Hydrographic Survey of the River Drava Branches in the Process of Revitalization, Flood Control and Morphological Monitoring

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Key words: flood forecasting, hydrographic survey, methodological monitoring, revitalization, and river branch

SUMMARY

This hydrographic survey described in this paper is a contributionto the draft guide for the revitalization and improvement of watercourses and flood forecasting. Every year in Croatia at least one river experiences the emergence of an extreme water level and this forecasting upgrade will help provide a better defense against the ever more frequent flooding. Furthermore, this project is part of the process of establishing good environmental water quality through morphological monitoring of the river branches and their vegetation.

In this paper we will demonstrate the proper application of survey results and the subject of this project are the branches of the Drava River. By properly focusingthe application of the project results that were obtained by combining terrestrial and hydrography surveying (single-frequency echo sounder) we will form a good basis to perverse dynamic processes of rivers, the survival of the most valuable habitat and endangered species, and slow down the process of eutrophication, which will enable the survival of man in these areas.

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1. INTRODUCTION

This hydrographic survey described in this paper is part of the draft guide for revitalization and improvement of watercourses and flood forecast upgrading for the better defense against the increasingly frequent flooding. It is also an important component of the process to establish good environmental water quality through morphological monitoring of the river branches.The majorities of the branches are covered in lush vegetation and are a tremendously important habitat for flora and fauna, a vital part of our ecosystem.

The Drava river located in Central Europe has a total catchment area of 42 000 m^2, rises in the South Tyrol in Italy, while in the Danube flows by the settlement Aljmaš in Croatia, its total length is 725 km.The total height difference of the river Drava in Croatia is 105 m, and the length of the flow is 323 km. Its slope is approximately 0.03%.With the flow of water, the substantial sediment of sand and gravel characterizes the Drava River. Downstream of the river Mura, the Drava River carries about 40,000 m3 of sediment annually. Under normal conditions, transport of sediment in the river is balanced, which means that the sediment removed is replenished with the same amount from upstream. With sediment moving from the source to the river mouth, there is lateral erosion that feeds sediment from the riverbank.

Along the riverbank where the water is deeper, and thus faster, there is increased riverbank erosion. On the other riverside, the water flows slowly and leads to the deposition of sediment. The consequence of this action on the river channel is that there are more and more twists until the big curve (meander) river finally breaks through and creates a parallel short channel. Eventually longer branch because of its lower slope and slower flow becomes coveredby sediment and forms a separateriver stream (figure 1).The Drava River's branches are some of the last remaining river ecosystems of Europe and home to numerous endangered habitats and species. With the deteriorating river health and many species in severe risk of extinction, these riversdeserve special attention and protection measures. (Grlica 2008)

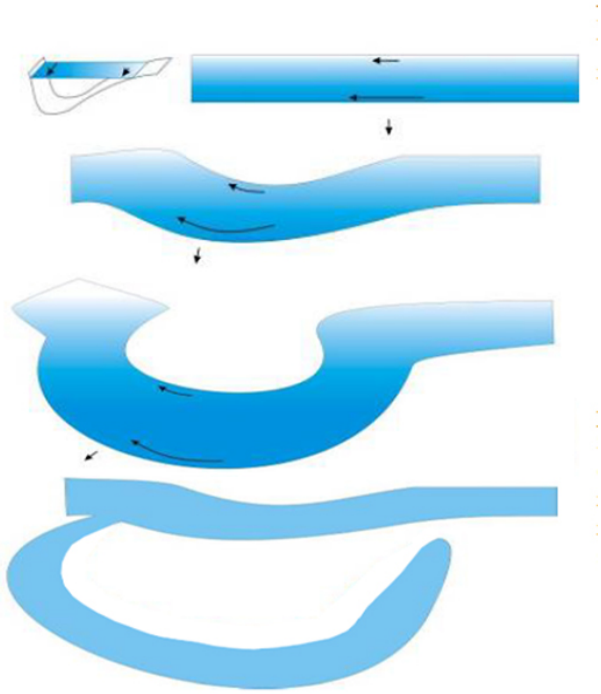

Figure 1. River processes – branch formation

It is important to mention that the construction of hydropower plants, river channeling and sediment exploitation has lead to a "lack of sediment" in the river. That means that the Drava Riverhas more sediment removed than it gets from upstream. Therefore, the river sediment is taken from the riverbed, which is being increasingly deepened each year with an annual average dents troughs on the river is 2.6 cm/year.

