLFUW[2]), the ViaDonau (BMVIT[3]) and the Forest Engineering Service in Torrent and Avalanche Control (BMLFUW).

The framework for coordination of the land use and spatial planning with flood protection generates the Water Act in the Slovak Republic (Act Nr. 364/2004). This Act defines the notion of the floodplains and principles of their determination and approval. The area of floodplain is suggested by the administrator of watercourse and proposal is submitted to the competent water law state authority. The state authority makes the decision about the proposal of the floodplain area and afterwards the map of floodplain to the territorially relevant building bureau. The Flood Protection Act (Act Nr. 666/2004) contains the rules for permitted activities in the floodplains. The Flood Protection Act and connected bylaws will be amended (2009) in order to achieve accordance with the Directive 2007/60/EC. Regulations for activities in the floodplains are stricter in the ongoing proposal of the amended law.

The Water Act and the Flood Protection Act create a legal framework for regulation of activities in the territories that are endangered by floods only. Neither from them has power to order the modification of the land use or change of spatial plans.

Owing to the particular physico-geographic and hydrographic situation, the Hungarian state is obliged to take a responsibility considerably higher than in the majority of the EU member states in controlling water born damages and in improving the structural measures thereof.

Under the provisions of the law LVII of 1995 on water management, in flood basins with more than two communities flood control is a function of the state and the defences are owned by the state. The locally competent KÖVIZIG is responsible for managing and maintaining these defences.

The territory of the country is divided on the basis of the catchment principle into twelve districts, which form hydrographic units, with a KÖVIZIG competent in each.

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[2] Translator's note: German acronym for Federal Ministry of Agriculture, Forestry, Environment and Water Management

[3] Translator's note: German acronym for Federal Ministry for Transport, Innovation and Technology

Legislation, policy and strategy of the water management are set by the KVVM, while operative control of the KÖVIZIGs is provided by the VKKI. The local functions are performed by the KÖVIZIGs.

The Minister of KVVM controls the technical functions of flood fighting with support by the National Technical Co-ordinating Body as long as the workforce and resources of the SWS can control the emergency situation.

In emergency situations, which extend to large regions where several KÖVIZIGs are no more capable of handling, national control is taken over by the government commissioner.

The commissioner is the Minister of KVVM. To perform all defence activities in such emergency situations, he is vested with powers to draw on the labour of the population, further on the equipment, tools, materials, machines and vehicles of economic organizations, following the rules laid down in the National Flood Emergency Mobilization and Cooperation Plans. In cases where the public workforce is inadequate, he is authorized to resort by the intermediary of the Minister of Defence as well as the Minister of Interior to the units and equipment of the military, the civil defence and the police as well. The state secretaries of cooperating ministries implement administrative tasks of emergency operations.

In exceptional cases of emergency, like an impending national disaster, supreme control is taken over by a Governmental Co-ordinator Committee, the members of which are the administrative state secretaries of the sectors involved in flood fighting. The GCC is a decision preparatory organism to the government. Power it exercised through the government commissioner.

In conclusion mention must also be made of the organization of local damage control, which is a responsibility of the municipalities. Local damage control is understood as mitigation of effects of intensive local rainfall that might cause inundations in the deepest parts of a community, mitigation of effects of the flood of small torrential streams crossing villages not protected by embankments, and similar, local problems. The tasks involved being of local importance, the organization is founded on the local government structure of the various communities. The head of the defence organization is the mayor, who is free to request in cases of emergency technical assistance from the KÖVIZIG competent in the area.

Flood protection in the Republic of Croatia has been regulated under the Water Act and the Water Management Financing Act. The competent bodies for flood protection issues are: the Ministry of Regional Development, Forestry and Water Management as a state administration body and Hrvatske vode as a state agency.

The roof state-level Water Management document, the implementation of which is provided for under the Water Act, is the Water Management Strategy which is prepared by Hrvatske vode and adopted by the Croatian Parliament. It is a long-term planning document which is systematically harmonized with changes occurring in the water system and socio-economic development, and is also mutually harmonized with the National Physical Planning Strategy, Environmental Protection Strategy, the state-level forest management planning documents and the planning documents of inland navigation system development.

The basic aim of the Water Management Strategy is the establishment of an integrated and coordinated water regime on the national territory, which includes the following:

- Provision of sufficient quantities of drinking water of adequate quality to the population,
- Provision of the required quantities of water of adequate quality for various economic purposes,
- Protection of people and assets against floods and other adverse effects of water,
- Protection and improvement of the status of water and of aquatic and waterdependant ecosystems.

The UN/ECE Guidelines on Sustainable Flood Prevention, the principles of EFD and Action Programme for Sustainable Flood Protection in the Danube River Basin are included in the Water Management Strategy.

For an efficient and a feasible implementation the cooperation of all the authorities is required and thereby the coordination of particular sector policies: Nature Protection, Regional Planning, Agriculture, Traffic and Urban Development. As far as the watercourses across the border are concerned, the cooperation of all the countries in the river basin is required in order to coordinate the national policies and strategies and to elaborate coordinated operational plans.

2.1.6. Recent awareness of flooding

The largest catastrophic historical flood at the Slovak section of the Danube occurred in 1501. This flood is documented with water marks in the Austrian river section. Return period of the flood is estimated to more than 1000 years. Other significant historical floods, which were usually connected with catastrophic consequences date back to 1572, 1594, 1598, 1670, 1682, 1787 (second largest historical flood with respect to water stages), 1850, 1853, 1876, 1899. Historical floods in the Slovak section of the Danube River were connected with flooding of extensive territory. The beginning of the construction of flood protection measures (dykes) dates back to the XIIIth century. Large floods were very frequently connected with the dyke breaches. Complex flood protection works in the territory of interest were realized in the XXth century. The most significant floods in that century occurred in 1920, 1923, 1954, 1965, 1975 and 1991. Especially, 1965 flood resulted in catastrophic consequences, because of dyke breaks and flooding of the huge territory (72 000 ha, 54 000 inhabitants evacuated from almost 50 affected municipalities). Large floods, together with other aspects (navigation, power production) initiated construction of the complex of hydraulic structures in Cunovo and Gabcikovo.

The 2002 flood was a record high flood in Budapest. Just four later the 2006 flood produced the highest ice free flood in Budapest; the present record. The 2006 flood has created a difficult situation on the lower stretch of the Danube and the lower stretch of the Tisza River because the flooding on both river happed at the same time and backed the water levels up resulting in delicate flood management situations in Serbia, Croatia and Hungary.

2.2. Review and assessment of the predictable long term developments

In **Austria**, and thus also in the Danube sub-basin of the Pannonian Central Danube, hazard prevention is given the highest priority. The identification and taking into consideration of hazard zones on watercourses is an important aim of the next few years. The targeted retention of floods in the catchment areas is likewise one of the main focuses of strategic action. To supplement these, technical protective measures will continue to be implemented and maintained, whereby passive flood protection measures are given priority over the active protective measures. The Austrian Hydraulic Engineering Assistance Act provides a basis for financing these measures.

In addition, the individual administrative offices of the federal hydraulic engineering administrations are making efforts to achieve greater cooperation with a wide variety of specialist fields (integrated flood management), particularly spatial planning and disaster control. In future, protective water management measures will require increased coordination with spatial planning in order to support and boost the effectiveness of the implemented measures in a target-oriented way. The respectively-prevailing general legal conditions form the basis for interdisciplinary cooperation.

The planning and implementation of protective water management measures in Lower Austria are oriented towards the Technical Guidelines for the Federal Hydraulic Engineering Administration (RIWA-T) 2006 and also the objectives, strategies and measures for flood protection established by the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

The strategic objectives set for the Danube sub-basin of the Pannonian Central Danube aim to achieve a combined approach. With regard to future measures, increasing efforts are being made to rapidly push ahead with the preservation as well as the expansion of natural retention areas, thereby pursuing the aim of reducing the discharge peaks to fit the structural capacity of the consistently regulated waters in the Danube sub-basin. As well as the maintenance and adaptation of existing protective structures, increased cooperation with spatial planning and disaster control departments is being speeded up, in accordance with the principle of integrated flood management. Discharge analyses, hazard zone maps, as well as a wide variety of measures for the prevention of hazards are intended to improve the protection of the population against the natural force of water.

The Danube in Vienna, together with its side channels the Neue Donau and Donaukanal, as well as the Wienfluss and the Liesing stream, represent the largest watercourses in the Austrian province of Vienna. As well as these, a large number of smaller watercourses are also being carefully supervised.

In Vienna, the main focus of attention with regard to flood protection is the maintenance and adaptation of the existing protective structures and systems.

Besides the ongoing maintenance and implementation of flood protection projects in the province of Burgenland, the main focus of protective water management here is the construction and maintenance of flood retention basins. The aim is to mitigate the impact of the flood wave and to thus cut down the flood discharge to fit the structural capacity of the waters by means of a targeted retention of the water masses in the catchment areas.

The existing objectives and strategies of protective water management in Styria have been set up in accordance with the principle of integrated flood management. Besides the ongoing maintenance of existing protective structures and facilities, the most important aspects are the combined approach, increased retention of the water masses arising in the catchment areas, hazard prevention through land-use planning measures, as well as public relations work concerning the essential strategic objectives and key activities. The implementation of these activities takes place on an ongoing basis within the framework of the work programmes.

The United Nations Framework Convention Climate Change (UNFCCC) was adopted and opened for signature at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The **Slovak** Republic ratified UNFCCC in 1994. The first preliminary scenarios of the climate change were elaborated in Slovakia in 1993. Totally nine General circulation models from four world climate centres have been utilized in Slovakia up to 2005. The most important are models CCCM 2000 and GISS 1998. The method of statistical downscaling is used in regional modification of the GCMs outputs. Climate scenarios are provided with regard to annual development of individual climate elements for certain time horizons. Climate change scenarios are developed for several elements, such as air temperature, atmospheric precipitation, global solar radiation, and air humidity. While temperature scenarios might be used for whole Slovakia, precipitation scenarios vary at individual stations by more than 10 %. Higher increase in precipitation is expected in the northern part in winter, while higher decrease in summer in the southern part of the territory of Slovakia.

The assessment of climate change impacts on the hydrological cycle is carried out based upon mathematical modelling of potential changes of the hydrological regime. The changes of the hydrological regime were assessed based upon hydrological balance models. A spatial model using GIS methods was developed to construct anticipated changes of long time average runoff. The relationship between average annual runoff, average annual precipitation and air temperature was assessed and the maps of changes in a long-time average precipitation were developed.

Adoption measures to mitigate negative impacts of the climate change are formulated generally only. It is due to the uncertainties of impact assessment. In addition, the political, social, ecological, economic and technological considerations are necessary. Currently, it is recommended to prefer decisions that decrease the risk of negative impacts of the climate change and in mean time, approaches towards the sustainable development should be applied. The latter includes integrated water resources management.

After the 1956 icy flood on the Danube the dykes have been strengthened. Especially the stretch downstream of Esztergom is particularly well protected because of the difference between the 1:100 year flood and the 1956 icy flood level, this later being the design level for

this stretch. In spite of these improvements there are still some locations where the standard is not met.

