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THREAT OF TORRENTS TO THE LANDSCAPE IN THE CZECH REPUBLIC

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ABSTRACT

The territory of the Czech Republic is inconsiderable in comparison with the area of other Central European countries. Also the morphology is not relatively conspicuous and not too high border mountains surround the whole country. The country, lying on the crossroads of several big rivers, creates main European watershed divide called the "roof of Europe". Rainfalls drain away by the River Elbe to the North Sea, with the Moravia River waters to the Black Sea and by the River Odra to the Baltic Sea. Temperate climate subordinates to oceanic and continental influences. High weather mutability is also strongly influenced by elevation above see level and exposure. Windward mountainsides have up to 1,500 mm of rainfalls while rain shadow areas usually have less than 500 mm. These precipitations represent one of the most important inputs for development of the country. This input has become negatively regulating in the recent years as it has already happened in the past, too. It is caused by extraordinary climatic events with disastrous rainfalls and massive, destructive floods. The amount of damages caused by floods reached annually up to 10% of GDP in the years 1997, 1998, and 2002. At the same time, the Czech Republic is the country that has experiences with flood-control protection of stream parts of watercourses, particularly since the end of 19th century. The services of torrent control were jointly organized in the Austrian Empire of that time up to 1918. Our predecessors, who removed consequences of floods in Czech lands in the years 1872, 1890, 1897, and1904, has been using systems learnt from Alpine countries adapted to Czech physical-geographical conditions. We can compare whether systems of that time, used for torrents control and measures inside of catchments, was sufficient and efficient, in the light of August 2002 flood in the basin of the rivers Vltava and Elbe. The paper is focused on the assessment of 100 years old measures at the concrete torrent watershed.

Key words: floods, forest hydrology research, torrent control service

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INTRODUCTION

The territory of the Czech Republic is not large in comparison with the area of countries of Central Europe, and its morphology is relatively indistinct. The entire area is surrounded by relatively low border mountain ranges. The main European watersheds run through the territory of the Czech Republic. It is the “roof of Europe”, rainfall runs off into the Elbe and thence to the North Sea, into the Morava and then to the Black Sea, or into the Odra river and into the Baltic. This rainfall represents one of the most important inputs for the development of the state. The mild climate is subject to oceanic and continental influences, and the great changeability of the weather is also strongly influenced by the height above sea level and position. Windward mountain slopes have up to 1500 mm of rainfall, and in the rainfall shadow they have less than 500 mm.

As in the past, in recent years there has been abnormal rainfall, and catastrophic floods have negatively influenced both society and nature. They are caused by the extraordinary climatic situation. In the years 1997, 1998 and 2002 the subsequent damages reached up to 10% of the value of gross domestic product of the individual years.

The Czech Republic is also a country with experience in flood protection of the source areas of rivers, primarily since the end of the 19th century, when the activities were dealt with jointly until the year 1918 in the former Austria Empire. Our predecessors who rectified the consequences of the floods in the Czech Lands (Bohemia, Moravia and Silesia) in the years 1872, 1890, 1897 and 1904 dealt with them using the systems of the time which they had learned of in Alpine countries and adapted to our physical-geographical conditions.

By looking at the course of the August 2002 floods which were channelled along the course of the Vltava and Elbe, we can compare whether the systems used at that time to ameliorate torrent activity and measures in the river basin where suitable, adequate and effective.

HISTORICAL CATASTROFIC FLOODS

Natural disasters, whether on a local or regional scale, have in recent years been subject to public comment, and the opinions of the commentators are given as being absolutely definitive concerning the causes of damage and their scope. The causes given are unfavourable human activity, the greenhouse effect, atmospheric pollution, deforestation, the adjustment of rivers etc. But they rarely refer to the absolutely decisive cause of the catastrophes, i.e., commentators rarely refer to abnormal rainfall resulting from exceptional meteorological conditions, and if they do they see it as merely an accompanying factor. As a result of insufficient systematic climatological and hydrological measurements, a comparison of historical floods is decidedly difficult. For the Czech Lands the length of the required measuring for the river Vltava is from 1825, for the river Morava from 1893 and for the river Odra from 1896. For other parts of the territory and other rivers, not even these records have been preserved, and there remain only subjective reports from chronicles and indications of high water for certain cases of floods. For small rivers of the source territories which have the character of mountain streams, even these records are rare. Despite the fact that every flood situation is different, certain milestones of these natural phenomena are preserved in the consciousness of people working in water management, such as the flood of March 1845, May 1872, June 1883, September 1890, July 1897, July 1903, August 1925, March 1941, July 1997, July 1998 and August 2002.