Furthermore, a flood in 2012 was caused by a large water wave on the Drava River that was responsible for more than 15 million euros in damage and in 2013 floods were a regular occurrence and caused substantial damage.This clearly indicates the importance of improving the forecasting system and morphological monitoring of the Drava riverbed. In addition, according to prognostic meteorological models, we expect an even greater intensity and frequency of the water waves appearance. The results of this survey will be used to upgrade these processes and records and will become an integral part of the main implementation plan for flood control.

2. HYDROGRAPHIC SURVEY OF THE DRAVA RIVER BRANCHES

Taking into account the above information and the goal of quality hydrographic surveying and determining the morphology of the riverbed and river banks of the Drava, we performed extensive office and field preparation for the demanding field work by using modern methods of measurement and data processing.Given that it is the very beginning of the research on the river branches and their design elements do not exist, we designed itas part of the preparatory works.Hydrographic surveyswere performed at 5 branches on the Drava river:Right bank branch near Legrad (length of 3 km), Right bank branch near Komatnica (length of 5.7 km), Left bank branch near Križnica (length of 13.5 km), Right bank branch near Čađavica (length of 5.0 km) and Right bank branch near Višnjevac (length of 5.5 km).The total number of surveyed and processed cross sections in this project is 581. Locations of the branches are shown on the picture below.

Figure 2. Locations of the five Drava River's branches (Source: Google Maps)

A geodetic survey was performed using a satellite positioning system (GNSS) and where this was not possible, terrestrial measurements were performed with total stations (tachometric method).Specificity of the bathymetric measurement is the integration of the different measurement systems, in order to determine coordinates of the echo sounder and depths in real time. For this purpose we used single-frequency Sonarmiteecho sounder (235 kHz) and Topcon Base and Rover GNSS RTK System. Software package Hypack Max, which is used in this hydrographic survey automatically transform coordinates from WGS84 datum to Croatian Terrestrial Reference System (HTRS96/TM). All of the devices are connected to a laptop PC and integrated in abovementioned software Hypack Max.

A Base station (Figure 3) was set up above the existing geodetic points along the Drava River, while the rover and echo sounder (immersed 0.32 m in the water) were placed on the construction of the side of the vessel. By placing a RTK antennaand echo sounder in the vertical plane, the presence of lateral offset in the position of the echo sounder calculating wasavoided.The main challenge was a hydrographic survey of small depths in the river branches, where the bottom of the river branch is covered with plants and vegetation. For this reason, we had a large number of redundant measurements, in order to ultimately obtain reliable and accurate depth information. Since bathymetry is performed using acoustic method, it is necessary to measure the sound velocity in water, which is dependent on the temperature and water depth, ranged between 1422 m/s and 1437 m/s.During the hydrographic survey, due to the large amount of precipitation the water level of the river Drava was increased and hydrographic survey of the branches was significantly impeded.We experienced extremely unfavorable conditions during the survey of the Drava River, including submerged piers, sedge and other vegetation, and a large water wave that significantly raised the water level of the river and its branches.

Figure 3. Survey of the Drava River branches

When questioned about the accuracy of survey data, there are three errors that affect the accuracy and validity of this survey: GNSS measurement’s error, bathymetric error and echo sounderpositioning error. According to statistical analysis of the survey results (distribution of measurements, the standard deviation of the mean error) the reliability of hydrographic survey and required centimeter accuracy are confirmed and satisfied ($s_{vertical}$= 2.8 cm, $s_{horizontal}$= 2.3 cm). The following are some of the main branches features, as a result of the survey analysis.