The protection of Komárom and Esztergom flood basins has been foreseen within the construction of the Gabcikovo-Nagymaros Hydropower Plant Project. When the construction stopped the development of the flood protection dykes (it was the dyke of the reservoir too) stopped as well. The protection of the three km long open floodplain in Budapest (Óbuda) has to be solved after the financing is solved and the public debate is concluded. There other location along the Danube and its tributaries where the strength of the dyke is not sufficient and also the freeboard doesn't meet the standard. The "Danube project" has been launched to solve the above mentioned problems.

For the development of the flood protection system in Croatia see Chapter 2.1.2.

3. TARGET SETTINGS

3.1. Regulation of land use and spatial planning

In many cases, floods first become a threat to human beings and their constructions due to ignorance or through spatial planning mistakes of the past. Particularly in the Alpine valleys of **Austria**, characterised by the low proportion of usable land to be found there, the problem of land utilisation pressure is aggravated immensely due to different interests, and is fiercely competing for space with the natural area. Ever more buildings and facilities are being constructed at locations with an existing risk potential. This has given rise to the call for modern spatial planning to incorporate more into its plans the threat posed by natural disasters, and to also designate space for natural areas, in addition to the many other spatial planning aspects. One of Austria's ten flood protection strategies is to ensure that the use of specific locations is regulated by spatial planning. Flood protection departments are strategically considering pushing ahead with further, closer cooperation between the spatial planning and the water management and flood protection departments, in order to keep areas in river basins free of buildings.

Water management has various planning instruments for safeguarding flood hazard areas and keeping them free of buildings; these instruments include the flood protection schemes, river development schemes, regional studies, general and detailed projects, as well as the identification of hazard zones by the Federal Hydraulic Engineering Administration.

Regional planning programmes as well as regional development programmes represent the general legal framework for spatial planning at the supra-local level for implementing measures to secure areas of land nationwide. Local development schemes and land utilisation plans are available as instruments at the local level.

The respective spatial and land-use planning acts passed by the individual provinces of Austria contain regulations which provide for the designation of areas of land threatened by natural hazards. Likewise, the building regulations of the provinces contain suitability criteria for constructions and building plots with regard to natural hazards. Here, hazard zone

mapping constitutes an important and valuable element for assessing the existing hazard situation.

Within the framework of hazard zone mapping, the Federal Hydraulic Engineering Administration identifies a wide variety of indicated and reserved areas, in order to draw attention to the threat of hazards and/or to safeguard areas for measures or for the upkeep of the flood protection system. However, as this is not legally stipulated in the land-use planning acts, no indicated and reserved spatial planning areas have been identified. The Federal Hydraulic Engineering Administration is, however, endeavouring to coordinate and cooperate more intensively with the technical discipline of land-use planning. The resulting synergic effects should make it easier to identify and to keep indicated and reserved zones free, thus increasing the effectiveness of flood protection measures. Flood plains must be clearly shown on the land utilisation plan.

In Austria, hazard zone maps are drawn up either by the Federal Hydraulic Engineering Administration or the Forest Engineering Service in Torrent and Avalanche Control, depending on their respective spheres of authority. The hazard zone maps are technical plans which show not only those zones at risk from natural disasters, but also areas which must be kept clear for protective measures or a special kind of area management. They serve as the basis for alarm plans, and also for planning, the development of projects and experts' reports. Hazard zone maps must show the type and extent of the hazards at the onset of the design event (flood discharge occurring statistically every 100 years), while taking into account the bed load and driftwood carried in the discharge). Furthermore, they must also show the hazard zone in the event that the design event is overstepped up to $HQ_{300,}$ as well as the resulting failure of protective hydraulic engineering systems. Based on the consequences of a wide variety of potential dangers, hazard zones to which various directives and prohibitions are linked are identified by the relevant administrative office.

As well as hazard zone mapping, there are also discharge analyses. Discharge analyses are expert reports which describe the flood discharge area in the case of specific occurrences of flooding (mainly HQ_{30}, HQ_{100} and HQ_{300}) and which must be taken into account in official approval procedures. The flood discharge area of a flood statistically occurring every 300 years, which is presented from the year 2005, shows areas of residual risk which serve as a basis for future spatial planning in the municipalities.

The results of the discharge analyses of the provinces of Syria and Lower Austria can be accessed online in the Digital Atlas for Styria or Lower Austria, thus making them accessible for interested members of the public.

River development schemes or water management and flood protection schemes are river-basin-related plans which contain flood protection aims and tasks based on the water situation. In addition, the river development schemes also deal with freshwater ecological issues.

3.1.1. Targets set by Austria:

- *Compilation and adaptation of flood hazard maps and flood risk maps*

- *Complete identification of all flood hazard zones*
- *Increased interdisciplinary cooperation between the individual specialisations*

3.1.2. Targets set by Slovakia:

- *Landscape development plans and spatial plans contain and respect flood hazard maps and flood risk maps.*
- *Limitations related to land use in flood prone areas are defined.*

3.1.3. Targets set by Hungary

- *Transposition of the EU Floods Directive into the Hungarian Water Act*
- *Preparation of flood risk maps*
- *Preparation of flood risk management plans*

3.1.4. Targets set by Croatia

- *Solve problems related to the water estate in order to prevent inappropriate exploitation of land required for proper functioning of the current water management systems, for their regular economic and technical maintenance, and for their development.*
- *Provide information of areas at risk to give input to spatial planning.*

3.2. Reactivation of former, or creation of new, retention and detention capacities

One of the ten strategies of flood protection in **Austria** is aimed at recognising the negative developments that are relevant to flooding, such as the loss of retention areas, and to implement suitable measures accordingly. As well as the meaningful and sustainable implementation of technical flood protection measures, and improved flood forecasting, the preservation, reactivation and creation of retention capacities may be regarded as a significant measure for improving flood safety levels in the future. In addition, these measures improve the ecological functioning of the waters, thus satisfying the requirements of the Water Framework Directive.

Ecological river engineering is increasingly becoming an integral component of protective hydraulic engineering. In order to cover the increased demand for land and to ensure the availability of land for both ecological and flood protection purposes, the hydraulic engineering administrations are increasingly endeavouring to purchase areas of land on the rivers and streams.

Technical flood protection measures usually separate watercourses from their natural retention and flood areas (alluvial forests, extensive agricultural areas and the like). Besides the resulting negative ecological consequences for the waters and their hinterland, this also creates an increase in the flood discharge and, therefore, a risk to downstream riparian. The experiences of past floods have shown that natural retention areas are often already full before the floodwater reaches its peak and therefore already ineffective at that point. The reactivation and enlargement of natural retention areas is therefore usually done in combination, to a greater or lesser extent, with technical construction measures, depending on the specific protective water management requirements.

According to the degree of construction, some watercourses in the Lower Austrian Danube sub-basin of the Pannonian Central Danube still have natural or semi-natural areas which function as flood retention areas. For example, about 20 hectares of natural retention areas with a retention volume of about 250,000 m³ are available on the Russbach stream. Yet extensive, wide-ranging agricultural areas, such as, for example, exist on the Leitha, the Triesting or the Schwechat, also contribute to mitigating the flood peak.

More extensive restructuring or revitalisation measures have been carried out on both the Mödlingbach and the Krottenbach streams in the Lower Austrian portion of the Danube sub-basin. Further measures are planned for the creation of natural retention areas or for widening the discharge cross-section. Thus, on the Donaugraben, about 10 hectares are being reconnected to the river area. In the course of protective water management building or maintenance measures, such as exist currently on the Mödlingbach stream, or within the framework of the implementation of the Water Framework Directive, smaller revitalisation and restructuring measures are being implemented on an ongoing basis.

Some of the watercourses of Vienna have already undergone restructuring and revitalisation measures, insofar as these are compatible with technical flood protection. The straightened Liesingbach stream has been revitalised along a 5.3 km-long sub-section. As well as removing the heavy flood control construction on the stream bed, and also making the bottom sills passable, the discharge profile has been widened with the aim of improving both the ecological functional integrity of the stream and flood protection.

On the Wienfluss too, a river which has undergone extremely heavy flood control construction, revitalisation measures have been implemented in the area of the Auhof retention basin. Due to the general protective water management conditions on the Wienfluss, the measures served rather to improve ecological potential than protective water management.

On the Lafnitz, a border river between Burgenland and Styria, it was possible to recover an area of about 200 hectares within the framework of one project and to transfer it to extensive management. Together with a further area of 600 hectares, which it has been possible to obtain, these areas are available for passive flood protection as potential flood plains in the event of flooding.

With the aim of strongly promoting natural water retention in water meadow areas and undeveloped valley areas, thus dealing with the flood risk at its root, it has already been possible to carry out restructuring, revitalisation and renaturation measures on some watercourses in Styria. More extensive measures in the catchment area of the Pannonian Central Danube have up to now been mainly carried out on the Lafnitz. Further measures are planned on both the Lafnitz and the Raab over the next few years. The urgent need for action regarding flood retention is being met here partially through the reactivation of natural flood retention capacities.

The implementation of projects for lengthening watercourses is a further objective or strategy with regard to natural flood retention.

3.2.1. Targets set by Austria

- *Natural retention of floods in the catchment areas*
- *Protective water management, morphological and ecological improvements in the river bed*

3.2.2. Targets set by Slovakia

- *Water in every sub-basin is detained as long as possible - realization of non-structural measures within whole sub-basins in the forested and agricultural lands either.*
- *Provision of suitable tools for the retention of the water - water management reservoirs and polders.*
- *Provision of adequate space for flood waves routing in settled areas especially.*

3.2.3. Targets set by Hungary

- *Reactivation of former retention capacities*
- *Maintenance of existing retention capacities*

3.2.4. Targets set by Croatia

- *Preserve and improve retaining capacities*

3.3. Structural flood defences

Following the marked increase in the population in the 17th and 18th centuries, and the resulting shortage of space, settlements were also increasingly established in the flood-endangered valley-bottoms. As a result, the call for flood protection grew in the Alpine regions of **Austria**, with its partially very limited available space. In addition, the constantly-growing need for space and the basic protective water management requirements, which are subject to continual change, demand new strategies to achieve the aims of protective hydraulic engineering.

A fundamental aim of protective water management in Austria is the nationwide protection of areas of settlement and infrastructure facilities. The aim is for these areas to be adequately protected from floods that statistically occur every 100 years, while taking into account ecological compatibility, as well as the economic requirements. In Austrian protective water management, HQ_{100} represents a flood rate that is eligible for supportive measures. If flood protection is to be increasingly safeguarded through spatially-effective measures in the future as well, the technical flood protection of residential and industrial areas must continue to be one of Austria's flood protection strategies.

Regarding flood protection, most rivers and streams in Austria are equipped with technical flood protection measures. Most of these protective measures now only require selective widening and additional measures, as well as constant maintenance. Increasingly, the main focus of attention is now the maintenance of protective structures. Based on this, flood protection in Austria is undergoing a change. Besides the identification of hazard zones and areas of risk, the forecast and control of floods is also becoming more and more important.