Fig. 1: The confluence of rivers Vltava and Sazava at Davle on August 13, 2002. The mouth of the Zahoransky Creek described below is 200 meters ahead to the north.

The greatest total daily rainfall in the Czech Lands was recorded as 345.1 mm in the Jizerske Mountains on 29th July 1897. Another critical event, the flash flood on the evening of 25th May 1872 to the morning of 26th May 1872 in the basin of the river Berounka, cost more than 200 lives.

In addition to these historical catastrophic floods, the rivers of the Czech Republic are affected by local floods, concerning the course of which there have been sporadic records over the past one hundred years and a few photographs or, in the past twenty years, film recordings made by the randomly afflicted inhabitants.

One such case in relation to the August flood of 2002, which provoked a reaction to the damages in the capital Prague, is the local flood on the right-hand tributaries of the river Vltava in its further section upstream of the city.

The catastrophic flood of August 2002 impacted virtually the entire basin of the river Vltava, the lower part of the river Elbe and the river Ohre and a large part of the river Dyje (Thaya). The estimate for the greatest flow of water in the Vltava in Prague was 5 300 m^3/s in comparison with the long-term average flow of 147 m^3/s. The previous value for a one-hundred year flood is a flow of 3 700 m^3/s and the figure of 4 000 m^3/s was assumed for the protection of the city. This protection was derived from the flood of 1890, previously the greatest summer flood documented by historical records. The flood of 2002 resulted from rainfall which had no precedent in the history of the country and which was multiplied by the concurrence of floods on significant tributaries, the river Berounka and Sazava, which flow into the river Vltava a short way upstream of the city. On the southern border of the city there were recorded 182 cm higher water level comparing with the year 1890.

The rain fell mostly on southern and western Bohemia, with a lesser intensity in eastern Bohemia. The first wave of rainfall was recorded on the days 6th and 8th August 2002 in the southern part of the Sumava area (Bohemian Forest) ranging from 130 mm to 200 mm (maximum 254 mm). The second wave from 11th to 13th August 2002 was once again in a range from 130 mm to 200 mm (maximum 400 mm). During this second wave of rainfall with the greatest precipitation northern Bohemia (the Ore mountains/Erzgebirge) and south-west Moravia were impacted most. The subsequent high flow rates in rivers exceeded the previously know maximums, and downstream of the confluences of the large rivers in particular the peak water levels combined. A periodicity of 500 years was credited to the greatest flow in the river Vltava, on the river Berounka it was 250 years, and on the river Malse (south Bohemia) it was one thousand years.

HISTORY OF TORRENT AND GULLY CONTROL SERVICE

After 1872 the adjustment of mountain streams and gullies was carried out very sporadically despite the fact that its urgency was known. There was no legal basis, and, as a result of this, there was no possibility of constant resources. There was also a lack of understanding for the carrying out of alteration and flood prevention measures in distant source areas instead of adjustment only in the afflicted and inhabited valleys.

The turning point came in 1884, when these relations and the impacts of climatic and hydrological phenomena were evaluated, and the government issued the first legal, administrative regulations to enable this beneficial activity. Later, in the interests of a systematic and unified procedure for the adjustment of water-management constructions on significant rivers and in order to eliminate the influence of interested parties or random initiatives or incommensurate or unavailable financial resources, an Act was passed on 11th June 1901 No. 66 Coll., concerning the construction of water courses and the adjustment of rivers. This law stated which rivers and which of their tributaries were important, and it established the essential nature of their adjustment. It also designated the requisite financial securing for the period 1904 to 1912.

The regional laws issued on 13th February 1903 Nos. 31, 32 and 33 Coll., which specifically ordered the adjustment of rivers in the Czech Kingdom, also followed on from this act.