2.1. Right bank branch near Legrad

In this narrow river there is not enough space to create large deep meanders, lost slope and slow down the flow, but it is possible to create short inlets and river branches that are quickly overwhelmed with new sediment deposits. Maximum surveyed depth in this river branch is 8.16 m and its position is shown below in figure 4.

Figure 4. Right bank branch near Legrad

2.2. Right bank branch near Komatnica

Inflow of water into this branch comes out of the Drava River and the Gliboliki stream. The western part of the branch (to the mouth of the creek) is steeper and the surface is gravel while in the eastern part of the branch is tilted lower and the surface is sand.The nearby hydroelectric plant caused permanent changes in the water level, which required extra vigilance during this survey. The maximum surveyed depth in Right bank branch near Komatnica is 5.66 m.

2.3. Left bank Branch near Križnica

At a length of 13.5 km the left bank branch near Križnica is the longest branch of these five branches. The research of this survey, in agreement with long-term professional research has undoubtedly demonstrated the necessity to ensure the dressing of fresh water from the Drava River in order to reduce the impact of eutrophication and siltation intensity.The river has changed its course due to various regulatory interventions implemented in the 1820's. These interventions were implemented without a comprehensive plan and had almost no theoretical scientific basis.Further interventions in the period between 1842 and 1966 were designed to shorten the waterway and to improve the protection of the surrounding area from flooding. Finally, in 1966 there was adequate access to regulatory procedures performed,however there is still room for better river channel management, which is discussed in this paper. All of the above resulted in the formation of the Left bank branch near Križnica(magenta color in figure 5), which is, among the other branches, the subject of this hydrographic survey.

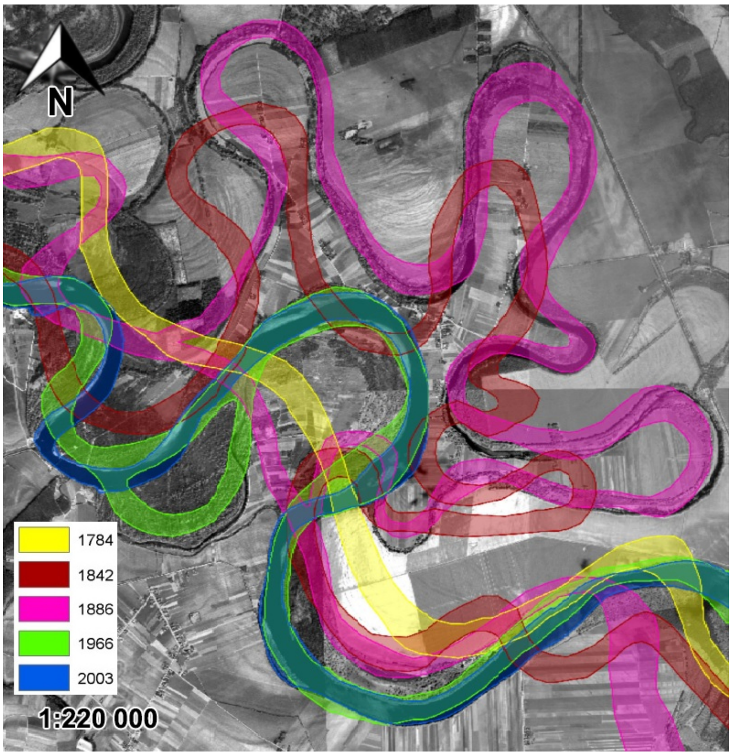

Figure 5. Changing the position of the Drava River during the years (near Križnica)

2.4.Right bank branch near Čađavica

This branch was created after making an artificial ditch, which shortened the Drava by 1.8 km. It was found that while diverting water into the new channel, there was a significant slowdown in the old water channel, and thus an appreciable deposition of sand, which resulted in raising the bottom of the old riverbed. In contrast with the ditch, the water flow speed is increased considerably and there has been increased riverbed erosion and falling water levels. The result of these actions over time will completely interrupt the flow of water in this branch and it will gradually heal the forest. Maximum depth in the Drava River channel is 9.77 m, while in the branch it is 6.90 meters.