Technical flood protection will increasingly include systems for controlling the flood wave, as well as selective protective measures (ring dams). Furthermore, due to changed general socio-political conditions, as well as legal requirements, such as the Water Framework Directive, for about three decades Austrian protective water management has again been increasingly paying heed to the ecological aspect of measures. Through activating existing natural flood discharge and retention areas, discharge capacity can be increased and damage prevented.

As a result of the agreement (in accordance with Article 15a of the Austrian Federal Constitutional Law[4]) between the Federal State of Austria and the provinces of Lower Austria, Upper Austria and Vienna concerning the scheme for flood protection in the area of the Austrian Danube, accelerated, efficient protective measures are being implemented to protect against future occurrences of flooding, in reaction to the consequences and experiences of the Danube flood in 2002.

The implementation of the agreed flood protection projects on the Danube requires special financing. In all, 420,300,000 million Euros will be invested up to the year 2015, of which half will be borne by the Federal State, a further 30 per cent by the provinces and the rest by stakeholders. Of this sum, 87,900,000 million euros (Vienna: € 76,800,000; Lower Austria: €11,100,000) are to be invested in the catchment area of the Pannonian Central Danube.

With regard to protective water management, the waters in the Danube sub-basin of the Pannonian Central Danube have undergone a considerable amount of structural development. Along major sections of the watercourses, areas of settlement and infrastructure are protected against a flood statistically occurring every 100 years. Many of the larger watercourses, such as the Russbach stream (47 km), the Leitha (40 km), the Schwarza (30 km), the Donaugraben (17 km) and the Schwechat (10 km) have embankments as flood protection.

As a result of the large amount of construction carried out on many watercourses, one of the main focuses of attention of flood protection is therefore the maintenance and enlargement of existing protective constructions. There is, to a greater or lesser extent, an urgent need for renovation in the case of about 98 of the total 122 embankment kilometres in the Lower Austrian sub-basin. The embankment structures are subject to a regular geotechnical inspection.

Further major flood protection measures are, however, in the planning or implementation phase, as is the case on the Laxenburger Entwässerungsrayon, the Triesting, the Piesting and the Schwarza. The strategic objectives give preference to measures for retention rather than clear linear flood protection measures.

There is an urgent need for action regarding flood protection in the area of Wolkersdorf (Russbach stream) and in the area of Korneuburg and Bisamberg (Donaugraben). The aim is to protect about 500 people on the Russbach stream and about 1,000 people on the Donaugraben by means of these protective measures.

[4] Bundesverfassungsgesetz

Besides the Danube and its side channels, the Donaukanal and Neue Donau, there are only two other large watercourses in the federal province of Vienna – namely, the Wienfluss and the Liesingbach stream. The watercourses in Vienna are, to the greatest possible extent, structurally equipped to offer a degree of protection capable of dealing with at least a flood statistically occurring every 100 years. Where this is not the case, the degree of protection is determined based on cost-benefit studies. There is also a flood protection priority programme.

Following several devastating floods in Vienna, flood protection today consists of a combination of several measures. In 1988, a new overflow watercourse (5,200 cubic metres, and 21.1 kilometres long) was created and, in combination with accompanying measures for Danube flood protection, designed for a total flood volume of 14,000 cubic metres per second.

Three weir plants represent an essential component of Danube flood protection. An intake structure regulates the dividing-up of the water volume between the main river and the Neue Donau in the event of flooding. The two other weir plants serve, *inter alia*, to regulate a mean static water level.

In addition, a system of embankments along tributaries and ring dams, extending from the Donaugraben to the Lobau (22.5 km on the right bank, 43.9 km on the left bank), also contributes to flood protection. The Wien Freudenau power station and the Stauraum Wien reservoir together also ensure additional flood protection on the Danube for Vienna.

With its Neue Donau floodway channel, the Danube possesses a degree of protection in the area of Vienna capable of dealing with a flood statistically occurring approximately every 10,000 years.

Heavy flood control construction on the Wienfluss in the metropolitan area of Vienna, combined with retention basins, constitutes Vienna's flood protection. In the city centre, the river displays a degree of protection capable of dealing with a flood statistically occurring every 1000 years. Outside the city, it is possible to guarantee protection against a flood statistically occurring every 100 years.

The Liesingbach stream flows through the city of Vienna along a length of 18.5 kilometres. In the urban areas, flood protection is designed to deal with a flood statistically occurring every 100 years. Agricultural areas outside the city are safeguarded against a flood statistically occurring every 30 years.

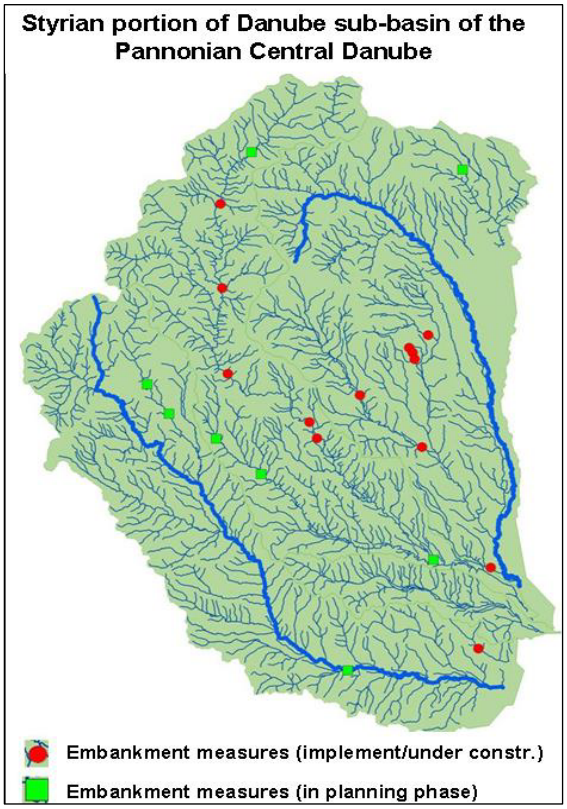
Flood protection in Burgenland is predominantly ensured by means of retention basins and retention areas, and therefore flood protection embankment measures are hardly ever implemented here. Besides technical measures, the other focus of protective water management is the compensation of the hydraulic effect (tractive force, discharge rate) through widening measures, optimising discharge areas and creating new retention areas. The maintenance of existing constructions and protective measures represents a further focus of protective water management.

With the exception of the Leitha, there are hardly any flood control dams or embankments on the watercourses in Burgenland. However, due to their age, the flood control constructions on the Leitha no longer match modern technological standards.

By the end of 2009, the need for action concerning protective water management on the Wulka will have been being fulfilled through the completion of the river development scheme. In the course of the river development scheme, discharge and retention area analyses are being carried out on the Wulka, while a scheme for flood protection embankment measures is also in process.

Over the past few years, it has been possible to complete technical flood protection embankment measures in the Styrian portion of the Danube sub-basin on the Feistritz, the Hühnerbach stream, the Lehenbach stream, the Minibach stream and the Pöllauer Saifen (see Figure on the right).

There is a further need for action regarding protective water management on the Feistritz, the Ilzbach stream, the Pinka, the Raab and the Weizbach stream, for which reason further protective measures are to be completed here by 2020.



It is estimated that approximately 8-10 million euros will be spent annually on future flood protection measures (embankment measures), in the province of Styria. About 30 per cent of this investment sum is to be spent on measures in the Danube sub-basin of the Pannonian Central Danube.

A further objective for the future course of action is the implementation of the Floods Directive.

Depending on the natural topological situation and general conditions, protective water management is endeavouring to ensure that flood protection will be increasingly safeguarded by area-effective and spatially-effective measures in the future. The occurrence of flooding can be effectively influenced by means of valley barrages, flood retention basins and natural lakes. Increased flood control potential will be developed here in the future, through the continual development of better forecasting models. Based on improved and forward-looking forecasting models, specific retention areas can be activated. In addition, technical possibilities and strategies for flood control enable the targeted mitigation of the flood peak flow.

In contrast to the provinces of Austria with an Alpine character, such as Tyrol or Vorarlberg, the morphological formation of the land (plain) in extensive parts of the Danube sub-basin of

the Pannonian Central Danube favours the creation and enlargement of retention areas and basins. The specialist protective water management departments of the individual provinces in the Danube sub-basin of the Pannonian Central Danube are therefore making efforts to achieve secure flood protection in the settlement and infrastructure area from a flood statistically occurring every 100 years by means of the current degree of construction on the waters, by means of measures to create and reactivate retention areas.

Besides the flood protection measures on the Danube already mentioned, which are in part also based on the retention of water masses arising during flooding, retention measures have also been implemented on the following two watercourses in particular.

In total, 7 retention basins, six on the Wienfluss (1,160,000 m³), as well as one on the Mauerbach stream (150,000 m³), are intended to guarantee flood protection on the Wienfluss in the area of Vienna. The Wientalstausee ("Vienna Valley Reservoir"), which is located upriver on the Wienfluss, constitutes another retention area with a retention volume of approx. 1,150,000 m³.

The Liesingbach stream, which extends for 18.5 kilometres along the metropolitan area of Vienna, is protected by three retention basins with a total retention potential of 300,000 cubic metres from overflowing its banks in the event of a flood statistically occurring every 100 years.

There is currently no need to implement any further flood retention measures in the federal province of Vienna, as adequate flood protection can be guaranteed.

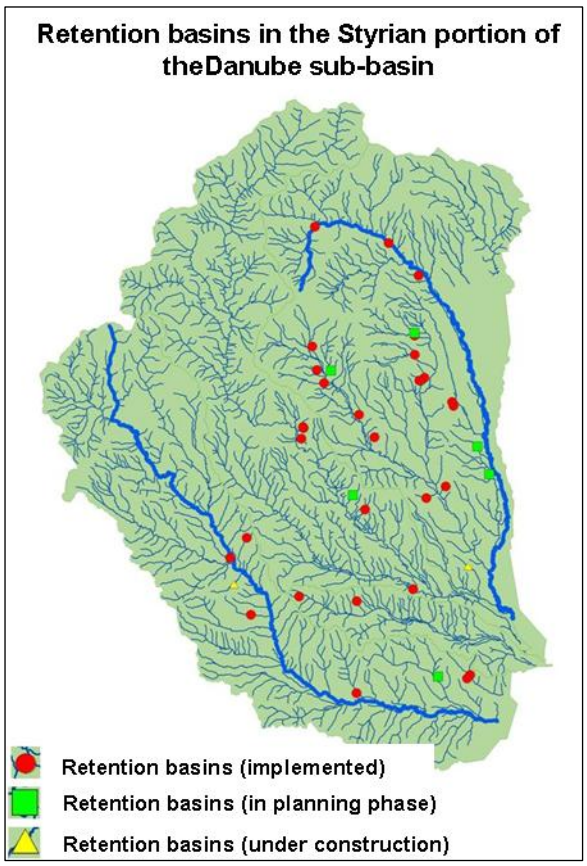
Over the past few years and decades, numerous retention measures have therefore been implemented in the Lower Austrian portion of the Danube sub-basin of the Pannonian Central Danube. For example, two technically-controlled retention basins with a total retention volume of 3.8 million m^3 contribute to flood retention on the Leitha. In the catchment area of the Zöbernbach stream, there are three large retention basins with a total retention potential of 424.500 m³. Two further retention basins on the Schwarza (256,000 m³), one on the Schwechat (300,000 m³) and a large number of smaller basins, ensure retention of the water masses and, thus, flood protection in Lower Austria.