Act No. 31 made it possible to establish a Regional Commission for the Adjustment of Rivers in the Czech Kingdom, its organisation and decisions concerning all technical, administrative and financial matters. This act also made it possible for its permanent expert to be the superintendent of the forestry-technical department for the torrent control of mountain streams (Karel Gorner during the establishment of the regional commission), the head of the section in Prague. This state was not a mere administrative act, but it expressed that flood prevention measures in source areas of rivers are always correct, and adjustments of mountain streams carried out from the year 1884 represent the protection of lands threatened by these streams and are an irreplaceable protection for the use of large rivers. The regional commission was established on 24th October 1903 with its headquarters in Prague. The general programme for the adjustment of rivers which was carried out according to the three acts referred to incorporate the fundamentals and an overview of the allocation of money for the individual construction periods. The basic fundamentals consisted of sub-programmes of valley dams, of the torrent control and adjustment of mountain streams and gullies, of the forestation of their perimeters, of the order of urgency, of the material scope of adjustments, of the significance of fishponds, of the procedure for the securing of projects, of the allocation and carrying out of work and of the designation of costs of work. This was a strategy of water management which has no equal in the area of what is now Czech Republic even today. At its plenary sessions the regional commission approved general projects or detailed projects for adjustment and forestation.

ZAHORANSKY CREEK

At its seventh meeting on 23rd May 1905 some of the adjustments it approved were the adjustment of the Librice Creek, the then name of the Zahoransky Creek, which flowed from the right directly into the river Vltava between Prague and the town of Stechovice, just behind the confluence of the rivers Sazava and Vltava at the locality called Davle.

The frequently recurring floods in the embouchure of the section, which carried an increasing amount of debris, culminated in 1904 with a local flood which resulted in damage preventing access to the valley and preventing the citizens from using rail transport on the branch line put into operation in 1896. The body of the railway was not damaged, nor was its iron bridge spanning the Zahoransky Creek. But the deposited debris created a gravel bed reaching almost into the centre of the river Vltava. Primarily the washing away of land waste caused the damage from the flood from insufficiently forested slopes in the entire system of the hydrographic network of the catchment. It was not possible to ascertain the intensity and duration of the rainfall, but it is estimated that approximately 35 m^3/s flowed out from the catchments, which is the value for today's one hundred-year flood. In order to limit such damages in the future, the regional commission decided to regulate this stream, including measures in its catchments and its tributaries. They asked the royal and imperial forestry-technical department for the adjustment of mountain streams, department Kralovske Vinohrady, to make an investigation and prepare a detailed project. The project was prepared in January 1905, and the costs were designated as 240,000 crowns. It was prepared by Vojtech Kaisler, a graduate of the Faculty of Forestry Engineering at the Agricultural University in Vienna from 1893 who, following service in Corinthia at the section in Villach, worked from the year 1904 at the section services for the adjustment of mountain streams in Kralovske Vinohrady.

The main Zahoransky Creek itself was less harmful than some of its tributaries. But its meander in the section 3.5km to 5.5 km downstream of the municipality Zahorany was harmful and there was a danger of the river banks collapsing and a subsequent landslip of hillsides.
Its right-hand tributary at 2.0 km, which is the Okrouhelsky Creek and the side gullies flowing into it (of which at that time the Olesska gully was highly active at 0.7 km), was dangerous.

The bottom of the valley of the Zahoransky and Okrouhelsky Creek and Olesska gully consists of deposits of gravel, which during higher flows of water was carried into the lower reaches

Fig. 2: Confluence of the Okrouhelsky and Zahoransky Creeks before the regulation (July 1904)

A significant amount of gravel comes from the hillsides which at that time were virtually bare. In terms of geology the basin belongs to the area of the Central Bohemian Pluton consisting of Algonkian with slate, siltite and greywacke, in the southern part of the basin there are interstratified beds of spilites, flinty shales, quartz porphyry and porphyrites. In the northern part of the basin the Pleistocene era is represented by loess and loessial soils.

In order to stabilize the conditions in the basin there was a proposal for the reinforcing of the river banks on the main flow using vegetation fences, at 1.5 km to 2.1 km adjustment using stone sills and downstream floor for 487 running metres channelled by the gravel deposit of the main valley, which also distanced the flow from the foot of the left side with local landslips.

Fig. 3: Mouth of the Okrouhelsky Creek to Zahoransky Creek (1906)

Fig. 4: Precincts of the mouth of the Okrouhelsky
to Zahoransky Creek - current situation (2004)

Fig. 5: Zahoransky Creek (2004)

On the tributary of the Okrouhelsky Creek a correction was designed for a length of 907 running metres from the mouth, and higher up, a series of stone weirs, longitudinal walls, or vegetation fences to stabilize the foot of the slopes.

It was proposed that side gully be systematically regulated only in embouchure courses and higher up by a few stone weirs. One part of the project was the forestation of the slopes with trees on an area of 97 ha, and in places their escarpment and reinforcing before the vegetation fences and stone walls.