2.5. Right bank branch near Višnjevac

The branch near Višnjevac part of the former course of the river Drava in the sixties and seventies to mid-and high water represented the branch total length of 4.66 kilometers.
A system derived from hydraulicengineeringwasintroduced to stabilize the riverbank and control the junction of the right bank and the Drava river. However, thiscauseddeposition of sediment on a low bank and the connection of the branch with lowwaterlevelswasdisabled. Maximum depth in this branch according to highest water level is 4.34. m, while maximum depth in Drava River channel is 4.95 m.

3. Revitalization, flood control and morphological monitoring

Revitalization can be easily defined as a return to the situation as close as possible to an unchanged ecosystem.The problems of the branches water systems are mainly linked to the supply of nutrients (nitrogen and phosphorus), sediments and other organic pollutantscarried by water from agricultural areas, and the absence of adequate sources of fresh water. The overload of water with nutrients and poor water-floware preventing development of swamp flora that additionally slows down the water current.

Eutrophication is a global problem. In the world there are 415 eutrophic ecosystems, and that number is growing as a result of the growing human population and increased pollution. From the hydrologic point of view, the river branch is characterized by very small flows and unsteady water regime. Ultimately, all this leads to a reduction in the volume of water or its complete disappearance (figure 6) in the river channel which results in reducing the number of specimens of fauna and further settling of all pollutants.Actions and parameters that provide revitalization progress are: water surface management by digging canals and clearing forest vegetation, silt removing, marsh vegetation cleaning and the construction of hydraulic structures, reducing the difference of water level between river channel and river branch.

Figure 6. Dried up river branch

As noted above, every year at leastone of the rivers in Croatia has recorded the emergence of new extreme value and meteorological models in future expect even greater changes (Figure 7). This is just another example of why we need to work systematically to improve the system of hydro-meteorological forecasting. Output data of this survey provides information of the river channel configuration and of the maximum volume of water that a river channel can accept. In Croatia, there are natural retentions such as Lonjskopolje and Kopačkirit where part of the floodwaters can be kept.A simple and effective project that is being implemented ‘Development of the system for the prediction of floods on the river Drava’ will contain a database that will be used to create digital mathematical model of flood forecasting. Databases will inter alia contain the following information: the amount of water discharged by the hydroelectric plants, amount of the rainfall and melting snow in the Alps, geoinformatic and hydraulic models for the Drava’s hydrographic stations, morphological monitoring data obtained by hydrographic survey etc.

The ultimate goal of this project is to establish a mathematical model, which is going to be used to analyze the possibility of establishing a system for flood forecasting and simulation occurrence of flood waves. Outputs of this survey show that due to digging canals, water level in branches decreases, therefore branches could affect water from the Drava River. Theconstruction and upgrading of flood protection is a complex and lengthy process but that does not mean it should be pushed aside, because ultimately, the damage from floods and droughts are a much higher expense than the investment to prevent the damage from the natural disasters.

Figure7. Flood in the upper course of the Drava River, November 2012.

4. Conclusion

The areas that we have displayed have the characteristics of high biodiversity, and water surfaces of the branches represent the potential for tourism and recreational purposes. Performed hydrographic survey is the contribution to various studies, such as: revitalization, forecast systems improving and morphological system monitoring with the purpose of creating better hydrologic and ecologic conditions and the preservation of these undeniably important habitats.

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BIOGRAPHICAL NOTES

Dino Dragun was born on June 08. 1987. in the town of Vinkovci in the Republic of Croatia. He has a Master's degree in 2011, in geodesy and geoinformatics and works as a Head of the hydrographic department in the MIG d.o.o. company in SlavonskiBrod, Republic of Croatia. During the college he got Dean’s award in 2008 for his work: ’Alternative way of studying – using interactive and multimedia concepts’.

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