In order to be able to implement and achieve the flood retention measures and objectives, investments for implementation are being estimated on an ongoing basis for the coming years. Further large retention basins are planned on the Triesting (100,000 m³), the Pitten (310,000 m³), on the Russbach stream (200,000 m³) and the Leitha (1 million m³), as well as in the catchment area of the Schwarza (65,000 m³). The implementation of these retention basins is a direct response to the protective water management need for flood retention that exists in the Danube sub-basin, particularly on the Pitten, the Leitha, the Russbach stream, the Triesting and the Schwechat.

All major watercourses in the Styrian portion of the Danube sub-basin have a series of flood retention basins in their catchment areas. The majority of the 29 existing basins are designed to deal with a flood statistically occurring every 100 years. At present, two further basins are in the implementation phase and six more in the planning phase.

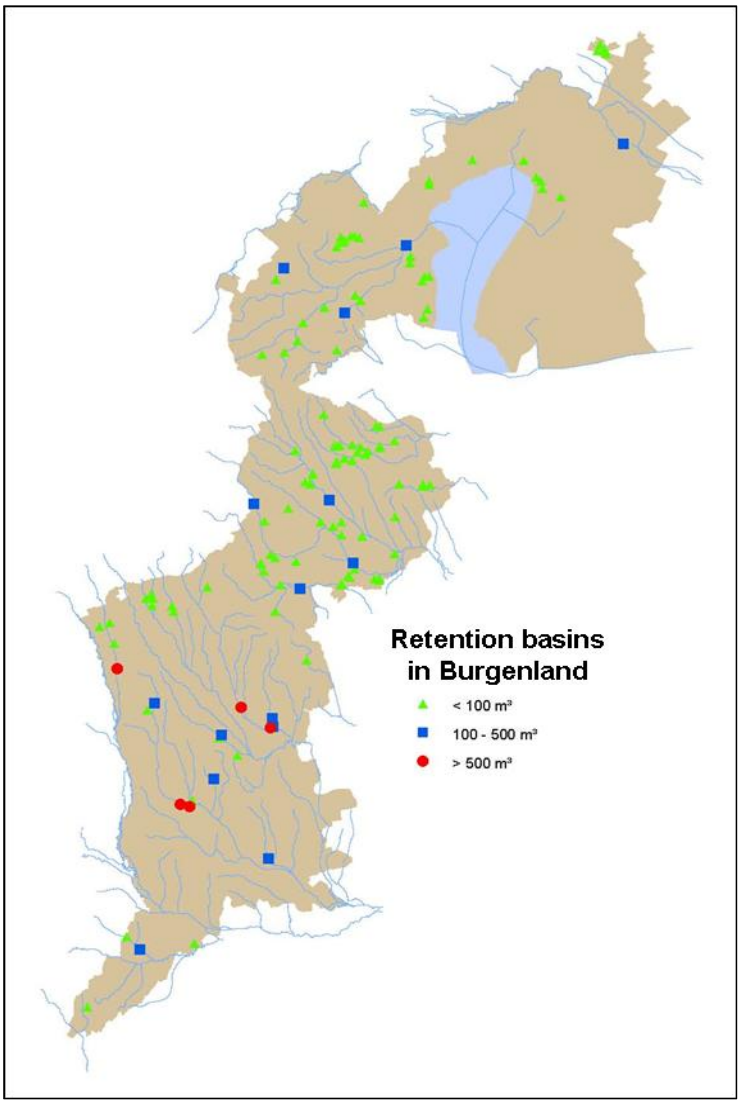
Of the total 37 retention basins, nine are in the catchment area of the Feistritz, seven in the catchment area of the Lafnitz, eight in the catchment area of the Raab and 13 in the catchment area of the Safen. Together, the retention basins already implemented or under construction have a retention potential of about 3.54 million m^3.

About 8-10 million Euros will be available for the implementation of future retention plants over the coming years. About 35 per cent of this investment sum is being invested in retention measures in the Danube sub-basin of the Pannonian Central Danube.



Technical flood protection in Burgenland focuses mainly on measures to retain the water masses. Therefore, over the past 10 years, about 100 million Euros has been invested in flood protection and, here, mainly in flood retention. Approx. 200 existing retention plants are intended to guarantee people's protection as well as their infrastructure facilities. Together, the retention plants have a total storage volume of approx. 10 million m^3.

Further retention basins are currently in the building or planning phase. For example, a major plant with approx. 400,000 m³ of retention volume in the catchment area of the Pinka is currently in the planning phase. In addition, a further potential 200 retention basins are going through the preliminary planning phase. Within the framework of the project planning, both the effectiveness and the degree of protection of each project is placed in relation to the volume of investment required. In this way, it is possible to allocate a protective effectiveness to each implemented measure that is adjusted to the specific need for protection.



There is an urgent need for action regarding flood retention in Burgenland, particularly on the waters of the Wulka, Zickenbach and Staberbach streams.

Some of the existing retention basins in the Danube sub-basin area of the Pannonian Central Danube have been designed to be controllable. Located above settlements, these facilities reveal their high degree of effectiveness during major floods, thus ensuring that at least an HQ_{100} flood can be diverted without damage.

For example, the targeted flood control of the Auhof retention basin on the Wienfluss is based on a flood forecasting model. The two large retention basins Lichtenwörth (2.2 million m³) and Katzelsdorf (1.7 million m³) on the Leitha likewise have technical facilities for the targeted control of flood retention in the event of disaster. The calculation of how the water volumes would be divided up between the retention areas is carried out by means of 2D hydraulic discharge models.

The foundation for effective and sustainable flood protection on the rivers is laid through carrying out appropriate measures in the catchment areas of the torrents and smaller tributaries. The following Section therefore deals with the strategies and measures for flood protection on the torrents lying within the sphere of competence of the Forest Engineering Service in Torrent and Avalanche Control (WLV) in the Danube sub-basin of the Pannonian Central Danube.

The Vienna, Lower Austria and Burgenland Section of the Forest Engineering Service in Torrent and Avalanche Control takes care of 2,356 torrent catchment areas. Most of the torrents pose potential hazards for areas of settlement and infrastructure. About 730 of the supervised torrents have already undergone protective measures (Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2008).

With regard to strategies, the Vienna, Lower Austria and Burgenland Section of the Forest Engineering Service in Torrent and Avalanche Control focuses on the professional execution of its core competences. These include the following six fields of activity: consulting services, expert services, hazard zone mapping, the planning and implementation of measures and the arrangement of subsidies. A further strategic aim is the continued ordering of priorities adapted to the specific need and the hazard situation. Another special focus is public relations work, with the aim of risk dialogue and the raising of public awareness.

Whereas construction activities used to be the main focus, nowadays preventive protection is gaining ever more importance through the creation of hazard zone maps and the involvement of flood experts within the framework of official procedures.

Within the framework of construction and maintenance activities, particular consideration is given to the requirements of the Water Framework Directive. In addition, the Torrent and Avalanche Control Section is making efforts to achieve a continuous alignment and coordination with the Federal Hydraulic Engineering Administration responsible for the downstream riparians and with the Via Donau waterway management company.

About 90 per cent of the available financial resources of the Vienna, Lower Austria and Burgenland Section of Torrent and Avalanche Control are invested in measures to protect against torrents. The Section thereby has between 8 and 9 million euros annually at its disposal for flood protection measures. Its building activities increasingly include measures for maintaining existing constructions. In addition, flood protection measures are continually being implemented, according to need and urgency. The effectiveness and the degree of protection of these projects is placed in relation to the necessary investment volumes in order to thus be able to allocate to all implemented measures a protective effect which matches the specific need for protection.

About 407 municipalities located within the sphere of competence of the Vienna, Lower Austria and Burgenland Section of Torrent and Avalanche Control need hazard zone mapping (BMLFUW[5], 2008). Within the sphere of competence of the Vienna, Lower Austria and Burgenland Section, the rate of meeting hazard zone mapping targets is, on average, about 60 per cent. However, the trend is dramatically increasing. The aim is to achieve blanket hazard zone mapping of all the settlement-relevant areas lying within the sphere of competence of the Section by 2011. Hazard zone mapping has proved to be an effective instrument, as during the mapping process it has been possible to locate existing hazards before they could cause actual damage.

Within the framework of hazard zone mapping, Torrent and Avalanche Control is endeavouring to identify indicated and reserved spatial planning areas (blue, brown and violet

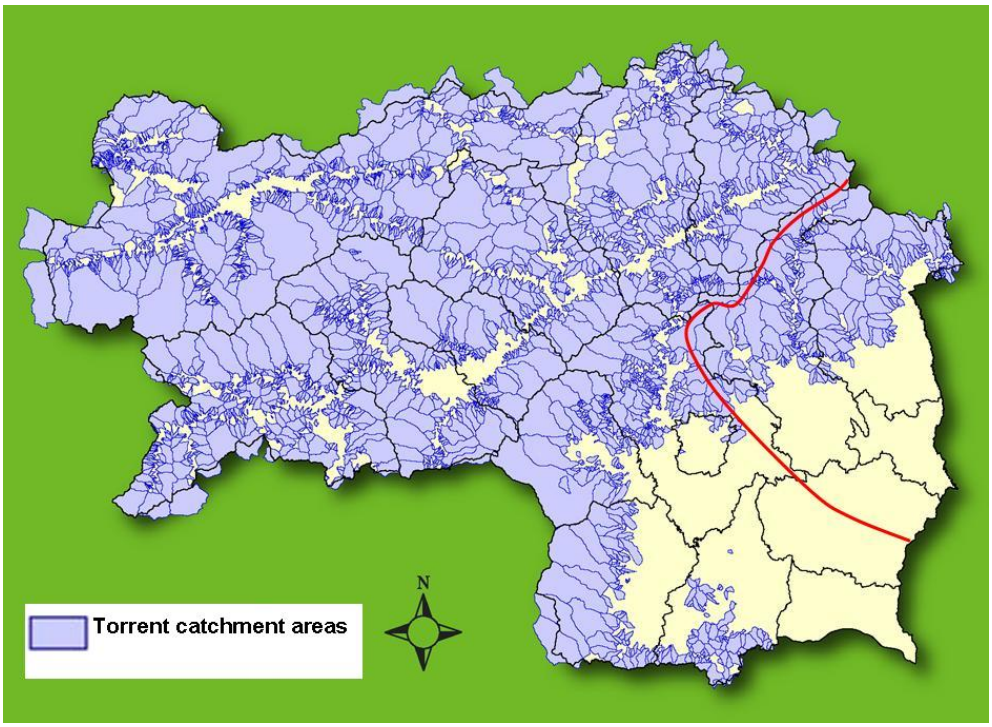
[5] Translator's note: German acronym for Federal Ministry of Agriculture, Forestry, Environment

areas). In this way, existing hazards are indicated and also important areas are kept free for further protective measures. In this endeavour, the foundation for sustainable flood protection is to be found in the catchment areas of the torrents, which are often characterised by their limited available area.