The detailed project was approved on 7th July 1905, and the royal and imperial forestry-technical department for the adjustment of mountain streams commenced work on the proposed adjustments, department Kralovske Vinohrady. But work did not develop fully in this year as a result of a shortage of construction stone, which was quarried close to the construction site as a result of the difficulty of access. Only the adjustment finishing the correction on the Okrouhelsky Creek, the access road to its valley, the establishment of two nurseries of trees and the start of work on the correction of the hillsides for forestation were done.

Construction work continued in the year 1906 on the Okrouhelsky Creek and its tributaries, including forestation. The only change in contrast to the project during construction was carried out in the section of correction, and fewer stone sills were built than were in the design, but they were higher. They were made of concrete and their crown was capped with stone. In 1907 and 1908 the adjustment continued according to the project, and in 1909 minor forestry steps were completed, and in July the adjustment of the Librice Creek received official construction approval. In 1911 there were certain additions to the meshwork downstream of Zahorany in the embankment failures in the meanders, including the addition of fascines.

In the detailed project special attention was given to the forestation of bare hillsides in the basin. Seedlings of Norway spruce, larch, Austrian pine, Scots pine, black locust, birch, maple, ash, alder and hornbeam were used, and acorns were sown. The losses in the individual years were from 10% to 15%, after improvement, the state of the newly established plantations in 1912 was highly favourable.

MAINTENANCE WORK

The first maintenance work and repairs carried out on the adjustments in the catchments were performed from 1920 to 1922, also by the department for forestry-technical amelioration for the adjustment of mountain streams, department Kralovske Vinohrady. Embankment failures were repaired, there were repairs to wooden sills in the main river in the section of 4 km to 5.5 km, there was cultivation work and the vegetation on the river banks was added to, in the Okrouhelsky Creek there were repairs to the longitudinal walls of the foot of the slopes, and the river bed was partially cleared of deposits.

Fig. 6: Okrouhelsky Creek close to the mouth (1906)

In 1941 a project was prepared to add transverse constructions on the main flow with two weirs at a height of 1.0 m and 2.4 m. The reason was the erosion in places of the river bed and faults of the downstream floors of the existing constructions at the section 1.5 km to 2.1 km. The project was not, however, implemented.

In 1961 the transverse constructions on the Okrouhelsky Creek were repaired in the correction section at 0.0 to 1.0 km. In 1966 work began on a new adjustment of the Zahoransky Creek in the municipality and upstream of the municipality Liber in order to increase the protection of the urban area. In 1968 eight reinforced fords were built in the section of 4.5 km to 5.8 km downstream of the municipality of Zahorany to enable forest transport in this forested section. In 1979 maintenance work was carried out in the section 0.1 to 0.4 km (embouchure of course), the dredging of silt from the bed, the stabilisation of the river bed using wooden sills in combination with rock filling and repair of embankment failures using wooden cribwork.

INVESTIGATION OF THREATS IN THE CATCHMENT

In the first half of 2002 an investigation was made on the threat in the catchment from the activity of mountain streams and the definition of the active spreading of flood during catastrophic rainfall. The Zahoransky Creek has a basin area of 52.1 km^2 and length of 14.1 km, and at 82.8 km along the river length it pours into the surge reservoir Vrane on the river Vltava. The surge of the flood reaches to an average distance of 80 running metres above the profile of the inlet of this tributary. The value of Q100 is designated as 34.5 m^3/s. The highest elevation of the catchment is 480 metres above sea level, the lowest point is 199 metres above sea level, the gradient of the stream is 1.27%, the length of the hydrographic network is 56.7 km, the forestation of the basin is 37.3%, the percentage of arable land is 41.0%, the percentage of permanently grassed meadows is 9.9%, the percentage of the urban area of the municipality and area of recreational cottages is 11.8%. The characteristic data concerning the catchment is contemporary, and it is not possible to gain data for one hundred years ago. The forestation of the catchment according to the modern conception was significantly lower, even if in terms of the type of land it involved forestry land. The percentage of the urban area was approximately the same as today's, but it is possible to concede that there was no area of recreational cottages in the valley, but the built-over area of the municipality was greater as a result of scattered construction on its edges. The value of the maximum outflow from the catchment at that time reached today's value of flow with the probability of incidence of 1%. But it differed fundamentally in terms of the amount of floating debris during the flood of May 1904 from the amount in August 2002. From the graphic documentation concerning the consequences of the flood in the year 1904 it is estimated that more than one hundred thousand m^3 of coarse floating debris was taken and deposited in the lower reaches of the stream, its tributaries and gullies and in the river Vltava. Virtually the movement of floating debris and soil erosion in 1904 impacted the entire catchment.