With regard to flood retention, no major retention measures have up to now been implemented within the sphere of competence of the Vienna, Lower Austria and Burgenland Section of Torrent and Avalanche Control. The retentive effects of the existing facilities hardly extend beyond local conditions.

In Styria, about 3,089 torrents lie within the sphere of competence of the Forest Engineering Service in Torrent and Avalanche Control. Here too, the majority of the torrents present potential dangers for settlement and infrastructure areas. Currently, there are already protective measures on about a third of the torrents under supervision (BMLFUW, 2008).

The districts of Bad Radkersburg, Feldbach and Fürstenfeld are not included within the sphere of competence of the Styrian Section, whereby the two latter districts extend over the southernmost portion of the Danube sub-basins of the Pannonian Central Danube in Austria.



9. Figure Torrent catchment areas of the Forest Engineering Service in Torrent and Avalanche Control in Styria (Image: Styrian Section of Torrent and Avalanche Control)

The Styrian Section has set itself a main strategic focus regarding flood retention. The aim is that flood retention in the catchment areas should increase and improve the protection of settlement and infrastructure areas against natural hazards.

The field of activity involving bed load management includes a further strategic objective. By means of a wide variety of activities, such as area management measures, the construction of bed load retention basins and the use of debris flow barriers and debris retention basins, the potential dangers are already mitigated in the catchment area.

A further protective strategy deals with the prevailing problem of dead wood and driftwood. It is not the bed load carried by the torrents, but their load of dead wood which mainly results in log jams and the resulting potential dangers. Area management measures in the catchment area, such as afforestation measures or protection forest structuring measures, serve on the one hand to reduce the volume of dead wood and, on the other, to stabilise (bed load management) the markedly Alpine-type catchment areas. Additionally, through taking care of the waters, the discharge areas are kept free of driftwood. Furthermore, construction measures for retaining not only dead wood but also bed load (barriers for holding back dead wood) are increasingly being implemented on the torrents.

In terms of implementing the Water Framework Directive of the European Union, one objective of the Forest Engineering Service in Torrent and Avalanche Control is to dismantle impassable obstacles within the framework of current protective projects.

The Styrian Section invests about 15 to 16 million euros annually in its work programmes. The monetary value of this sum is guaranteed, and therefore an amount at least equal to this will also be available over the coming years.

With regard to flood protection, the Forest Engineering Service in Torrent and Avalanche Control is pursuing the aim of designing the channel to provide adequate flood protection and/or to preserve it by means of flood retention. Currently, the main area of focus of Torrent and Avalanche Control in the Danube sub-basin of the Pannonian Central Danube lies in the Upper Feistritz Valley (catchment area of the Feistritz) in the district of Weiz. The aim is to safeguard the affected region by means of solid bed-load-retaining constructions and regulatory flood protection measures.

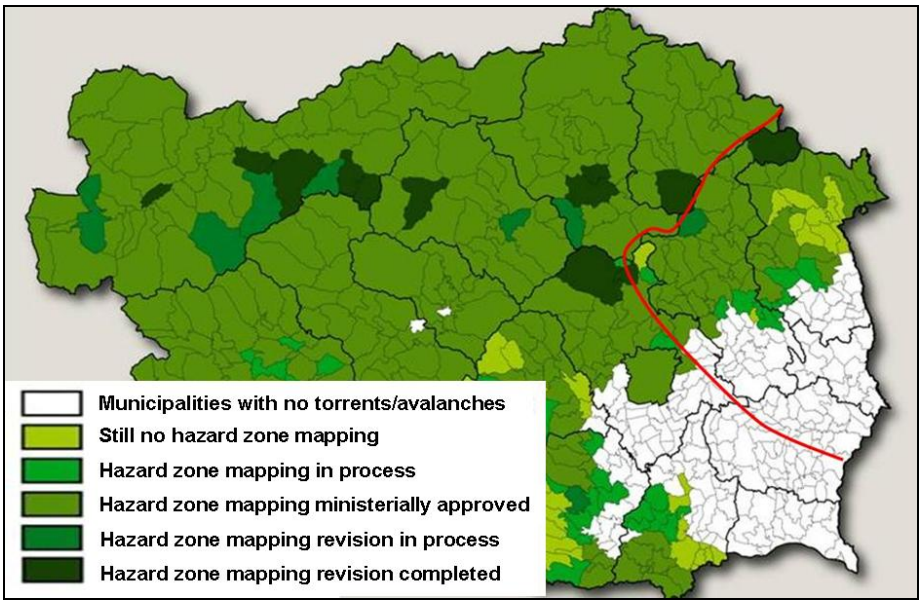
As the Forest Engineering Service in Torrent and Avalanche Control has already been implementing measures to protect against natural hazards for the past 125 years, the proportion of maintenance and supervision work is increasing in relation to construction measures. The adaptation of old projects is also being carried out in the course of maintenance. Based on improved technical implementation options, these projects are complemented by means of retention areas for bed load and debris flows. The documentation of occurrences and the provision of proof regarding protective effectiveness together form a significant part of sustainable flood protection. The documentation and analysis of flood occurrences constitutes a useful instrument for learning from experiences of disasters and, where necessary, adapting structures accordingly.

The settlement of hazard areas has heavily increased over the past few decades. In addition, the consequences of climate change and its influence on disastrous events to come are difficult to estimate. The Forest Engineering Service in Torrent and Avalanche Control has therefore already been pursuing a strategy of preventive protection against natural hazards, through drawing up hazard zone maps.

The Styrian Section of Torrent and Avalanche Control has already drawn up a ministerially-approved series of hazard zone maps for 290 of the total 342 relevant municipalities in Styria. In Upper Styria, the set objective of blanket-coverage hazard zone mapping of the

geographically-relevant areas was already achieved years ago. Over the coming years, these hazard zone maps will undergo revision (changed bases and methods, increased degree of protection). At present, hazard zone maps are increasingly being compiled in the Danube sub-basin of the Pannonian Central Danube (districts of Hartberg and Weiz). By 2010, the hazard zone mapping process will have been concluded in all the 342 affected municipalities of Styria lying within the sphere of competency of Torrent and Avalanche Control.

Since 2008, the hazard zone maps of Styria have been available to the public online, via the digital GIS Atlas of the province. In addition, in the event of disaster, operational command can rapidly and easily access the hazard zone maps via the disaster control server of the province of Styria.



10. Figure Current status of hazard zone mapping by the Forest Engineering Service in Torrent and Avalanche Control in Styria (Image: Styrian Section of Torrent and Avalanche Control)

As has already been described in the section on Vienna, Lower Austria and Burgenland, reserved and indicated areas are identified within the framework of hazard zone mapping. In terms of a long-term safe, future-oriented utilisation of the landscape and of settlement areas, there is a strategy to increase the usage of the large body of information gained through the instrument of hazard zone planning. As the interaction between water management and land-use planning represents an important key for minimising flood damage, cooperation with spatial planning has been intensified by means of the "Programme for the floodproof development of settlement areas in Styria". The focus of this programme is to find and consistently apply land-use planning fields of action in order to minimise risk in the event of future occurrences of flooding.

In 2008, an information brochure for all municipalities and their spatial planners was produced jointly with the Association of Towns and Municipalities. The aim of the brochure is to provide information on water-related natural hazards, as well as on the need to take them into account in the building and land-use planning process.

One of the strategic objectives of the Styrian Section is the implementation of measures for flood retention in the catchment areas of the torrents. The aim is to already hold back the

water masses as they arise in the catchment area. On the one hand, this makes it possible to ensure flood protection for downstream riparians, while on the other reducing the need for cost-intensive measures and also for flood control embankment measures, which affect the state of the waters.

There are currently about 20 flood retention basins within the sphere of competence of the Styrian Section. Two more are under construction, and five basins are at present in the planning phase. Due to the morphological conditions, the Torrent and Avalanche Control basins mostly have an average volume in the region of 10,000 to 50,000 m³. The retention basin on the Waisenbach stream, a tributary of the Feistritz, is one of the few exceptions here, with a retention potential of 383,000 m³.

Within the framework of a pre-project, a series of smaller potential retention basins are currently undergoing a feasibility study. As well as the morphological conditions, land availability or land provision pose particular problems in implementing such measures. About 3 and 4 million euros are invested annually in the implementation and maintenance of retention basins in the Styrian Section.

3.3.1. Targets set by Austria

- *To ensure adequate flood protection for the relevant settlement and infrastructure areas*
- *Protection and management of natural hazards on the torrents*
- *Flood protection by means of area-and-space-effective measures*

3.3.2. Targets set by Slovakia

- *Maintenance of existing retention volumes (removal of sediments) in reservoirs and polders.*
- *Design and construction of reservoirs with flood retention volume and polders.*
- *River training works in urban areas and rural municipalities.*
- *Reconstruction of the trained stretches in the towns and villages in order to achieve sufficient discharge capacity.*
- *Removal of obstacles in the channels, like bridges of insufficient flow capacity, improperly designed culverts and other barriers.*
- *Realization of ordinary maintenance in trained river stretches.*
- *Design and construction of measures to decrease erosion and to increase water retention in the river basins (trenches, ditches, canals, etc.)*
- *Torrents regulation in the mountainous areas.*

3.3.3. Targets set by Hungary

- *Improvement of present flood protection structures to meet the existing safety standards*
- *Removing bottlenecks*

3.3.4. Targets set by Croatia

- *Achieve the 100-percent functionality of flood protection systems by the end of 2038*

3.4. Non-structural measures (preventive actions, capacity building of professionals, raising awareness and preparedness of general public)

In **Austria**, the flood protection strategies envisage measures to improve flood warning and forecasting, thereby preventing or reducing potential damage. The *Chapter 2.1.4* offers an overview of the current status of flood forecasting and flood warning in Austria, and in the Danube sub-basin of the Pannonian Central Danube.

The Hydrographic Service runs a basic network of observation points in Austria, to document and process the most important components in the hydrological cycle, and if necessary to be able to rapidly implement measures. This space and time-related data is displayed by means of a Geographic Information System (GIS) and can be accessed at any time.

The basic network of the Hydrographic Service consists of 950 precipitation gauges, 750 snow-depth gauges and 586 air temperature gauges. In addition, there are 800 water-level gauges, 600 discharge gauges and 210 water temperature gauges throughout Austrian territory. Of these, the Hydrological Services in Austria have 221 remote interrogation or transmitting stations at their disposal. GSM gauges (Groupe Spécial Mobile; mobile phone systems) currently represent cutting-edge technology. The collected hydrographic data is managed through a standardised Hydrographic Data Management System (HyDaMS) and can be accessed via the GIS application eHYD.

The precondition for establishing the flood forecasting system for Lower Austria is the further development of the network of telecommunicating gauges. The real-time hydrological data serves as a basis for appraising the situation.

Within the Danube sub-basin of the Pannonian Central Danube, the Hydrographic Service has at its disposal 80 precipitation, air temperature and evaporation gauges, which have remote transmission, as well as 43 surface water and solids gauges, which have remote transmission. In addition, there are 2 further surface water and solids gauges, as well as 17 precipitation, air temperature and evaporation gauges in the metropolitan area of Vienna.

Of the total 103 surface water and solids gauges and 187 precipitation, air temperature and evaporation gauges in the Danube sub-basin of the Pannonian Central Danube, the Hydrographic Service of Burgenland has about 40 surface water and solids gauges and 65 precipitation, air temperature and evaporation gauges at its disposal.

The Hydrographic Service of Styria can currently access 157 surface water and solids gauges, of which 4 are equipped with staff gauges, 30 with recording strips and 123 with data collectors. Of these gauging stations, 33 are designed to be able to telecommunicate or be remotely interrogated. Of these, 18 gauges are in operation in the Danube sub-basin of the Pannonian Central Danube.

For measuring precipitation, the Hydrographic Service has 186 precipitation, air temperature and evaporation gauges at its disposal throughout Styria. Of these stations, a total of 87 are already equipped with digital data collectors, 71 of which can telecommunicate. 25 of these gauges are located in the Danube sub-basin of the Pannonian Central Danube.

The further expansion as well as concentration of the existing gauge network over the next few years is one of the objectives of the Hydrographic Service of Styria.

The flood news services represent the basic precondition for smoothly-functioning flood risk management. When issued at an early stage, advance warnings make it possible to carry out preventive measures in time. For this purpose, the Offices of the Regional Governments in Austria must, commensurate with their responsibility, set up news services in the event of flooding, in accordance with the Water Rights Act. Any announcements will immediately be passed on to the regional warning centres and other emergency services.

The regional Hydrographic Services of the Federal Hydraulic Engineering Administration provide information concerning the current precipitation and discharge values at the individual gauging stations in the region to all interested citizens, free of charge, by telephone, teletext and via the homepages of the regional governments. The discharge situation on the larger rivers, subdivided into flood danger levels, can likewise be accessed at the Hydrographic Service at any time. For example, the following diagram shows the gauge data from an online-accessible discharge gauging station of the Regional Hydrographic Service of the Federal Hydraulic Engineering Administration in Lower Austria.

The flood warning systems of the provinces are based on close cooperation between Hydrography and the Central Institute for Meteorology and Geodynamics. The torrential rain forecasts and torrential rain warnings issued by the Central Institute for Meteorology and Geodynamics meteorological service are analysed by the Hydrographic Service. A flood standby service is set up whenever the Central Institute for Meteorology and Geodynamics (ZAMG) warns of heavy precipitation (> 30 mm/d). If occasion demands, the Hydrographic Service also sets up a water-level news service at short notice. Activation in the event of flooding then takes place once the flood signal marker (~ HQ_{1-2}) has been reached at one of the telecommunicating water gauging stations. In addition, the Hydrographic Services in Austria function as a hub for all the information and data. Based on these, flood warnings are, if necessary, issued for the affected regions.

The flood news services in Austria have set themselves the goal of developing and improving the information system further. This is to be done by means of automatic data gathering and data transmission, and also based on forecasting models in conformity with cutting-edge technology. Improved data material will thus be available for both the experts and citizens affected by flooding in the future to be able to quickly carry out the right decisions and measures in case of emergency.

Water knows no national borders. Therefore, decades ago Austria already concluded water agreements with its neighbouring states Germany, Slovakia, the Czech Republic, Hungary, Switzerland, Liechtenstein and Slovenia and has set up bilateral and multilateral water commissions (see the brochure “Flood Protection in Austria” Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2006). Sustainable flood protection that is fit

for the future can only be tackled in cooperation with the riparian states in the individual river basins, including active collaboration and the exchange of knowledge and strategies.

In order to speed up water management cooperation with neighbouring countries and to regulate water management relations, Austria has concluded "**water agreements**" with them. The work is conducted at the level of bilateral or multilateral **water commissions,** as well as at the level of local water management departments. Cooperation in the form of the "Austrian-Czech Boundary Waters Commission" as well as the "Austrian-Hungarian Boundary Waters Commission" is headed by the Federal Ministry of Agriculture, Forestry, Environment and Water Management. The main focuses of the work include the upkeep of the waters on the border as well as of the constructions built on them, flood protection measures and the organisation of a warning service for extraordinary water pollution incidents and for floods.

The Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) is making strenuous efforts to adequately inform the general public on the subject of floods, as well as their dangers and possibilities of flood prevention. The Austrian flood protection strategies envisage a furtherance of public knowledge and awareness of hazards. Another aim is to point out the limits of protection and the responsibility of those involved. The Federal Ministry therefore regularly publishes brochures and folders on the subject of flood protection, and makes them available to the public. Thus for example, in 2007 it published the brochure "The Force of Water – How to protect buildings adequately from floods and high groundwater levels", an issue that will still be dealt with in greater detail. The Hydraulic Engineering Administrations regularly organise a variety of informative events aimed at sensitising the general public to this issue. Furthermore, a wide variety of internet platforms set up by the authorities and organisations offer the opportunity to become adequately informed on the subject of flood protection.

The staff of the Federal Hydraulic Engineering Administration is extremely eager to conduct a lively exchange of information with the resident population, in order to draw people's attention to the risks and hazards caused by floods. In order to acquire well-founded expert knowledge on the subject of disaster control and awareness-raising, training sessions, for example expert disaster control conferences, municipal training in risk analysis or integrated training sessions in staff work and crisis communication, are regularly offered. In addition, exercises are regularly conducted.

The publications, brochures and folders of the BMLFUW[6] serve as the predominant information and illustrative material. However, within the framework of large-scale detailed planning projects, the designation of hazard zone maps and the setting-up of river development schemes, the Ministry also compiles its own, mostly river-specific brochures and folders.

In addition, a great deal of information and relevant reading materials are available for interested members of the public on the homepages of the provinces. For example, the latest water levels of watercourses can be continually accessed.

[6] Translator's note: German acronym for Federal Ministry of Agriculture, Forestry, Environment

In Styria, there has for some time been the option of viewing the hazard zone plans of the Forest Engineering Service in Torrent and Avalanche Control online, via the Civil Protection Server of the province. This is aimed at supporting the disaster control authorities in implementing preventive measures and precautions, as well as ensuring the targeted planning of emergency operations.

In several subzones, Flood Risk Zoning Austria is already fulfilling the requirements of the EU Directive on the assessment and management of flood risks. Flood Risk Zoning Austria is, in particular, fulfilling the requirement to provide more information to the portion of the population affected by flooding, both in general and specifically with regard to existing flood risk areas.

With its "Flood Risk Zoning Austria – HORA" project, the Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Association of Austrian Insurance Companies started a nationwide risk zoning system for natural disasters, particularly for floods. As well as promoting risk awareness, the aim of this measure is to highlight the limits of active protective measures and the need for the sensible utilisation of areas at risk of flooding. Valuable information on the current flood risk, based on digital hazard maps, can be accessed by every citizen via the internet. In addition, these risk maps also offer each Austrian citizen the basic possibility of assessing risk.

The Austrian flood protection strategies envisage measures to further expand emergency planning and disaster control in Austria. Based on the allocation of authority laid down in the Austrian Constitution, disaster control in Austria is the responsibility of the federal provinces. In the event of flooding, the relevant disaster control department determines operational command on the spot and supports the authority in combating the disaster. In case of emergency, the relevant regional warning centre of each province is entrusted with coordinating the crisis management of the local emergency services. During the disaster operation, the relevant district operational commands coordinate their work with one another at the regional level, as well as with the superordinate operational command.

However, a permanently-manned Federal Warning Centre is installed in Vienna for supra-regional and international disaster control. This centre is in constant contact with the regional warning centres, as well as other bodies both in Austria and abroad. In Austria, the Federal Ministry of the Interior is responsible for the government's crisis and disaster control management.

The respective regional laws (disaster control laws and emergency help laws), which *inter alia* provide for the creation of disaster control plans, constitute the legal bases for disaster control. In terms of target-oriented disaster management, the disaster control plans provide for an area analysis, the assessment of the potential dangers, the organisation and tasks of the individual emergency services as well as the disaster alarm plan.

The development of flood forecasting models on Austria's watercourses represents a fundamental step towards improving disaster management. The institutionalisation of closer cooperation between the hydrographic services and disaster control departments over the past few years has resulted in the targeted implementation of measures in the area of flood warning and forecasting. By means of the improved flood warning systems, it is possible to considerably reduce the potential damage caused by flooding. Based on the knowledge of

impending weather conditions, potential victims and disaster control organisations can be warned in time.

Protection from disasters is not only the responsibility of the public authorities, but is also the concern of every individual. In order to promote public risk awareness, and to give people information and instructions concerning flood protection and flood precautions, the Federal Ministry of Agriculture, Forestry, Environment and Water Management has issued a brochure entitled "The Force of Water – How to protect buildings adequately from floods and high groundwater levels".

The destructive effect of large-scale floods is also accompanied by the pollution of waters. Floods can therefore have far-reaching consequences for the environment. Liquid fuels which escape from storage tanks, damage to supply lines, industrial enterprises, sewage treatment and chemical plants or filling stations can lead to contamination or the loss of biological diversity in waters. Increased efforts must therefore be made by planners and executing bodies to prevent the contamination of waters in the event of disaster in the future. To achieve this, it is necessary for spatial planning to be integrated to a much greater extent into the protective water management planning process and for the legislator (building regulations) to make clear stipulations in this regard. The Ministry also offers the public valuable information with regard to floodproof building in its brochure "The Force of Water – How to protect buildings adequately from floods and high groundwater levels". The brochure explicitly goes into the floodproof design of heating systems, with the aim of preventing pollution of waters with heating oil later on. In addition, flood protection strategies in Austria aim to encourage citizens to take individual precautions by offering them good information and, if need be, suitable incentives.

In view of the threat of water pollution in the event of flooding, the Building Technique Ordinance of Lower Austria provides for special precautions and stipulations relating to the installation of storage containers for liquid fuels (heating oil).

In Austria, constructions such as new sewage plants or industrial workshops are basically built outside the inundation zones of floods that statistically occur every 100 years, and/or suitable structural precautions are taken to design the construction to be floodproof. This represents the primary foundation for preventing the pollution of waters in the event of flooding. When carrying out construction measures on watercourses in future, the Hydraulic Engineering Administrations will endeavour not to lay any more pipelines from which polluting emissions could escape in the event of disaster.

In Vienna, the storage and handling of water-contaminating substances (e.g.: heating oil, fuels) is inspected from the viewpoint of potential risk at both private plots of land as well as industrial undertakings. This inspection is carried out by officially-authorised experts in technical flood protection.

Information material regarding the problem of oil tanks which float up in the event of flooding is made available by the Regional Government of Burgenland. There are currently no legal stipulations covering this situation, so it is only possible to indicate or draw attention to this problem.

There are also at present no legal stipulations or methods of resolution concerning the problem of sewage treatment plants in a flood area.

The majority of sewage treatment plants in the catchment area are not situated in flood-endangered locations. In the event of a threat of flooding, any measures to reduce the risk are the responsibility of the plant operator applying for official approval.