← Fig. 7: Zahoransky Creek; upper part of the stream (2004)

The results of the investigation concerning the threat to the basin from 2002 provide information about a movement of floating debris significantly lower and flood damage incomparably less. The annual production of floating debris in a year with normal rainfall reaches 3 500 m^3 for the basin of the Zahoransky Creek, of which erosion in the mouth 788 m^3. With a flow of Q100 along the bed, 7500 m^3 of floating debris is generated in the basin, of which erosion in the mouth is 3000 m^3. With a flow of Q20 along the bed, 4700 m^3 of floating debris is generated, of which erosion in the mouth is 1900 m^3. The investigation into the state of the adjustments and their one-hundred year functionality is acceptable overall. The construction adjustments on the main flow require minor maintenance work, but the fundamental silvicultural work on the bank vegetation in order to achieve the required capacity of the channel. The weirs for collecting floating debris, on the main flow and on the tributaries, are filled with floating debris, and the detrital cone of sediments exceeds the crest of the weir. There are significant faults in the construction structures on the tributary of the Okrouhelský stream in the correction of the embouchure of the section, where out of a total of 45 sills, 20 have been destroyed and 15 are badly damaged. It is a section where during the construction the stone sills were replaced with concrete ones with a facing of stone on the through-flow section. It is not possible to rule out the possibility that an error was made in the technology of the construction of the sills. The forested hillsides of the basin are stable with a good condition of forest stands.

The extraordinary rainfall which afflicted the basin of the Zahoransky Creek in July and August 2002 gradually reached a value of 210 mm, of which in July it was 40 mm, from the 6th to the 8th of August 50 mm, and from the 11th to 13th August 120 mm. The first rainfall caused a significant saturation of the soil profile. The August rainfall, and primarily in the second period, had no possibility of infiltration into the soil, and virtually all the rain that fell ran off into the river channels. Despite this, in the year 2002 there was only movement of floating debris on the bed of the main channel at 4.5 km to 5.8 km (existing meander of the channel) with localised damage to the valley's transportation forestry tracks, in the channels of the tributaries by a shift of deposits from the retaining areas of the weirs. Gravel settled on the bed of the main channel and on neighbouring lands in the section 0.3km to 0.5km in an amount of approximately 2,500m^3. In this section, there was a significant effect of the reservoir, Vrane put into operation in the year 1935, on the river Vltava. The level of the reservoir of 200.5 above sea level increased by more than two metres during the August floods of 2002. Only light floating debris was washed into the river Vltava. The active flood zone during the flood of 2002, which reached Q100, affected part of the urban area in the upper part of the basin and the embouchure section with scattered recreational cottages. The course of the flood and the scope of flood damages are in compliance with the conclusions of the investigation into the threat to the basin of the Zahoransky Creek from the activity of mountain streams. The conclusions also contain preventative measures to limit erosion and damage.

IN CLOSING

Forests and forestry management has no impact on the incidence of catastrophic rainfall. The owner of a forest cannot change the geomorphologic elements, but he can influence the period of the water cycle from the time of its falling into the system of the concentration of flow off. The course of the floods in the years 1904 and 2002 justify the opinion that forest stands significantly contribute to protection against soil erosion. But forests and forest soil can only dampen a flood of water up to a value of approximately 70 mm of continuous rainfall. With an increasing saturation of the environment and continuing rainfall, forests and forest soil are incapable of preventing the incidence of catastrophic floods. Construction alterations carried out in the catchment nearly one hundred years ago have achieved functionality even today, and they have fundamentally limited the movement of floating debris in the basin and the extent of flood damage. It is therefore essential to ensure all measures in the catchment to secure the permanent functionality of the existing constructions and the permanent function of the forests.

This also applies for other catchments of mountain streams, which were protected in the past from flood damage by adjustments, and it also arises from the results of forestry-hydrological research in Czech Lands. We w0ill commemorate both activities in the year 2004, when the Torrent and Gully Control Service celebrates its 120th anniversary and forestry-hydrological research celebrates its 50th anniversary. An international seminar re. these anniversaries are supposed in October 2004 in the Czech Republic.

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