3.4.1. Targets set by Austria

- *Optimisation and development of flood forecasting*
- *Optimisation of flood warning and the flood warning systems*
- *Promotion of the national and international exchange of knowledge between all the specialisations of integrated flood management*
- *Promotion of the knowledge and awareness of hazards*
- *Optimisation and development of disaster control and emergency planning*
- *Protection against disasters by means of preventive measures*
- *Prevention and mitigation of water pollution produced by flooding*

3.4.2. Targets set by Slovakia

- *Reduce flood risk*
- *Introduce principles of EU flood directive*
- *Build capacity of professionals and institutions responsible for flood management*
- *Upgrade flood monitoring, forecasting and warning services*
- *Introduce regulations for emergency situations response*
- *Prepare flood risk management plans*
- *Improve awareness of stakeholders on floods*
- *Update/build scientific base for flood management*
- *Improve international cooperation in flood management*
- *Improve information system on floods and flood risk management accessible to public*

3.4.3. Targets set by Hungary

- *Improvement of flood forecasting system*
- *Improvement of flood warning system*
- *Capacity building of professional staff*
- *Increase PR activity to raise awareness of general public*

3.4.4. Targets set by Croatia

- *Reduce flood damage risk*

- *Increase the efficiency of operative flood defence measures*
- *Increase the capacity building and raise the level of preparedness of organizations responsible for operative flood defence*
- *Build capacity of professionals and institutions responsible for flood management*
- *Introduce principles of EU flood directive*
- *Raise awareness and preparedness of the general public on sub-basin-wide and local scale*
- *Prevent and mitigate pollution of water caused by floods*

4. MEASURES TO ACHIEVE TARGETS

4.1. Regulation on land use and spatial planning

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
Austria						
1	Flood Risk Zoning Austria (HORA)	Prevention Raising Awareness	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)		Ongoing	To be worked out in cooperation with the Austrian Insurance Association. In certain sub-areas (informing the public, flood-endangered areas), this already corresponds to the EU Directive on the assessment and management of flood risks.
2	Adoption of the objectives and principles of the EU Floods Directive	Administration	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)			
3	Full-coverage identification on hazard zone maps in the relevant settlement and infrastructure areas. Flood Discharge Analyses	Hazard zone mapping	Administrative offices of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control (WLV) (both BMLFUW)		Ongoing until 2010 or 2020	Complete identification of all hazard zones in the sphere of competence of the Federal Hydraulic Engineering Administration will take place by 2020. Complete identification of all hazard zones in the sphere of competence of the Forest Engineering Service in Torrent and Avalanche Control will be completed by 2010.
4	Identification of reserved and indicated areas	Hazard zone mapping	Sections of the Forest Engineering Service in Torrent and Avalanche Control (WLV)		Ongoing	In this way, existing hazards are indicated and also important areas are kept free for further protective measures.

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
5	Promotion of closer interdisciplinary cooperation between protective water management, spatial planning, disaster control and the legislative process	Strategy	Federal government, provinces and municipalities Specialist departments		Ongoing	Efforts are being made not only to increasingly integrate the threat from natural disasters in the mapping process, but also to identify space for the natural area. Example: Flood Risk Study
6	Adaptation of laws, ordinances and directives to the claims and demands of protective water management.	Administration	Federal state, provinces		Ongoing	Spatial planning and land-use planning laws, building regulations, building technique ordinances
7	Assure suitably-adapted area utilisation through spatial planning. Coordinate planning projects carried out by the public authorities.	Strategy Protective water management land-use planning	Provinces (Lower Austria Land-Use Planning Law)		Ongoing	Land designation, land provision and protective water management instruments for keeping areas clear.
8	Identification of areas in need of protective water management in coordination with spatial development	Strategy Flood protection Raising awareness	• Provinces Specialist departments			Pilot project: Protective Water Management Spatial Development Plan Currently only exists for the province of Carinthia, though its extension to cover all Austria is under discussion.
Slovakia						
1	Transposition of EU Directive 2007/60/EC on the assessment and management of flood risks to the Slovak national Flood Protection Act	Legal	MoE SR			
2	Implementation of the Slovak national Flood Protection Act (i.e. also EU Directive 2007/60/EC on the assess-ment and management of flood risks)	Admin/Technical	MoE SR, SWME, SHMI, municipalities			
3	Introduction of flood maps into spatial plans of regions, districts, municipalities	Administrative	MoE SR, SWME, SHMI, EPDO, municipalities			

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
4	Application of Land use limitations introduced in spatial plans	Technical	EPDO, municipalities		continuous	
Hungary						
1	Modify the text of the Water Act to incorporate the aim of the EU Floods Directive	Administrative	VKKI, KvVM		2009	It is under way
2	Methodological development of flood hazard and risk mapping	Administrative	Consultants		2010	It is under way
	Data collection	Administrative	KÖVIZIGs[7]		2011	Projects under preparation
	Flood hazard mapping	Administrative	KÖVIZIGs and Consultants		2013	
	Flood risk mapping	Administrative	KÖVIZIGs and Consultants		2013	
3	Preparation of flood risk management plans	Administrative	KÖVIZIGs		2015	
Croatia						
1	drafting and adoption of regulations (criteria for identification, zoning of the terrain, and gradation of limitations restrictions in the use of the water estate)	Administrative	MRDFWM, HV, MEPPPC			
2	delineation of the water estate, entry into land registers and physical plans	Administrative	MRDFWM, HV, MEPPPC			
3	solving property-right relations to legalise flood protection structures (repurchase of real estate, getting location and construction permit)	Administrative	MRDFWM, HV, MEPPPC			

[7] Five KÖVIZIGs are dealing with the Hungarian stretch of the Danube

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
4	systematic monitoring of the status of ownership on the water estate.	Administrative	MRDFWM, HV, MEPPPC			
5	Preparation of relevant water management planning documents					
6	Introduction of flood risk maps and flood damage maps for the entire country, and their presentation to the interested public	Administrative	MRDFWM,HV, MC		uncertain	
7	Introduction of appropriate indicators and systematic monitoring of the efficiency of flood and erosion control measures	Administrative	MRDFWM,HV, MC		uncertain	
8	Preparation and systematic maintenance of: the Inventory of water bodies, water estate and water structures, the Inventory of extreme hydrologic phenomena (floods, storms and droughts), and the Inventory of the status of erosion and anti-erosion measures taken	Administrative	MRDFWM,HV DHMZ, HS		continuous	

4.2. Reactivation of former, or creation of new, retention and detention capacities

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
Austria						
1	Prevention of existing retention areas	Flood retention Strategy	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Targeted flood retention in the catchment areas. Passive flood protection takes priority over active flood protection.
2	Reactivation and creation of retention capacities	Flood retention Strategy	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Implementation by the Federal Hydraulic Engineering Administration and the Forest Engineering Service in Torrent and Avalanche Control.
3	Recognition of negative flood-relevant developments	Strategy Research	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)		Ongoing	
4	Implementation of protective water management, morphological and ecologically valuable measures in the riverbed (restructuring, revitalisation, renaturation)	Strategy Flood protection	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	
Slovakia						

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
1	Tighten the rules applied during giving permission for activities within whole sub-basin	Administrative/ legal	MoE SR, SWME, EPDO, municipalities		continuous	
2	Design and building of new polders, retention reservoirs	Technical	SWME, SHMI, municipalities			
3	Reassessment of rivers retention and detention capacities	Technical	MoE SR, SWME		continuous	
4	Updating and implementation of results of the study "The survey of water courses in towns and villages (SWME)".	Admin/Technical	SWME		continuous	
Hungary						
						No flood retention capacities exist or planned on the Danube due to the large discharge
Croatia						
1	Existing large lowland retention storage in the Danube river basin is preserved	Administrative	MRDFWM, HV		continuous	Nature Park Kopački rit
2	Design and construction of new mountain reservoir storages and/or lateral channel	Technical	MRDFWM, HV		started	
3	Introduction of renaturalization measures of preventive flood protection					
4	– Implementation of the Best Practices of Flood Prevention Protection and Mitigation in land use management	Administrative	MRDFWM,HV, MC, MEPPPC, L&RSG, OTHER		continuous	

4.3. Structural flood defences

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
Austria						
1	Maintenance and adaptation of the protective measures and protective structures	Maintenance Flood protection Strategy	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Due to the increasing volume of protective water management construction work on the waters, maintenance is gaining increasing importance.
2	Implementation of measures for flood protection where necessary	Flood protection	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Basic principles: Passive flood protection takes priority over active flood protection. Measures in the catchment area take priority over measures on the main channel of a watercourse. Retention measures take priority over linear construction measures.
3	Upkeep and improvement of floodwater passability on watercourses	Flood protection	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Improvement of passability (outlets, channels, bridges…) in the course of the project activity

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
4	Coordination between planning projects of public authorities and the relevant special fields.	Strategy Integrated flood management	Departments of the Federal Hydraulic Engineering Administration Departments of the relevant special fields.		Ongoing	
5	Recognition of negative flood-relevant developments	Strategy Research	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)			
6	Measures for bed load and dead wood retention in torrent catchment areas	Protection from natural hazards	Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	
7	Implementation of area management measures in the catchment areas	Protection from natural hazards	Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	
8	Creation and enlargement of retention areas and basins	Flood protection	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Main strategic focus: retention measures take priority over linear construction measures.
9	Controlled retention	Flood protection	Departments of the Federal Hydraulic Engineering Administration		Ongoing	Regarding controlled retention, greater potentials for the future lie in the continual further development of prognosis and forecasting models. The taking into account of protective water management aspects in the operating regulations of power stations, valley dams or lake reservoirs

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
10	Preservation and protection of the function of the groundwater body	Flood protection	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering ***Service*** in Torrent and ***Avalanche*** Control		Ongoing	
Slovakia						
1	Regular maintenance of dams, water courses and water structures, e.g.: - recovery of water courses vegetation protection - technical-farming activities at embankments and in river beds - maintenance of natural river beds - removal of obstacles from river beds - removal of sediments etc.	Technical	SWME, owners		continuous	
2	Systematic technical monitoring of key water structures	Technical	SWME, owners		continuous	
3	Bratislava – Flood protection project, Danube and Morava Rivers	Technical	SWME	41 373 764	2010	
4	Váh River, left-side flood protection dike Kolárovo - Komoča, hkm 23,040 - 27,075 flood protection, sealing	Technical	SWME, SHMI	5 178 000	2011	the Slovak National Flood Protection Plan
5	Rusovce – Čunovo water canal revitalization	Technical	SWME, SHMI	3 365 034		

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
6	Danube River, Komárno - flood protection wall reconstruction	Technical	SWME, SHMI			
7	Malý Dunaj, Klátovské rameno, Kolárovo – Aszód IW pumping station, flood protection improvement	Technical	SWME, SHMI	8 020 215		the Slovak National Flood Protection Plan
8	Malý Dunaj, Klátovské rameno, Aszód IW pumping station – Horné Mýto, flood protection improvement	Technical	SWME, SHMI	30 976 067		the Slovak National Flood Protection Plan
9	Stoličný creek, Modra – river training	Technical	SWME, SHMI	1 327 757	2011	the Slovak National Flood Protection Plan
Hungary						
1	Strengthening and heightening flood protection dykes to resist the 1:100 year floods	Structural measure	KvVM, VKKI, KÖVIZIGs			Under way
2	Improve flood conveyance capacity	Structural measure	KvVM, VKKI, ÉDU KÖVIZIG			Old Danube between Rajka and Szap (Gabcikovo)
Croatia						
1	Gradual implementation of repair and reconstruction works on about 110 km of protective systems	Technical	MRDFWM,HV, HEP, OTHER		2038	It is anticipated that 100-percent functionality by the end of 2038. From the point of view of health, safety and environment, the priorities of first order in preventive flood protection are the areas of large and larger towns with more than 30,000 inhabitants, potentially at risk from the Danube River. The priorities of second order are other towns and settlements along the Danube.
2	Regular maintenance of watercourses, water estate, and water structures; systematic technical monitoring of key water structures	Technical	MRDFWM, HV		continuous	

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
3	Support to solving flood protection problems within multi-purpose systems for the regulation and use of water and land	Technical	MRDFWM,HV, HEP, OTHER		continuous	

4.4. Non-structural measures (preventive actions, capacity building of professionals, raising awareness and preparedness of general public)

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
Austria						
1	Development of flood forecasting and prognosis models	Prevention Research Strategy	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)		Ongoing	Gradual development of flood forecasting systems for all major main rivers
2	Networking of regional and international systems	Cooperation Research Strategy	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) Neighbouring states (Czech, Slovakia)		Ongoing	The intended result is to be an international flood forecasting and flood warning system that not only covers the entire Danube river basin, but also responds to the respective needs and requirements of the individual regions.
3	Adaptation and development of the gauge network	Maintenance	Hydrographic Services of the Federal Hydraulic Engineering Administration		Ongoing	Further development of, in particular, the basic network of telecommunicating gauges (see Section 3.5.2. "Installation of gauges and measuring points". Deployment of state-of-the-art technical devices and systems.

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
4	Optimisation of flood warning and the flood warning systems (improved early warning)	Prevention Strategy Disaster Control	Provinces (Hydrographic Services, disaster control departments)		Ongoing	Well-functioning early warning systems and flood news services (improved data gathering and transmission process) represent the basic prerequisite for well-functioning flood risk management.
5	Improvement of international cooperation in flood management	Cooperation Research	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)		Ongoing	Action Programme for sustainable flood protection in the catchment area of the Danube Action Programme on Flood Prevention, Protection and Mitigation of the European union (Floods Directive of the European Parliament and Council)
6	International cooperation within the framework of water agreements or bi- and multilateral water commissions	Cooperation	Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) Representatives of the participant countries		Ongoing	Sustainable flood protection that is fit for the future can only be tackled in cooperation with the riparian states in the individual river basins, including active collaboration and the exchange of knowledge and strategies.
7	Execution of transnational projects; partner of international platforms	Cooperation	Federal government, provinces Participant neighbouring countries and various organisations		Ongoing	For example, through INTERREG pilot projects an effort has been launched to develop river management schemes internationally in the direction of a river basin management plan. The intention is to thus boost structured cooperation and the exchange of knowledge between all the administrative departments working in the river basin, starting with hydrology, and then involving spatial planning, water rights, nature conservation, agricultural and forestry departments, etc

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
8	Keeping the public continually informed	Public Relations Raising Awareness	Federal government, provinces and municipalities Disaster control departments, emergency organisations, insurance companies…		Ongoing	Brochures, folders, information sheets on the subject of flood protection Internet platforms Information and events designed for different age and person groups Flood news service, online services
9	On-the spot informative events held by the Federal Hydraulic Engineering Administration and Torrent and Avalanche Control	Public Relations Raising Awareness	Departments of the Federal Hydraulic Engineering Administration Sections of the Forest Engineering Service in Torrent and Avalanche Control		Ongoing	Informative events within the framework of detailed planning projects, hazard zone mapping or river development schemes
10	Identification and publication of potential flood hazard areas within the framework of Floor Risk Zoning Austria (HORA)	Information Raising Awareness	Federal Ministry of Agriculture, Forestry, Environment and Water Management		Ongoing	Assessment of the flood risk. Making already complete-coverage, public information available to the general public. Basic possibility of online risk appraisal. Elaboration in cooperation with the Austrian Insurance Association.
11	The carrying out of disaster control exercises	Disaster control	Provinces Disaster control org.		Ongoing	
12	Streamlining and optimisation of the emergency response chain	Disaster Control	Provinces Disaster control org.		Ongoing	
13	Creation of disaster control plans and special alarm plans	Disaster Control	Provinces Disaster control org.		Ongoing	

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
14	Promotion of incentive systems to encourage people to take their own precautions	Prevention Disaster Control	Federal government, provinces		Ongoing	
15	Securing financial provision	Prevention Disaster Control	Federal government, provinces		Ongoing	
Slovakia						
1	Implementation of the Slovak national Flood Protection Act (i.e. also EU Directive 2007/60/EC on the assess-ment and management of flood risks)	Admin/Technical	MoE SR, SWME, SHMI, EPDO, municipalities		continuous	
2	Regular updating and implementation of the Slovak National Flood Protection Plan	Administrative	MoE SR, SWME, SHMI		continuous	
3	Implementation of flood forecasting and early warning system POVAPSYS	Admin/Technical	MoE SR, SHMI		ongoing	
4	Introduce directive for emergency situations response	Legal	MoI SR + MoE SR,			
5	Bring into force bilateral agreements	Administrative	MoE SR		continuous	
6	Improvement and formalizing of international basin wide online flood related meteorological and hydrological data and operative flood defense information exchange	Admin/Technical	MoE SR, SHMI, SWME			

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
7	Introduce and carry on the web sites focused on floods and flood risk management	Technical	MoE SR, SHMI, SWME		ongoing	
Hungary						
1	Incorporate the newest monitoring data available (automatic station, ECMWWF etc.) and improve the algorithm	R&D	VKKI, VITUKI		Continuous	
2	Intensive use of EFAS	R&D	VITUKI		Continuous	Incorporate, test and use the outputs of EFAS into the daily forecasting models
3	Regular, yearly training of professional staff; improve vocational and post-graduate education to bring up new generation of staff	Training	KvVM, VKKI, KÖVIZIGs, Universities, High schools		Continuous	
4	Production and distribution of leaflets and other PR materials; paid programmes on broadcasting stations	PR	KvVM, VKKI		Continuous	
Croatia						
1	Implementation of operative flood defence measures	Technical / Organizational	MRDFWM,HV		continuous	
2	Managing and coordinating the operation of water distribution structures during high water periods	Technical / Organizational	MRDFWM, HV, HEP, OTHER		continuous	
3	Improving the system of automated weather stations and gauging stations, and making the measured data available to relevant services in real time	Technical / Organizational	MRDFWM,HV, DHMZ		continuous	

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
4	Improving the system of hydrological and weather forecasting, and making the created forecasts available to relevant services; establishment of local forecasting centers and application of the latest technologies in forecasting - monitoring and water information system	Technical / Organizational	MRDFWM,HV, DHMZ		continuous	
5	Improvement of alarm systems and systems for issuing timely warning to population at risk; organizing improved operations of the police and firefighting forces during floods; organizing evacuation of population, if needed; organizing life on damaged areas by providing humanitarian aid, organizing medical services, and emergency recovery of essential infrastructure	Technical / Organizational	NPRD		continuous	
6	Improvement and formalizing of international basin wide on line flood related meteorological and hydrological data exchange	Administrative	HV, DHMZ		continuous	
7	Improvement and formalizing of international basin wide on line operative flood defense information exchange	Administrative	HV, NPRD		continuous	
8	Preparation, adoption, and regular updating of the National Flood Defence Plan	Administrative	MRDFWM, HV		continuous	

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
9	Support of scientific and educational projects related to all aspects of floods.	Administrative	HV, MSES, MRDFWM		continuous	
10	Professional education of scientific personnel to perform the tasks of integrated water resources management. It is necessary to create new interdisciplinary plans and programs of education.	Scientific	HV, MSES, MRDFWM		continuous	
11	Continue action in the framework of international multilateral and bilateral agreements.	Administrative	MRDFWM,HV MFAEI, MEPPPC,MC		continuous	
12	Continue action in the framework of international multilateral and bilateral agreements.	Administrative	MRDFWM,HV MFAEI, MEPPPC,MC		continuous	
13	Bring into force the laws, regulations and administrative provisions complied with Flood Directive	Legal/ Administrative	MRDFWM,HV		26 November 2009	
14	Decision on units of management	Legal/ Administrative	MRDFWM,HV		26 May 2010	
15	The preliminary flood risk assessment	Scientific/ Technical	MRDFWM,HV		22 December 2011	
16	Preparation of flood hazard and flood risk maps	Scientific/ Technical	MRDFWM,HV		22 December 2013	

Targets	Measures	Type of intervention	Institution in charge	Costs (k€)	Deadline	Comment
17	Preparation of Flood risk management plan	Scientific/ Technical	MRDFWM,HV		22 December 2015	
18	Presentation flood risk and flood damage maps to the interested public	Administrative measure	MRDFWM,HV, MC		continuous	
19	Introducing the principle of covering uncovered flood damage risks through insurance policies	Administrative measure	MRDFWM, HV, MF		continuous	
20	Recovery of the current sources of pollution on the areas potentially at risk	Administrative measure	MRDFWM,HV, MEPPPC, MHSW, L&RSG		continuous	

Annex 1 List Acronyms

Slovakia

Acronyms:	Name of institution
MoE SR	The Ministry of Environment of the Slovak Republic
MoI SR	The Ministry of Interior of the Slovak Republic
SWME	The Slovak Water Management Enterprise, state owned enterprise Žilina
SHMI	The Slovak Hydro Meteorological Institute
EPDO	The Environment Protection District Office
municipalities	Municipalities
owners	Owners of water structures, water courses
WRI	The Water Research Institute

Hungary

Acronyms:	Name of institution
KvVM	Ministry of Environment and Water
VKKI	Central Directorate for Water and Environment
KÖVIZIGs	Environmental and Water Management Directorates
ÉDU KÖVIZIG	North-Trans-Danubian Environmental and Water Management Directorate
KDV KÖVIZIG	Central Danube Valley Environmental and Water Management Directorate
KÖDU KÖVIZIG	Central Trans-Danubian Environmental and Water Management Directorate
ADU KÖVIZIG	South Danube Valley Environmental and Water Management Directorate
DÉDU KÖVIZIG	South Trans-Danubian Environmental and Water Management Directorate
VITUKI	VITUKI Environmental and Water management Research Institute Non.profit Ltd.

Croatia

acronyms:	
DHMZ	Meteorological and Hydrological Service
HEP	Hrvatska elektroprivreda (Croatian power company)
HS	Hrvatske šume (state-owned company in charge of forest management)
HV	Hrvatske vode
LRSG	local and regional self-government units,

MC	Ministry of Culture
MEPPPC	Ministry of Environmental Protection, Physical Planning and Construction
MF	Ministry of Finance
MHSW	Ministry of Health and Social Welfare,
MRDFWM	Ministry of Regional Development, Forestry and Water Management
MSES	Ministry of Science, Education and Sport,
NPRD	National Protection and Rescue Directorate, Ministry of the Interior
MFAEI	Ministry of Foreign Affairs and European Integration
OTHER	other water and land users